June 2026

Nine Springs Watershed Study Report

DRAFT

City of Madison, Dane County, WI



The City makes no representation about the accuracy of these records and shall not be liable for any damages.

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1 Executive Summary

Background

Recognizing the changing rain patterns, and likelihood of more frequent future large rain events, the City of Madison (City) is conducting a multi-faceted approach to address stormwater flooding. As one component of that approach, the City is developing comprehensive stormwater management studies for each watershed within the City. The studies are conducted in two phases. Throughout both phases, the City incorporates multiple opportunities for public involvement and interaction.

Phase 1, Existing Conditions: Development of a hydrologic/hydraulic stormwater runoff model representing the physical and drainage properties of the watershed under existing conditions. The model is then calibrated to measure runoff events and used to identify the areas of the watershed most likely to flood under various rain conditions.

Phase 2, Recommended Solutions: Using the model, evaluate alternative methods and/or infrastructure improvements to eliminate, or reduce flooding impacts from large rain events.

It should be noted that the improvements documented in this report are not meant to be full design-level efforts; they are conceptual solutions that help the City's Engineering Division understand the magnitude of solution needed in each area to meet the targets. As projects are looked at further, and if they move to the point they are contemplated for programming, projects will then go into a more detailed design phase. This project phase collects detailed data needed for design and looks at refined design, permitting, and environmental issues associated with the project.

The Nine Springs Watershed covers a large geographic area, much of which is not the City of Madison. Only the areas draining *through* the City of Madison were modeled; portions of Fitchburg and the Town of Blooming Grove were included in the modeling to account for flows that pass jurisdictional boundaries. The Dunn's Marsh Watershed is technically within the Nine Springs Watershed, but it was already modeled by the City in a different study and therefore not modeled again.

The Study Area is the modeling area that is within the City of Madison. **Figure ES-1** shows the extent of the model and study areas.

City's Flood Mitigation Targets

The City developed a set of flood mitigation targets that exceed their current minimum design standards, to better understand where targets are being met and where the flooding conditions could be improved. The City's flood mitigation targets for the Nine Springs Watershed Study are as follows, grounded by Annual Exceedance Probability (AEP) design storm events. Note that these targets may change in the future.

10% AEP design storm event:

a) No surcharging onto the street for up to the 10-year design storm; water shall be contained within the pipes and structures.
b) For locations limited by known inlet capacity, allow no more than 0.5 feet of water above storm sewer inlet rim. Note that this target was not included in the scope for the Nine Springs Watershed Study.

4% AEP design storm event:

a) Centerline of street to remain passable during 25-year design storm with no more than 0.5 feet of water at the centerline of the street for a length of 100-ft.

1% AEP design storm event:

a) No home or business will be flooded during the 100-year design storm. This is defined as no more than 0.5 feet of water at the 5-foot buffer around a structure.
b) Enclosed depressions to be served to the 100-year design storm (which can include safe overland flow within street, easements, greenways or other public lands). *For purposes of this watershed study, enclosed depressions are defined as depressions in public right of way where stormwater needs to reach private property to overflow from the depression.*
c) Greenway crossings at streets to be served to the 100-year design storm.

0.2% AEP design storm event:

a) Safely convey stormwater; i.e. limited impact on private property. For purposes of this watershed study, limited impact is defined as no more than 0.5 feet of water at the 5-foot buffer around a structure.

Existing and recommended Solution Conditions Results

The existing conditions analysis found numerous locations where the system does not meet the identified flood mitigation targets, as outlined in **Table 1-1**. Following the existing conditions analysis, an extensive process was conducted to brainstorm, evaluate, and select a series of solutions that would reduce flooding across the watershed. All the recommended solutions were integrated into the model and compared against the flood mitigation targets, to assess the anticipated flood reduction. **Table 1-1** shows how the recommended solutions reduce flooding relative to the City's targets, and **Figure ES-2** shows the location of the recommended solutions.

There are still some locations within the watershed where the flood mitigation targets are not yet met, even with the recommended solutions. This is due to a variety of reasons, including the lack of physical space for improvements, lack of topographical relief to adequately drain regions, and localized flooding on private property that cannot be remedied with public improvements.

Table 1-1. Existing Conditions and Recommended Solutions Results

Based on the City's Flood Mitigation Targets for the Nine Springs Study Area

Design Storm Event	ID	Target	Study Area metric	Existing Condition	Recommended Solutions Condition
10% AEP	1a	No surcharging onto the street	152 modeled public structures	67 modeled public structures surcharging (HGL>Rim elevation) (44%)	38 modeled public structures surcharging (HGL>Rim elevation) (25%)
	1b	No more than 0.5' of water at locations limited by inlet capacity	*Inlet capacity restrictions not included as part of this watershed study*		
4% AEP	2a	Centerline of street remain passable	21.6 miles of road centerlines	0.88 miles of roads with more than 0.5-ft of water (4%)	0.26 miles of roads with more than 0.5-ft of water (1.2%)
1% AEP	3a	No homes or businesses will be flooded*	1,202 buildings/structures	16 buildings/structures impacted (1.3%)	7 buildings/structures impacted (0.5%)
	3b	Enclosed depressions served	29 enclosed depressions	2 enclosed depressions impact private property when overflowing (7%)	2 enclosed depressions impact private property when overflowing (7%)
	3c	Greenway crossings at streets served	There are no greenways that cross streets within the Study Area		
0.2% AEP	4	Safely convey stormwater; i.e. limited impact on private property	1,202 buildings/structures	25 buildings/structures impacted (2%)	20 buildings/structures impacted (1.6%)

**This metric includes structures that are not occupied, such as garages and sheds.*

Recommended Solutions Cost

Improvements were recommended across the watershed by upsizing existing piped infrastructure. New regional ponds were considered but were determined to be an undesirable option for the Nine Springs Watershed.

Table 1-2 lists the final recommended solutions, along with an estimated design and construction cost for each. Figures for the recommended solutions are included later within this report.

Table 1-2. Recommended Solutions Project Cost Estimates

Project	Estimated Cost

**Costs only accounted for inlets requirements for the 10% AEP design event, not complete reconstruction.*

FIGURE ES-1

FIGURE ES-2

2 Introduction

2.1 Project Background and Purpose

The City of Madison has experienced increased frequency and intensity of rainfall events over the past ten to fifteen years. In August 2018, an unprecedented rainfall event occurred on the City of Madison's west side. A nearby United States Geological Survey (USGS) rain gauge in Middleton's Pheasant Branch Conservancy (site # 05427948) recorded 10.5 inches of rain over a 12-hour period. For reference, NOAA Atlas 14 statistics show the 12-hour 0.1-percent chance recurrence interval storm at 8.92 inches for the Madison area. This event caused flash flooding, most significantly across the western half of Madison, and prompted the City of Madison (City) to begin a comprehensive watershed planning process.

In response to the 2018 summer floods, the City of Madison initiated a city-wide focus on identifying and addressing issues within the urban drainage system. This includes creating comprehensive watershed plans for watersheds throughout the City, including the Nine Springs Watershed (the watershed).

This report will use the following terms to describe the project area. The term "Nine Springs Watershed" or "Watershed" will refer to the full watershed area (12.5 sq. miles), which also includes the Dunn's Marsh subwatershed (which was previously studied by the City, see **Section 2.4**). The term "Model Area" will refer to areas included in modeling, to account for flows draining through the City of Madison (2.15 sq. miles); note the Model Area includes portions of the City of Fitchburg and the Town of Blooming Grove. "Study Area" will be used to refer to the area inside the Model Area that lies within the City of Madison, where the study is focused (1.5 sq. miles).

Figure 1 provides a detailed view of the watershed, model area, and study area, with an inset map to show the location within the City.

2.2 Scope of Study

The scope of work includes:

- Development of an existing conditions XP-SWMM computer model of the 1,379 acre model area within the Nine Springs Watershed.
- Calibration of the model against rainfall and flow/depth data collected at selected locations within the watershed during the summer of 2023 to fall of 2024.
- Evaluation of calibrated model output for purposes of identifying locations within the Study Area where the existing stormwater management system does not meet City of Madison flood mitigation targets.

- Evaluation of flood mitigation alternatives.

During this project, significant resources were allocated to public involvement including multiple public information meetings and online data reporting efforts. Information collected during the public information meetings was used in the model development and the problem identification efforts of this project.

The first half of this report documents the development and calibration of the existing conditions Nine Springs Watershed model. Flood mitigation alternatives are documented in the second half of the report.

2.3 Historic Flooding in the Watershed

Within the Nine Springs Watershed, there are several areas that have experienced flooding in the past. **Figure 2** depicts known flooding reports provided by the City. The known flooding locations include flood reports from a variety of data sources, including resident reports, emergency services reports, operations staff reports, and inlets with repetitive clogging history. These flood reports are limited to areas within the City of Madison.

Street Flooding at Westview Lane
The Cannonball Bike Path and Knollwood Conservation Park were previously affected by street flooding at Westview Lane that resulted in historical flood reports. Initially, during the RFP process, the City wanted to verify that any additional flow being passed downstream to the City of Fitchburg was limited. Previous improvements in this area have reduced the number of residential flooding reports.

Post Road & Watford Way
There is known flooding around the Post Road and Watford Way intersection due to a shallow enclosed depression and a potentially undersized outfall. Some of the pipes and road right of way around this location are owned by the DOT.

Engelhart Drive
Engelhart Drive has experienced some historical flooding with reports along Settlement Drive. The Nine Springs wetland area and City of Fitchburg boundary are to the south. The existing storm sewer in the area is mostly on publicly owned land.

Villager Shopping Center (Park Street & Badger Road)
The Villager Shopping Center at Park Street and Badger Road is a relatively new development that has continued to experience inundation during large events in the past few years. The City wished to evaluate the existing infrastructure here due to frequent flooding reports and known street flooding along Badger Road and Park Street. There are several low areas located behind the existing buildings which are located on private property. Changes to the area occurred near

the early part of the study including the removal of the bus transfer station that was replaced as part of the City's Rapid Transit Program.

Park Street/US HWY 14/Beltline Interchange

Park Street (to the north) and Highway 14 (to the south) of the Beltline (Highway 12/18) is a cloverleaf interchange, with four (4) DOT ponds inside the cloverleafs. Park Street passes underneath the Beltline, effectively making it a sag. During large rainfall events, Park Street regularly floods and prevents traffic from using the underpass, sometimes with 2-ft of standing water. There are flooding reports north of the Park St/Beltline interchange, extending to the north all the way to Hughes Place. There is also some flooding on the northwest onramp (from Park St to the Beltline).

Fell Road Cul-de-Sacs

Historical flooding has been observed along cul-de-sacs at Arther Court, Book Court, and Marcus Court along Fell Road. Each cul-de-sac has a low point that collects runoff, and they drain to the east into a storm system behind the homes, outside of the right of way. Multi-family/condos to the east (S Sunnyvale Ln) also drain to this storm system. Flooding is likely caused by limited pipe capacity in this storm system network.

Latham Drive & Applegate Road Flooding

From Greenway Cross, along Lathan Drive, and to the north along Applegate Road, there are known flooding concerns. This area is shallow enclosed depression with limited topography; therefore, the area is prone to surface accumulation. This portion of the City was historically in the Town of Madison before being annexed into the City. The existing storm sewer system is undersized based on the City's current design standards, and transitions to open channel flow in private property used for storing heavy machinery and equipment (between Latham Drive and Perry Street). The City has limited ability to provide maintenance for this area. Improvements to this area should be focused on relocating the storm system into City maintained right of way, so staff can maintain the system more regularly.

Flood Mitigation Targets

The following flood mitigation targets have been established by the City of Madison, grouped by Annual Exceedance Probability (AEP) design storm event, with a final target focused on ensuring the solutions do not have negative impacts elsewhere within the watershed:

10% AEP design storm event:

a) No surcharging onto the street for up to the 10-year design storm; water shall be contained within the pipes and structures.

   There are locations within the City where low points exist that pond water; these low points are excluded from this target and will be addressed as streets are redesigned.

b) For locations limited by known inlet capacity, allow no more than 0.5 feet of water above storm sewer inlet rim. *Note that this target was not included in the scope for the Nine Springs Watershed Study*.

4% AEP design storm event:

a) Centerline of street is to remain passable during 25-year design storm with no more than 0.5 feet of water at the centerline. *Note that the modeling approach will not explicitly account for cross flow conditions where more gutter flow on one side of the street can overtop the crown*.

1% AEP design storm event:

a) No home or business will be flooded. This is defined as no more than 0.5 feet of water at the 5-foot buffer around a structure.

b) Enclosed depressions to be served (which can include safe overland flow within street, easements, greenways or other public lands). For purposes of this study, enclosed depressions are defined as depressions in public right of way where stormwater needs to reach private property to overflow from the depression.

c) Greenway crossings at streets to be served to the 100-year design storm.

0.2% AEP design storm event:

a) Safely convey stormwater, i.e. limited impact on private property. For purposes of this study, limited impact is defined as no more than 0.5 feet of water at the 5-foot buffer around a structure.

Provide flooding solutions that do not negatively impact downstream properties.

The City also stated that 'due to the inherent variability and complexity of stormwater conveyance systems, it may not be practical to meet the above level of service targets in all areas of the City.'

The focus of the Watershed Study is on the capacity/deficiencies within City-owned infrastructure and the right of way. The Watershed Study should be considered a "planning-level" analysis. Therefore, there are several limitations to the study that are documented further in **Section 7.3**.

2.4 Summary of Past Studies

The Nine Springs Watershed comprises several previously studied areas.

Dunn's Marsh
Before the City of Madison began this evaluation of the Nine Springs Watershed, Dunn's Marsh Watershed was previously modeled and studied, with the final report submitted for the project in 2024. At the time of the Nine Springs Watershed Study, the city has not yet published the final report from the Dunn's Marsh Watershed Study. Additional modeling work was completed after receiving the project deliverables. Due to the recency of this study, this area was not remodeled as part of the Nine Springs Watershed study. The hydrograph outputs from the City's updated models were used as input flows into the Nine Springs Model area.

The Dunn's Marsh area is 1,360 acres (or 2.1 square miles). The Dunn's Marsh portion of the study area can be seen online via the City of Madison Engineering Page under Watershed Study Page, or at the link below[1]. A similar modeling approach was used, and target metrics referenced to identify priority areas.

Previous Nine Springs Watershed Study Report
The Nine Springs Watershed was also previously studied in 2013 by the City of Fitchburg. This report helped guide improvements in the area, especially around the Cannonball path where existing conditions showed erosion, which was later addressed by the City. The 2013 models were not incorporated into this study.

[1] https://www.cityofmadison.com/engineering/projects/dunns-marsh-watershed-study

3 Water Resources Inventory

3.1 Study Setting

The Nine Springs Watershed is located along the southern edge of the City of Madison, with many areas of the watershed located along the border or inside of other municipal boundaries as shown in **Figure 1**. In general, the watershed incorporates land areas that flow to Nine Springs Creek and subsequently Lake Waubesa. The Nine Springs Watershed includes areas to the south of the City of Madison municipal boundary and includes large areas within the City of Fitchburg. Much of the southern portions of the watershed are open space within the City of Fitchburg and were therefore not modeled due to jurisdictional complications. The Nine Springs Creek watershed is one of the largest watersheds identified by the City of Madison Watershed Studies, encompassing portions of several neighborhoods including Allied Dunn's Marsh and Dunn's Marsh, Arbor Hills, Bram's Addition, Burr Oaks, Capital View, Highland Manor, Indian Springs, Leopold, and Moorland-Rimrock. US Highway 12 (the Beltline) cuts through the middle of the watershed along with several major intersections and roadways.

Three separate terms are referenced in this report to describe portions of the Nine Springs Watershed.

- **Nine Springs Watershed**: The Nine Springs Watershed comprises approximately 8,006 acres (including the Dunn's Marsh subcatchment area). The modeling area includes 26% is within the City of Madison, 67% is within the City of Fitchburg, 6% is within the Town of Blooming Grove, and a very small percentage (less than 1%) is within the Town of Dunn and the City of Monona.

- **Model Area**: For this project, only a portion of the total watershed area was modeled (Model Area). The City wanted to focus on flooding concerns within their jurisdictional area. Therefore, only the portions of the Nine Springs Creek watershed that drained through land within the City were included. Dunn's Marsh was already modeled in a prior study, so this area was not modeled again. Instead, inflows from this model acted as the starting boundary condition, and the remaining modeling area was inclusive of lands to the north of Nine Springs Creek. Of the Model Area, 31% is within the City of Madison, 66% is within the City of Fitchburg, and 4% is within the Town of Blooming Grove.

- **Study Area**: The Study Area is just the City of Madison lands within the Model Area. The Study Area is approximately 956 acres, or 12% of the full watershed area.

The Study Area comprises many land use types. Industrial land uses make up about 26% of total land area within the study area. Approximately 16% of the study area is single family residential, 12% multi-family residential, 2% Mobile Homes, and 2% duplex, totaling approximately 31%

residential land. There is a total of approximately 20% natural areas (including open space, woodland, parks, and water areas). Commercial spaces comprise approximately 12% of the total land area and government or institutional lands are approximately 5%. The major roadways in the area contribute to approximately 6% of the total land area as highway. **Table 3-1** below shows each modeled land use and its respective land area within the Study Area. This table does not include areas outside the City of Madison.

Table 3-1. Study Area Land Use

Land Use (WinSLAMM)	Total Area (acres)	Percent (%) of Study Area
Duplex	15.23	1.6%
Highway	54.08	5.7%
Institutional	36.18	3.8%
Light Industrial	244.20	25.6%
Medium Density Residential (No Alley)	150.62	15.8%
Multi-Family Residential	116.66	12.2%
Mobile Homes	14.89	1.6%
Open Space	159.81	16.7%
Park	20.42	2.1%
School	14.02	1.5%
Shopping Center	13.52	1.4%
Strip Commercial	103.80	10.9%
Water	3.14	0.3%
Wooded	8.97	0.9%

3.2 Watershed

The Nine Springs Watershed is bound by the Dunn's Marsh, John Nolen, and the Wingra Proper Watersheds as shown in **Figure 3**. To the east, the Yahara River Watershed forms the northern boundary between John Nolen and the chain of lakes, however the Yahara River Watershed was not studied. Dunn's Marsh is considered part of the Nine Springs Watershed and is bound by Wingra West to the north and East Badger Mill Creek to the west. The Nine Springs Watershed is the southernmost watershed identified in the City of Madison Watershed Studies but is bordered to the south by the City of Fitchburg and Story Creek and Swan Creek Watersheds. As of the writing of this report, the surrounding watersheds that were planned to be studied have been completed or are near completion.

Areas of interest within the Study Area include the Fish Hatchery and Post Road intersection, the interchange of the Beltline (Highway 12) and USHWY 14/Park Street, the commercial area known as the Villager Mall along Park Street and Hughes Place, residential areas along Engelhart Drive, and the Wastewater Treatment Plant operated by Madison Metropolitan Sewerage District (MMSD) on the east side of the watershed district. The watershed also includes portions of several Natural Areas and Parks including the Nine Springs Natural Resource Area and the Jenni & Kyle Nature Preserve to the south of the study area, as well as several City of Madison Parks including Community Parks Baxter Park, Aldo Leopold Park, and Highland Manor Park.

3.3 Topography

The following data sources were used for topography within the Model Area. Topographic data was needed for delineating the model area and defining overland flow paths/channels.

- 2024 Aerial Photography obtained from the City of Madison
- 2022 LiDAR DEM obtained from the City of Madison, and 1-foot contours generated from that DEM
- GIS data describing storm drainage infrastructure provided by the City of Madison
- Site observations by MSA and City staff

3.4 Drainage System

The Nine Springs Watershed has primarily urban drainage, with many streets/neighborhoods served by stormwater infrastructure. The major drainage system is comprised of large storm sewer pipes and regional public stormwater ponds. The list below identifies the ponds within the study area, which are discussed in more detail in Section 5.5. The major system is supplemented by the minor drainage system, which consists of street storm sewer, street surface flow, and private stormwater infrastructure.

- Avalon Pond (In City of Fitchburg)
- Engelhart Drive Pond
- Nine Springs Golf Course Pond
- Nine Springs Syene/Post Road retention pond (A-0540) (in City of Fitchburg)
- Ochalla Pond (in City of Fitchburg)
- Post-Watford Retention Pond
- The Vue Wet Pond (in City of Fitchburg)
- Valley View Pond (in City of Fitchburg)
- USH 18/14/151 Interchange Pond- Northeast
- USH 18/14/151 Interchange Pond- Southwest

- Nine Springs Valley Greenway (five sections)
    - Ocean Road
    - Ocean Court
    - Engelhart Drive
    - Knollwood Way
    - Leyton Lane

The overall drainage system is shown schematically in **Figure 1.**

3.5 Runoff Conditions

Runoff conditions within the watershed are dictated primarily by three components: land use, impervious area, and underlying soils.

3.5.1 Land Use

Land Use within the Model Area is shown in **Figure 4**. Much of the area is fully developed with ~34% of the study area consisting of single family, duplexes, mobile homes, and multi-family residential properties. The remaining land is associated with the road network, commercial properties, industrial properties, institutional properties, recreational parks, and natural areas. There has not been extensive development in this area in recent years. Note this list was updated as of January 2026.

The City is aware that some lands are likely to be redeveloped in the future, specifically those close to the Beltline and Park Street. However, there are no set plans for redevelopment currently.

Finally, the City of Madison received a Reconnecting Communities and Neighborhoods federal grant, to support the planning and feasibility efforts for a potential Perry Street Overpass, to connect the neighborhoods north and south of the beltline. At the time of writing this report, the project was still reviewing preferred alternatives and incorporating public feedback prior to presenting it to the Transportation Commission.

3.5.2 Impervious Area

The total impervious area for the Model Area is displayed in **Figure 5**. Impervious area for this study was obtained from several sources:

- City of Madison’s impervious area layer (based on 2020 imagery)
- Digitized impervious area by MSA using the most recent high-resolution aerial imagery available at the time (2024) to supplement with new development.

- Impervious areas within the City of Fitchburg were approximated based on available data and aerial photography for modeling inputs

The Model Area is approximately 1,379 acres (2.15 square miles) and is occupied by 548 acres of impervious, making it ~40% impervious.

3.5.3 Soils

The Hydrologic Soil Group (HSG) classifications within the watershed are shown in **Figure 6**. The HSG is a parameter that quantifies a soil's ability to infiltrate stormwater runoff. Well-drained soils with high infiltration rates are classified as 'HSG A', while poorly drained soils with correspondingly low infiltration rates are classified as 'HSG D'. Soils with classifications as 'HSG B' or 'HSG C' fall between these two values. Soils that have dual classifications such as B/D, indicate the respective HSG for drained and undrained conditions. Dual classed soils were treated as though they were in the drained condition; the City of Madison modeling guidance recommended treating dual classed soils as though they were in the undrained condition, but this approach was not followed for the Nine Springs Watershed Study.

The soils in this Model Area are primarily HSG B. Smaller percentages of the study area are classified as HSG A and HSG C. There are no areas of the study area defined as HSG D. Swathes of dual classification HSG 'A/D', 'B/D' and 'C/D" were treated in the drained HSG 'A', 'B', or 'C' condition, respectively.

4 Guidance and Data Sources

4.1 Modeling Guidance Documentation

The most current version of the Modeling Guidance Document that was available during model development was applied to the existing conditions calibrated model (**Appendix A**). Differences between the existing conditions modeling approach and the Modeling Guidance are noted in this report.

All elevations listed in this report are relative to the National Adjusted Vertical Datum of 1988 (NAVD88) unless otherwise noted.

4.2 Data Sources

The following is a list of data used in this analysis:

- City of Madison 2022 LiDAR DEM
- Dane County 2024 Aerial Imagery
- NRCS Soils Data for Web Soil Survey (downloaded 9/12/2024)
- Observed impervious surfaces as digitized by MSA using recent aerial photographs
- Existing storm sewer, inlet, and structure data from the City's GIS database and the City of Fitchburg
- Various construction drawings provided by the City
- Site observations performed by MSA staff
- Input obtained through Public Information Meetings (PIMs)
- Rainfall and pipe flow monitoring data collected by the City and the USGS

5 Model Development

5.1 Modeling Software

The version of XP-SWMM that was used for this study was XP-SWMM 2024.2.

5.1.1 Modeling Approach

Three elements of XP-SWMM were used for this model, the hydrologic model, the 1D-hydraulic model, and the 2D-hydraulic model. The hydrologic model was used to simulate the runoff resulting from various rainfall events. The 1D/2D hydraulic models were used to simulate the accumulation and flow of runoff through the watershed.

The one-dimensional (1D) portion of the model only includes subsurface drainage systems (storm sewer and culverts) and their connection to the surface drainage system. The surface drainage was modeled almost entirely in two dimensions (2D). Additional detail on the 2D portion of the hydraulic model development is included in **Section 5.6**.

5.2 Rainfall Files

Two different rainfall data sources were needed for this study:

- Design rainfall distributions, and
- Measured rainfall data (gauged data) used for the model calibration.

5.2.1 Design Rainfall Events

The MSE 24-hour rainfall intensity distribution with NOAA Atlas 14 rainfall depths were used for event-based modeling. The rainfall distribution uses a time step of 6 minutes. **Table 5-1** lists the design depths used in the analysis.

Table 5-1. NOAA Atlas 14 Design Storm Rainfall Depths

Rainfall Duration	100% AEP (inches)	50% AEP (inches)	20% AEP (inches)	10% AEP (inches)	4% AEP (inches)	2% AEP (inches)	1% AEP (inches)	0.5% AEP (inches)	0.2% AEP (inches)
24-hours	2.49	2.84	3.45	4.09	5.02	5.74	6.66	7.53	8.94

5.2.2 Measured Rainfall Events

Rainfall data was collected in a series of incrementally-recording tipping-bucket style rain gauges operated by the USGS and the City in regions near the watershed in the summer of 2023 through fall of 2024.

The City of Madison engineering staff developed a Thiessen polygon for each rain gauge indicating the area of influence that each gauge was to be assigned for purposes of calibrating the various watershed models. The Nine Springs Watershed is primarily divided into two regions corresponding to two separate rain gauges (Baxter Park and Marlborough Park). The majority of the Nine Springs Watershed was within the Thiessen polygon for Baxter Park (**Figure 7, Table 5-2**).

For calibration, the Baxter Park rain gage was utilized as both study meter locations are located within the Thiessen polygon for the Baxter Park rain gage.

Table 5-2. Rain Gage Locations for the Nine Springs Watershed

Gauge Location	Operated by
Baxter Park	USGS
Marlborough Park	USGS

Rain events to be used in the model calibration process were selected in coordination with the City of Madison engineering staff. The event selection criteria focused on the largest events recorded, with the most complete rainfall station records during the monitoring period. The total duration, total depth, and 3- and 5-day antecedent rainfall for the three selected calibration events used in the study are summarized in **Table 5-3**. Each event corresponds to a NOAA Atlas 14 Rainfall event of greater than 100% Annual Exceedance Probability.

Table 5-3. Calibration Events Rainfall Summary

Event Date	Start Time	Stop Time	Duration (hr)	Total Rainfall Depth – Baxter Park (in)	3-Day Antecedent Rainfall (in)	5-Day Antecedent Rainfall (in)	Peak Intensity (in/hr)
July 12, 2023	11:15	16:50	5.5	1.6	0.1	0.1	0.72
July 2, 2024	4:30	21:25	17	2	0.1	1.8	1.92
October 30-31, 2024	17:15	2:35	9.33	1.8	0	0	1.32

Other City of Madison watershed studies also evaluated the August 2018 flood event using rainfall hyetographs. However, this event was relatively small for the Nine Springs Watershed, and therefore the City did not request this event to be included within the modeling or calibration. The estimated rainfall in the watershed for this event was generally 3" or less in 12 hours. This roughly equates to a 5-year recurrence interval (20% AEP), estimated using NOAA Atlas 14.

5.3 Hydrologic Model Development

5.3.1 Methodology

Subcatchment runoff was computed using the XP-SWMM runoff (SWMM Runoff) routing method with Horton infiltration parameters. This approach was directed by the City.

The SWMM runoff method requires primary input values including subwatershed area, the percentage of directly connected impervious area, the subcatchment width, and the average subcatchment slope. Additionally, each subwatershed is assigned unique parameters describing the infiltration capacity of the soils within the subwatershed.

5.3.2 Subwatershed Input Data

5.3.2.1 Level of Detail

Subwatersheds (or subcatchments) were delineated to a level of detail such that subwatersheds:

- Contributed to each group of inlets along a street or at an intersection

- Corresponded to level of detail for the modeled storm sewer system (discussed later in **Section 5.4.1**)
- Contributed to points along long stretches of streets with no existing storm sewer such that the model could demonstrate whether new storm sewer would need to be extended further up the street

This approach is consistent with the Modeling Guidance referenced in **Section 4.1**.

5.3.2.2 Input Data

Appendix B contains the input data for each subwatershed. The list below provides a summary overview of the input parameters and how they were calculated for use in the "pre-calibrated" model recognizing that parameters would potentially need to be adjusted as part of the calibration process.

- **Subwatershed Area** –A total of 127 subwatersheds were delineated with areas ranging from 0.1 to 257 acres with a median size of 11.3 acres.

- **Impervious/Pervious Area**
  Total Impervious Area – The impervious area within the study area was provided by the City based on 2020 imagery, and manually updated by MSA using 2024 aerial imagery into the following seven categories:
    - Street
    - Roof
    - Driveway
    - Gravel Driveway
    - Parking
    - Gravel Parking
    - Sidewalk

  Directly-connected Impervious Area. Impervious area within the watershed was assigned a level of 'direct connectivity' according to ratios published in the WinSLAMM computer model standard land use data tables.

  Indirectly-connected impervious area. Impervious areas not classified as directly connected were classified as indirectly connected per Modeling Guidance. Runoff from indirectly connected impervious areas were directed via model routing, to flow over pervious areas within the hydrologic model before being transferred to the hydraulic model.

  Pervious area. Corresponding to lawns, terraces, parks, and greenways.

The sum of the area of directly connected impervious, indirectly connected impervious, and pervious areas equaled the total area of the subwatershed. Internal subwatershed routing was used as follows:

- Directly-connected impervious area assigned as Subcatchment 1 and routed to subwatershed outlet.
- Indirectly-connected impervious area assigned as Subcatchment 2 and routed to pervious area.
- Pervious area assigned as Subcatchment 3 and runoff (including run-on from Subcatchment 2) routed to subwatershed outlet.

- **Subwatershed width** - calculated by manually delineating (in GIS) the principal flow path of each subwatershed from its outlet to its physically distant upstream watershed boundary. The subcatchment area was then divided by the length of this flow path to calculate the subwatershed width.

  Width = Area / Hydraulic Length

  The same width value was assigned to each of the three subcatchments described above (directly connected impervious area, indirectly connected impervious area, and pervious area).

- **Slope for the subwatershed** - computed using the LiDAR DEM as the average percent slope along the hydraulic length of each subwatershed. The same slope was assigned to all three subcatchments. Subwatershed slopes range from 1.6% to 12.8% with a median of 3.95%.

- **Infiltration parameters** - assigned as an area-weighted average of the different hydrologic soil groups (HSGs) within a subwatershed. Horton infiltration parameters for each soil HSG were taken from the Modeling Guidance Document referenced previously.

- **Antecedent runoff conditions** - assumed to be standard for all statistical events simulated, with identical initial infiltration rates assigned for each event.

- **Depression storages for impervious and pervious areas** - set consistent with the Modeling Guidance referenced previously and applied to all events simulated.

- **Runoff routing destination / receiving node** – all subwatersheds were routed to either 1D or 2D surface nodes to begin inundation on the surface. Receiving nodes fall into two categories:
  - “Orphan” nodes are nodes where no storm sewer currently exists, but runoff to the 2D surface is needed to accurately reflect the potential inundation / flooding risk.

Flows from these nodes may flow over the 2D surface and contribute to the 1D system. Similarly, excess runoff from nearby 1D system elements may flow overland to collect at the location of an orphan node.

- A surface node that is the upstream end of a culvert or storm sewer system, or another loading point within a storm sewer system. These nodes are also connected to both the 1D and 2D model systems.

5.4 1D Hydraulic Model Development

5.4.1 Level of Detail

City of Madison Modeling Guidance requires, with flexibility, the following level of detail for the 1D hydraulic model:

Public System

- Standard: 18" pipes (or equivalent) and larger
- Process exemptions: Provided justification for reason that the pipe does not need to be modeled to evaluate the system relative to the City's Flood Mitigation Targets that are outlined in the Modeling Guidance.
- Process for requiring inclusion of smaller pipes: Necessary when they are the only pipes draining a part of the public system

Private System

- Private System Standard: Not included
- Process for requiring inclusion of private pipes: Necessary for modeling stormwater detention facilities or when they are a major part of the system

Figure 8 illustrates the 1D storm sewer system that is included in the model.

5.4.2 Hydraulic Conveyance Systems Analysis

All storm sewer and culverts were modeled with inputs consistent with the Modeling Guidance referenced previously. Inverts, pipe sizes, pipe types, and pipe shape were input from a variety of sources as outlined in **Section 4.2**. Where conflicts in data sources exist, the most reliable data source was used.

5.4.3 Inlet Capacity Analysis

Per the scope of work for this specific study, inlet capacity analysis was not included in this watershed study. It was assumed that sufficient inlets were present to accommodate stormwater flows.

5.5 Detention Pond Analysis

There are ten (10) ponds, five greenway sections, and two wetlands within the Nine Springs Watershed. Storage was inferred from LiDAR contours, as construction plans were either unavailable or did not contain the necessary information to infer the storage volume. Hydraulic structures controlling discharges from the ponds were entered into the 1D model system according to the information provided by GIS databases, topographic survey and visual inspections. The stormwater detention features included within the XPSWMM model are:

- Avalon Pond (In City of Fitchburg)
- Engelhart Drive Pond
- Nine Springs Golf Course Pond
- Nine Springs Syene/Post Road retention pond (A-0540) (in City of Fitchburg)
- Ochalla Pond (in City of Fitchburg)
- Post-Watford Retention Pond
- The Vue Wet Pond (in City of Fitchburg)
- Valley View Pond (in City of Fitchburg)
- USH 18/14/151 Interchange Pond- Northeast
- USH 18/14/151 Interchange Pond- Southwest

- Nine Springs Valley Greenway (five sections)
    - Ocean Road
    - Ocean Court
    - Engelhart Drive
    - Knollwood Way
    - Leyton Lane

There is one major wetland area within the study area near the MMSD Wastewater Treatment Plant.

5.6 2D Hydraulic Model Development

5.6.1 2D Modeling Area

With the exceptions of the ponds previously listed, the entire surface drainage system was modeled in the 2D model layer.

5.6.2 2D Terrain Data

The 2022 LiDAR DEM was used for the 2D terrain. The DEM was modified according to the available construction plans to reflect an approximate finished grading condition for a construction project at Hughes Place and South Park Street. Small DEM modifications were made for ditches and minor ridgelines, to push runoff to correct flow direction.

It should be noted that the LiDAR DEM for wet detention ponds reflect the pond water level and not the true ground surface. However, since the permanent pool of these ponds is not typically available for flood storage, the LiDAR DEM did not need to be edited to accurately model these systems.

5.6.3 2D Grid

A 10-foot grid cell was assigned in the model. A grid orientation default of 0 degrees was used as this visually appeared to match the orientation of many public streets within the watershed.

5.6.4 Roughness Values and 2D Land Use

Figure 9 shows the Manning's n roughness value that was assigned to the 2D terrain. All values assigned were in accordance with City Modeling Guidance.

Figure 10 shows the Land Use designations which were assigned through the watershed. As described in **Section 5.3.2.2**, the land use was used in conjunction with the digitized impervious data to determine DCIA and UCIA within each subwatershed.

5.6.5 Inactive Areas

Per the Modeling Guidance, all buildings were modeled as inactive areas within the 2D surface. It is important to note that this approach requires engineering judgment when evaluating model output to determine whether a building is at risk for flooding, since it is unknown whether a building has low openings above or below modeled flood elevations. Additionally, this approach ignores any minor storage that flooded buildings provide.

All open channels and detention ponds that were modeled using the 1D hydraulic model layer, were indicated as inactive in the 2D model layer so as to not 'double count' the hydraulic conveyance capacity and flood storage volume of the channel. Wetland areas were not modeled as ponds.

- Inactive areas list:
    - All building structures
    - Pond areas listed in **Section 5.5**

5.6.6 Model Inflow Data

Inputs from the Dunn's Marsh Watershed Study were used to establish model inflow conditions from the boundary of Dunn's Marsh Watershed with the Nine Springs Watershed. Hydrograph data was exported from the City's Dunn's Marsh model output, which is located at the far west side of the Nine Springs study area at Cannonball Path. The City provided the hydrograph data in

October 2024 for each studied rain event. Both existing and proposed conditions modeling utilize the same inflow hydrographs.

5.6.7 2D Boundary Conditions

There are several locations where surface flow was predicted to leave the study area under the scenarios evaluated in this study. In these locations, a 2D boundary line was added to the model with an elevation set below the ground elevation as defined by the 2D surface to allow surface flow to leave the model. Due to the more unique modeled area of this watershed, there are a total of 24 head boundaries included within the model. Many of the head boundaries are located at the southern edges of the model area along Post Road, Engelhart Drive, Moorland Road, and a number of piped outfall locations.

6 Model Calibration

6.1 Recorded Rainfall and Flow Data

Refer to **Figure 7** for locations of the Level Loggers and Rain Gages which recorded data from Summer 2023 to Fall of 2024.

6.2 Baseflow Conditions

Level logger data obtained during the metering process was steady in periods without rainfall, and baseflow conditions within the metersheds were considered to be negligible.

6.3 Selected Runoff Events

As described previously in **Section 5.2.2**, three rainfall events were used to calibrate the model using rainfall, water level, and flow monitoring data collect by the USGS under a separate contract with the City.

The three events used in the calibration were selected in collaboration with City staff; events were selected with the following considerations (generally in order of importance):

- Total rainfall/recurrence interval estimate
- Functioning monitoring equipment
- Differences between events (i.e. attempting to avoid similar events)

Based on these factors, the events summarized in **Section 5.2.2** were selected for use in the calibration.

6.3.1 Metering Gage Issues

The Marlborough Park rain gage, located in the Dunn's Marsh headwaters of Nine Springs Creek, malfunctioned frequently during the calibration period and did not provide data of sufficient quality for calibrating the model. So, data from the Marlborough Park rain gage was not used. More details are included in the Calibration Memo (**Appendix C**).

6.4 Calibration Performance

The criteria for calibration are as follows:

- Overall average model bias for water surface elevations (or flow) is within +/- 5% with reasonable effort made to minimize the largest absolute error while at the same time

balancing that effort with the relative importance of the model results at each monitoring site location.

- The largest absolute error at each monitored location is defined as +/- 25 percent.
- These calibration criteria are set recognizing that there may be some circumstances where calibration at a specific location cannot be accomplished. For example, to calibrate a larger portion of the model and/or produce results that are more accurate for the larger events, a particular gauge may have an error that exceeds the 25% threshold.

6.4.1 Calibration Results

Table 6-1, below, presents summary statistics regarding the bias of model output relative to meter data. Positive PBIAS values indicate model results tend to underestimate meter-observed values while negative PBIAS values indicate overestimation. Based on the PBIAS Limited method, this calibration is acceptable based on the City's requirements. Graphs comparing model results against metered data are shown in the Calibration Memo, seen in **Appendix C**. The Calibration Memo contains detailed discussion regarding the overall model calibration process.

Table 6-1. Model vs Meter Bias

Event Date	Engelhart Pond		Post Road	
	PBIAS TOTAL[1]	PBIAS LIMITED[2]	PBIAS TOTAL[1]	PBIAS LIMITED[3]
July 12, 2023	-45.2%	4.8%	35.6%	-9.8%
July 2, 2024	-43.4%	4.6%	27.3%	0.7%
October 30-31, 2024	-58.2%	-2.8%	31.7%	-3.0%

1. *Percent bias over duration of selected calibration event. Refer to duration of meter data on attached graphs*
2. *The limited duration bias assessment for Engelhart Pond extends from the beginning of the meter data and ends at the cessation of rainfall (refer to attached graphs). PBIAS data for the July 2, 2024 event is inclusive of only the first hydrograph peak.*
3. *The limited duration bias assessment for Post Road includes only data points where the level logger recorded a depth of 1.0-feet or more, reflective of the duration of the event where tailwater conditions are believed to affect system hydraulics.*

7 Results Evaluation

As noted in the Executive Summary**, Figure 11-Figure 19** illustrate the calibrated model results for the design storm events. Inundation figures were prepared for the 50% AEP, 20% AEP, 10% AEP, 4% AEP, 2% AEP, 1% AEP, 1% AEP as a long duration storm, 0.5% AEP, and 0.2% AEP.

7.1 Model Results Compared to City Observations

Existing conditions model results can be compared against the City Staff observations outlined in **Section 2.3**.

Flooding from the August 2018 event was less intense in the Nine Springs Watershed compared to areas further west.

To better understand and quantify the modeling results, a set of 25 locations were identified, and maximum flooding depth and duration of flooding was tabulated for a range of design storm events to use as quick reference for City staff. A map of the identified locations and associated tables are included in **Appendix D**.

7.2 Model Results Compared to Flood Mitigation Targets

The City identified five (5) major Flood Mitigation Targets. **Figure 20** through **Figure 25** show that there are numerous locations where the system does not meet the identified flood mitigation targets. *Note that for each target, only regions within the City limits were included within the analysis (within the Study Area)*. MSA prepared a series of GIS python scripts to determine problem locations based on the inundation maps produced by the Nine Springs model and other GIS datasets; these scripts will be provided to the City at the end of the project for future use.

Note that some of the Target criteria refer to “street centerlines”. Centerlines are defined as the centerline of the road; for most roads there is a single centerline, but there are two centerlines for boulevards where there is a median between each side of traffic.

Target 1: 10% AEP design storm event:

a) **No surcharging onto the street for up to the 10-year design storm; water shall be contained within the pipes and structures*.**

**There are locations within the City where low points exist that pond water; these low points are excluded from this target and will be addressed as streets are redesigned.*

This criteria was evaluated by comparing the rim elevations of the structures compared to the hydraulic grade line of the water in each structure. Evaluating the maximum water

level of the hydraulic grade line of each structure compared to the structure rim (model spill crest) elevation provides a clear indication of which structures are surcharging. Structures where the hydraulic grade line was higher than the rim of the structure were flagged as surcharging and classified as a 'potential problem location'.

Of the 197 modeled publicly owned access structures and inlets within the Study Area, 85 of them were classified as a potential problem location (**Figure 20**).

b) **For locations limited by known inlet capacity, allow no more than 0.5 feet of water above storm sewer inlet rim.**

Evaluating inlet capacity restrictions was beyond the scope of this watershed study. See **Section 5.4.3**.

Target 2: 4% AEP design storm event:

a) **Centerline of street to remain passable during 25-year design storm with no more than 0.5 feet of water at the centerline**.**

***Note that the* watershed study modeling approach will not explicitly account for cross flow conditions where more gutter flow on one side *of the street can overtop the crown*.

This criterion was evaluated by using a road centerline dataset, split at 100-ft intervals and intersected with the 4% AEP inundation raster. Any segments with an average of 0.5-feet or more of water depth were classified as a 'potential problem location'.

There are 1.2 miles of road centerlines (6.0% of all centerlines) with more than 0.5 feet of water at the centerline during the 4% AEP design storm (**Figure 21**).

Note that at the Park Street/US Highway 14 and Beltline interchange, areas where the Beltline crosses over Park Street, the Beltline bridges have been removed from the road centerlines to avoid false problem areas.

Target 3: 1% AEP design storm event:

a) **No home or business will be flooded during the 100-year design storm.**

This criterion was evaluated by buffering all buildings by 5-ft, and intersecting them with the 1% AEP inundation raster. Any buffered building with an inundation depth of 0.5-feet or greater was classified as a 'potential problem location'. Note that this analysis does not account for modifications residents take to mitigate flooding on their own properties. This metric does include structures that are not occupied, such as garages, sheds, and parking facilities.

There are 17 structures (1.4% of all structures) that could be impacted by the 1% AEP design storm (**Figure 22).**

b) **Enclosed depressions to be served to the 100-year design storm (which can include safe overland flow within street, easements, greenways or other public lands).**

This criterion was evaluated by identifying all the enclosed depressions at least 0.25 acres in size, based on the 2022 LiDAR DEM. This was completed using the LiDAR processing GIS tool created by Dr. Qiusheng Wu (https://github.com/giswqs/lidar). All depressions were intersected with the 1% AEP inundation raster. Any depression that had a maximum depth of 1-foot or more and touched public land (e.g. street ROW, greenway or SWU lands, etc) was flagged for review. The public lands and private ponds were removed from this subset of enclosed depressions, to determine if the depression also encompassed a portion of privately owned land.

Any enclosed depression that touched public land, included at least 0.25 acres of private land, and had more than 1-foot of inundation depth during the 1% AEP event was classified as a potential problem area.

There are five depressions within the watershed that are not adequately draining during the 1% AEP design storm (**Figure 23**).

c) **Greenway crossings at streets to be served to the 100-year design storm.**

This criterion was evaluated by identifying all the locations where channelized overland flow enters the piped stormwater system at roadway. Each location was intersected with the 1% AEP inundation raster, to determine the maximum water depth at the road centerline. See **Figure 24**.

There were no locations within the Nine Springs Study Area where greenways crossings intersected streets.

Target 4: 0.2% AEP design storm event:

a) **Safely convey stormwater; i.e. limited impact on private property**

This criterion was evaluated by buffering all buildings by 5-ft and intersecting them with the 0.2% AEP inundation raster. Any buffered building with an inundation depth of 0.5-feet or greater was classified as a ‘potential problem location’. Note that this analysis does not account for modifications residents take to mitigate flooding on their own properties. This metric does include structures that are not occupied, such as garages, sheds, and parking facilities.

There are 24 structures (2% of all structures) that could be impacted by the 0.2% AEP design storm (**Figure 25**).

Target 5: Provide flooding solutions that do not negatively impact downstream properties

This target was accounted for within the recommended solutions designs (See **Chapter 10**).

7.3 Limitations of the Study

The Nine Springs Watershed Study is a planning-level study, and as such, it has several limitations for using the model and results beyond the scope of this study. While not an exhaustive list, the following limitations should be considered when reviewing results or using the study for future work:

- Flooding on private property due to localized drainage issues (such as backyards that do not drain well) are outside the scope of this study. Inaccuracies in the LiDAR DEM due to the coarseness of the 10 ft grid cell could introduce some errors where a finer detail would not. An example of this would be a narrow-landscaped swale from a back of lot to the street. Such grading may not be reflected in the modeled surface.
- Because the study area covers 1.5 square miles, it is not possible to review and confirm flood inundation (or lack thereof) at every location throughout the watershed. Further, model calibration has its limitations as well, as described in **Section 6**.
- Inlets were modeled as simplified combined inlets into the system. Inlet capacity was not evaluated, and additional analysis may be required. Further, storm sewer laterals were in general not included in the analysis. Therefore, additional site-specific evaluations that more accurately review each inlet may be needed.
- Because every inlet was not modeled, there may be locations where there is more or less bypass flow or flooding depth on one side of the road than the other than what is shown in the model results.
- As noted in the calibration discussion (see **Appendix C**), the model may be biased to estimate marginally less runoff volume than actual rainfall would produce. Peak runoff rates appear to closely match with rates of actual rainfall.
- This study is not intended to be used for FEMA floodplain mapping purposes.

8 Public Engagement

As part of the Nine Springs Watershed Study, the City carried out an extensive public information effort. Various social media and web-based communication methods and public meetings were held. Key elements in the public information project are summarized below, with additional information available via the City's project website:

https://www.cityofmadison.com/engineering/projects/john-nolen-drive-watershed-study

8.1 Public Informational Meetings

An initial public information meeting (PIM #1) was held on September 23rd, 2024, over Zoom. The purpose of the meeting was to inform the public that the study was ongoing, provide an overview of what will be accomplished by the study, and collect feedback from residents on experienced flooding.

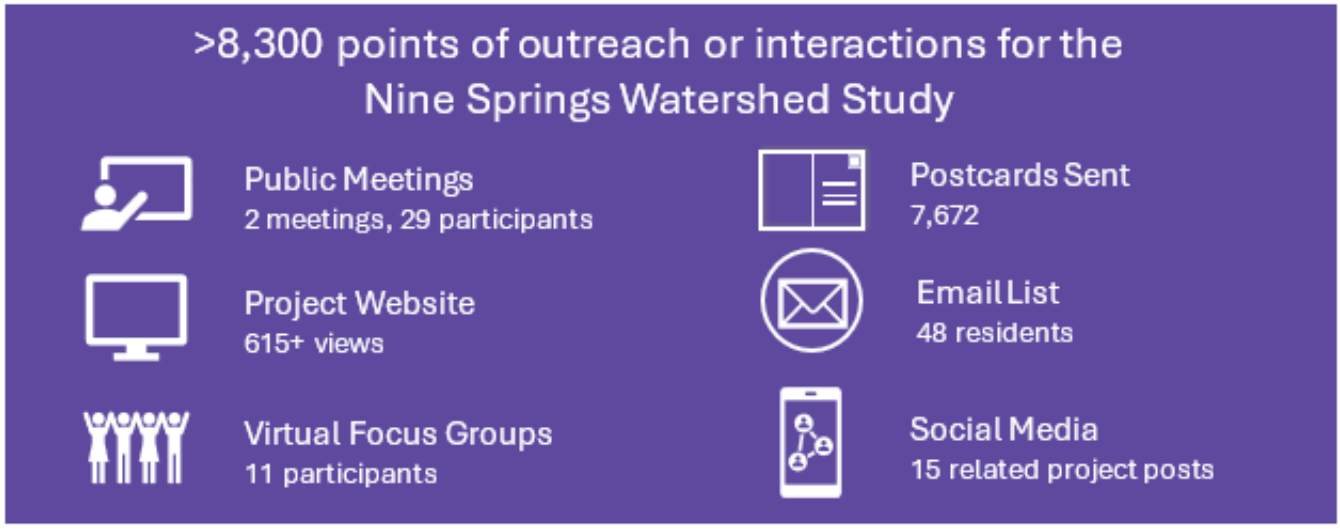
A second public information meeting (PIM #2) was held on March 30th, 2026, over Zoom. This PIM was formatted slightly differently than previous studies and was combined with information historically presented at PIM #3. Attendance was estimated to be around 12 individuals, and 'break out sessions' were intended to be held to allow residents to provide comments based on Focus Group areas. However, due to the small size of the group, City staff elected to keep everyone in the same Zoom room.

The discussions focused on the existing conditions modeling results, asking residents if the maximum inundation depth maps aligned with their local understanding of flooding within their neighborhoods.

This presentation also restated the targets of the watershed studies and presented the recommended solutions within the Nine Springs Watershed. Attendees were encouraged to ask questions about the project and recommended solutions within the meeting, either by writing in comments into the "chat" feature or asking questions aloud.

8.2 Focus Groups

This study only had virtual engagement with the public. Zoom PIMs were followed by either large group discussions or smaller breakout sessions (focus groups) for residents to provide feedback on flood modeling and the proposed improvements. Questions and comments from the public information meetings are summarized in **Appendix E**.



9 Recommended Solutions Development

Upon completion of the Existing Conditions analysis (outlined in Sections 1-7 of this report), a draft Existing Conditions report was approved by the City, and the project team moved into the second phase of the study: evaluating different flood mitigation alternatives. The recommended solutions development process focused on Peak Flow Control (PFC) solutions. PFC solutions are defined by the City as any stormwater control measure that can store or convey water but not infiltrate water.

9.1 Overall Process and Methodology

This chapter outlines the methodology or process used to identify the recommended solutions and elicit feedback from different agencies within the City. A list of all the solutions considered, including those that were not ultimately recommended, is included with brief descriptions of each potential solution. **Chapter 10** will provide more specifics on each of the recommended alternatives.

9.1.1 Data Review

The existing conditions modeling was reviewed to identify locations within the study area where City targets were not met for one or more targets. These locations were identified by reviewing the existing flood conditions and identifying a qualitative cause(s) at each location. Possible causes of flooding included: storm system is undersized, inadequate inlet capacity or poorly placed inlets, streets without existing storm sewer, and inadequate overland flow channels.

9.1.2 Solution Brainstorming

After the initial data review, MSA met with the City Engineering staff on October 13th, 2025 to discuss the existing condition model results, outline conceptual scenarios and identify potential opportunities for flood mitigation measures. Note that although the Nine Springs Watershed has many outfalls, many are restricted by the existing creek and lake levels. Increasing the pipe capacity only has a limited effect when the outlet is underwater, creating a tailwater effect. There are also several locations within the watershed where the outfall conditions are within private or DOT owned land, within which the City does not have jurisdiction to make improvements.

Improvements were grouped by areas/neighborhoods, and some involve a combination of improvements. Most involve upsizing piped infrastructure or changing routing to reduce strain on intersections prone to flooding. Solutions were targeted within street-right of way areas and lands already owned by the City for stormwater use. Regional storage solutions, such as

detention basins, were not viable in this watershed simply because there is not much, if any, available public open space within the study area for regional storage.

9.1.3 Evaluation of Potential Solutions

Following the brainstorming sessions, MSA developed preliminary solutions to address the flood mitigation targets for each of the identified problem areas. The calibrated existing conditions XPSWMM model was used to evaluate most of the flood control solutions (see **Section 9.2** for a brief description of all the solutions considered through this phase of the study).

9.1.4 Discussions of Potential Solutions with City Engineering Staff

Throughout the solutions modeling, MSA met with the City to review the intermediate modeling results and discuss the benefits and drawbacks of each. These discussions ultimately led to some new solutions being added to the list, while others were removed from further consideration. Some solutions were modeled individually at first, and then subsequently modeled in tandem with other improvements to determine their relative contribution to flood reductions.

9.1.5 Convergence on Solutions

As the evaluation progressed, a set of solutions (described in **Chapter 10**) were determined to provide the most viable path towards meeting the flood control targets for the project. This convergence was based on the performance of the solutions, technical feasibility and importance from the City Engineering staff. All the recommended solutions were subsequently mapped using the City's preferred template (to maintain a consistent format for recommended solutions from the various watershed studies) and provided to the City for internal review.

9.1.6 City Agency Meetings

Once there was a convergence on solutions, the City Engineering Staff coordinated with different City of Madison agencies to discuss the potential solutions and the challenges/obstacles to implementation. Engineering staff elected to send an email and a brief presentation about the proposed solutions. Information was sent to the Public Works Direct, Parks Division, Planning and Zoning, Water Utility, Transportation Engineering, and Engineering (Streets and Paths Section and Public/Private Development Section).

All agencies were given the opportunity to ask questions, provide comments, or request additional agency specific meetings or coordination. Only one comment was provided, from the Parks Department. The proposed improvement through Baxter Park passes through a managed meadow area, and there are active volunteers assisting with the vegetation maintenance.

Engineering will follow the standard approach for coordinate with Parks and make reasonable efforts to minimize short- and long-term impacts to the area if the project is constructed.

Appendix F provides a summary of the information shared in the City's internal meetings about the Nine Springs Watershed recommended solutions.

9.1.7 Finalization of Solutions

The City agency meetings did not result in any revisions to the solutions developed for the Nine Springs Watershed. Following this, the solutions were finalized.

9.1.8 Drafts sent to all City Agencies for Comment

A copy of the recommended solution designs and cost estimates were provided to the City Agencies for additional comment. The Parks comment about vegetation in Baxter Park was the only comment provided. There were no changes to the recommended solutions.

9.2 Description of All Solutions Considered

9.2.1 Solutions Not Recommended

The following flood mitigation methods were considered within the evaluation process; however, they were not ultimately recommended. Alternative solutions described below were evaluated only so far as it was necessary to find them infeasible or to be less feasible than other solutions addressing the same flooding concern. If, in the future, recommended alternatives are abandoned in favor of any of the solutions described herein, additional detailed investigations into the feasibility of each alternative will be required.

9.2.1.1 Curb Cutting at Post Road Outfall

- **Conceptual Project Description**: There is an outfall at Post Road and Watford Way that outlets to the south toward open space/parkland. During existing conditions, it was determined the existing pipes and alignment do not contain sufficient capacity for the existing inundation at this location. Due to restricted topography, pipe sizes can only be increased to a certain extent before slope and ground cover is insufficient. MSA proposed curb cutting on the south side of the Post Road and Watford Way intersection as a way of allowing excess overland flow to leave the right of way and flow freely into the parkland to the south.
- **Reason for Exclusion**: The City noted that curb cutting may cause additional problem, specifically icing on the road, and have impacts on the parcel to the south (owned by Dane County Parks). The City indicated this was not a preferred solution.

9.2.1.2 Upsizing Pipes along Applegate Road

- **Conceptual Project Description**: Several pipes along Applegate Road were determined to be undersized during existing conditions. MSA considered upsizing existing pipes along the existing pipe alignment.

- **Reason for Exclusion:** The pipes along Applegate Road are a mixture of privately owned and DOT owned pipes. Upsizing the existing pipe alignment was deemed too costly and time intensive due to the multiple property owners and agencies requiring coordination.

9.2.1.3 Upsizing Existing Alignment and Maintaining the Perry Street Connection

- **Conceptual Project Description**: Under existing conditions, pipe alignment travels from Perry Street eastbound toward Syene Road, but diverts north through private property between existing buildings before connecting to the east and traveling toward the existing outfall along Highway 14. Maintaining this connection with the proposed Applegate Bypass was considered.

- **Reason for Exclusion**: The existing pipes were installed when the land was part of the Town of Madison; pipes were installed on private property with an easement. The City requested proposed improvements stay within the ROW if possible and not between privately owned buildings (since this makes maintenance more difficult). Maintaining the connection does provide some additional flooding relief and can be considered if/when a project is completed in this area.

9.2.1.4 Secondary Syene Road Alternative Route

- **Conceptual Project Description**: A proposed improvement along Jonathon could continue to Syene Rd to the east, and continue directly to HWY 14, passing through privately owned property. The improvement would have less bends and provide more efficient conveyance. It would require either purchasing a parking lot or securing an easement with the private landowners.

- **Reason for Exclusion**: The City expressed a preference to avoid private property acquisitions and new easements as much as possible. The City did agree this alignment was mor efficient, and could be considered if land acquisition is feasible in this area.

9.2.1.5 Badger Road Water Quality Treatment Pond

- **Conceptual Project Description**: There is a vacant 1.5 acre lot at the northeast corner of Park Street and Badger Road. MSA noted it could potentially be used as a water quality or

rate control pond. The upstream watershed from this location is approximately 33 acres and the area along Badger Road and the Villager Mall experiences some inundation under existing conditions.

- **Reason for Exclusion**: The City noted that this parcel was previously slated for future development under the City's Future Land Use Plan and may have already been in discussion for planned development at the time of this proposed solution. It was determined a pond could not be placed at this location.

9.2.1.6 Maintaining the Beltline On-Ramp Open Ditch

- **Conceptual Project Description**: Under existing conditions, water from the Villager Mall and W Badger Road is diverted to the south via an existing ditch along the westbound Beltline on-ramp from Park St. The ditch experiences heavy inundation. MSA considered keeping this ditch as an open channel to continue containing incoming flows traveling toward the DOT Pond Area/Interchange of Highway 14/Beltline/S Park Street.

- **Reason for Exclusion**: The City indicated that although expanding the existing ditch into a wider greenway with more capacity could be viable, access to this location would be very limited. The City indicated that getting maintenance equipment (e.g. mowers, backhoes, etc.) into this location would not be feasible and therefore preferred a larger enclosed stormwater structure.

9.2.1.7 Secondary Outfall From Settlement Drive

- **Conceptual Project Description**: The existing stormwater pipes from Settlement Dr turn west on Engelhart Dr before discharging into the Nine Springs Valley Greenway (Engelhart Dr Section). A secondary outfall was proposed, continuing southwest from Settlement Drive and discharging into Indian Springs Park. This would allow the pipes along Engelhart Dr to remain in place and provide a secondary outlet for the system.

- **Reason for Exclusion**: The City indicated they preferred to keep the existing stormwater pipe alignment, as the secondary outlet would be in existing park land.

9.2.1.8 Relocating Fell Road Pipes

- **Conceptual Project Description**: The stormwater system along Fell Road includes pipes in an easement behind private property, outside the City right of way. The City notes that the existing alignment is complicated and less than ideal. Backyards are impacted by inundation. The Hunt Club condo complex (on Sunnvale Lane) also discharges to the pipes in the easement, and the system is undersized to serve the existing development.

One alternative was to relocated existing pipes outside the right of way into City-owned streets from the existing cul-de-sacs to Fell Rd.

- **Reason for Exclusion**: The cul-de-sacs slope to the east, forcing water to flow towards the existing pipes in the backyard easement. Regrading the cul-de-sacs to direct water west (towards Fell Rd) is not likely feasible with existing homes already in place.

9.2.2 Solutions Recommended

The following flood mitigation methods were recommended for implementation within the Nine Springs Watershed. The locations of the solutions are all displayed in **Figure 26** (an index map) and individual maps **Figure 27-A** through **27-H**. Further details about each design are provided in **Chapter 10**. The solutions are all piped improvements as the watershed did not have available space for new detention basins.

9.2.2.1 Westview Lane Improvements

- **Conceptual Project Description**: An isolated piped outfall located at Westview Lane is proposed to be upsized for increased capacity and improve conveyance within the Westview Lane right of way. A 19x30” elliptical pipe is proposed to increase capacity at the outfall.

- **Iterations Considered**: No additional iterations were considered for this solution location, as it is a singular pipe segment size increase. An alternative option is to use a circular pipe shape; however an elliptical size was chosen to more closely match the vertical dimension of the existing pipe.

9.2.2.2 Post Road and Watford Way Improvements

- **Conceptual Project Description**: The interceptor along Post Road and Watford Way travels south toward a detention pond and ultimately an outfall structure on the south side of Post Road. This proposed solution upsizes the existing infrastructure to accommodate additional capacity and improve conveyance. Upsized infrastructure will include 36” circular pipes along Stewart Street, and several upsized elliptical and box pipes downstream toward the outfall, ultimately discharging from a 60”x120” outfall.

- **Iterations Considered**: Other configurations and sizes were considered for this improvement, including:
    - Maintaining circular pipes throughout most of the system
    - Creating a curb-cut to allow flow to leave the street overland rather than through a piped system.

9.2.2.3 Applegate Bypass

- **Conceptual Project Description**: The Applegate Road area is defined as the interceptor running from Greenway Cross, along Latham Drive, and includes sections of Jonathon Drive, Applegate Road, and Syene Road, which then ultimately discharges along the western side of Highway 14 at the "Applegate Outfall". Several pipes along the interceptor within the Applegate Road area are privately owned/DOT, and portions of the existing infrastructure are within easements or outside the public right of way. MSA evaluated several alternatives here and ultimately determined a bypass to be the best course of action to improve conveyance and reduced inundation within the right of way for the surrounding area. New pipes are proposed, creating additional connections and improving capacity along the interceptor.

- **Iterations Considered**: Other configurations and sizes were evaluated in this area, including:

    - Fully upsizing the existing alignment
    - Alternative bypass pipe alignments, such as a Syene Road Bypass

9.2.2.4 Applegate Outfall and Cross Pipe

- **Conceptual Project Description**: There is an existing outfall located on the western edge of Highway 14, just south of the Beltline. This outfall serves much of the upstream watershed, including areas detailed in the DOT Pond area and the Applegate Road area. This outfall limits the pipe capacity of several upstream pipes and structures. MSA proposes upsizing this outfall to a 78" pipe and adding a new cross pipe as a 36"x 72" box. These improvements would likely occur when the DOT schedules reconfiguration of the existing interchange or improvements are made to Highway 14.

- **Iterations Considered**: Several sizes and pipe configurations were evaluated in this location , including the shape of proposed pipes. The City prefers that any proposed pipes under DOT roadways be box-shaped, so a box culvert is proposed for the cross pipe under Highway 14. One option would also be to have a secondary outlet *north* of HWY 14 but it would require a new culvert passing underneath the railroad tracks (likely requiring directional boring). The City preferred to keep solutions south of HWY 14 for ease of construction.

9.2.2.5 DOT Pond Improvements

- **Conceptual Project Description**: At the Highway 14/Park Street/Beltline interchange, several ponds/detention areas and various pipes of different sizes and shapes are present under existing conditions. MSA proposes several changes at this interchange to

improve capacity and the passage of runoff through the system. The upstream watershed of this improvement includes Badger Road and the Villager Mall (key locations noted by the City early in the study).

- **Iterations Considered:** Several pipe configurations and sizes were evaluated here, including the shape of proposed pipes. The City prefers that any proposed pipes under DOT roadways be box-shaped, so box culverts are proposed for any pipes that pass under the Beltline or Highway 14. Note these improvements would need to be implemented by the DOT, not the City. However, they were included in this study to support the City discussions with the DOT when the interchange is reconstructed.

9.2.2.6 Engelhart Settlement Improvements

- **Conceptual Project Description**: Under existing conditions, there is a short interceptor running south along Settlement Drive toward Engelhart Drive which ultimately outfalls south of Engelhart Drive to greenway along Nine Springs Creek. Proposed improvements include upsizing the existing infrastructure as well as adding new circular pipes beginning along Warner Street and along Diving Hawk Trail before joining with the existing alignment. Proposed improvements are designed to improve capacity and reduce on-street inundation.

- **Iterations Considered**: Several sizes were considered for this alternative, as well as a version which did not include new pipes along Warner Street and Diving Hawk Trail. Sizing the pipes to accommodate larger events, such as the 1% AEP, were evaluated but not recommended.

9.2.2.7 Fell Road Improvements

- **Conceptual Project Description**: The pipe infrastructure along Fell Road and adjacent cul-de-sacs (Book Court, Arther Court, and Marcus Court) is complicated and a known problem area. MSA sought to improve connectivity and reduce flooding impacts to adjacent homes and streets. This proposed solution includes new pipes from the Hunt Club Condos, new pipes along Fell Rd, removing the old pipe connection from the Hunt Club Condos, and upsizing of existing pipes toward the outfall pond south of Engelhart Drive.

- **Iterations Considered**: Many configurations and pipe sizes were considered for this area, including several solutions that are Not Recommended, including:
    - Upsizing the existing pipe alignment (no new pipes)
    - Relocating existing pipes into the right of way and removing them from backyards and easements

10 Recommended Solutions

The recommended solutions were introduced in **Section 9.2.2** and **Figure 26** is an index map, displaying all the recommended solutions within the Nine Springs Watershed Study Area. Within this chapter, the solutions are described in more detail, with specific reference to the flood reduction benefits, the land ownership for the project, known utility conflicts, other known concerns (e.g. landfills, wetlands, etc.), any anticipated permit requirements, and potential water quality benefits. A detailed figure is provided along with each recommended solution using the City's preferred template, to allow for easy comparison with recommended improvements from other watershed studies. **Figures 27 A-G** display each of the recommended improvements at a zoomed in scale, with all the City's mapped utility information. **Figures 28-36** display predicted maximum inundation depths with all the solutions implemented.

It should be noted that while there are improvements to the stormwater system functionality, even with all the solutions implemented, there are some locations where targets were not met. These are described in further detail in **Chapter 11.**

It should also be noted that the improvements documented in this report are not meant to be full design-level efforts; they are conceptual solutions that help the City's Engineering Division understand the magnitude of solutions needed in each area to meet the targets. As projects are looked at further, and if they move to the point they are contemplated for programming, projects will then go into a more detailed design phase. This project phase collects detailed data needed for design and looks at refined design, permitting, and environmental issues associated with the project.

10.1 Westview Lane Improvements

Detailed Project Description

The existing Westview Lane storm system includes a pipe that crosses Westview Lane and allows water to flow to the southwest toward the unnamed intermittent stream that contributes to Nine Springs Creek. Modeling predicted inundation within the right of way of Westview Lane during even small events and a structure was not meeting the conditions for Target 1a. The existing pipe size is 18".

This alternative increases the piped capacity within this structure under Westview Lane by upsizing the structure to a 30"x19" pipe. This improvement was focused primarily on removing inundation from the street and is intended to serve the low area along Westview Lane and improve the conveyance toward the waterway to the south during the 4% AEP event. This improvement will lessen inundation impact to the roadway and nearby multi-use path during large events.

A map of the recommended storm sewer improvements for the Westview Lane Improvement is included as **Figure 27-A**.

Associated Flood Reduction Benefits

As a result of the local storm sewer improvements, the City's flood control targets will be met as follows:

- **Target 1a**: The proposed solution reduces the flooding but does not eliminate all flooding within the street. The solution prevents one stormwater structure from flooding in the 10% AEP design storm.
- **Target 2a**: Inundation along the street centerline decreases with this recommended improvement, with 200-ft of additional centerline along Westview Lane no longer having 0.5-ft of water during the 4% AEP design storm event.
- **Target 3a**: No buildings were shown to be impacted by inundation during the 1% AEP design storm during existing conditions.
- **Target 3b**: There were no enclosed depressions within this corridor that were failing to meet the City's criteria during existing conditions.
- **Target 3c**: There are not any greenways within this area.
- **Target 4a**: Three buildings were shown to be impacted by inundation during the 0.2% AEP design storm during existing conditions and these continue to be impacted by inundation during the 0.2% AEP Event during proposed conditions.

Project Constraints/Considerations

This recommended solution is piped infrastructure and will be contained with the City right of way. If the project moves forward, additional consideration will be required to account for offsets from the sanitary and potable water utilities.

Anticipated permits

Based on the planning level design, the following environmental permits would be needed:

- City of Madison Erosion Control
- WDNR Water Quality Certification (if wetlands are present) *Note there are not mapped wetlands at the outfall, but a wetland survey would likely be required due to the presence of wetland indicators and proximity to a mapped waterway*.
- Intake or Outfall Structure General Permit. *Note there are exceptions to this permit, but it depends on the final design*.

Water Quality Benefits

Local storm sewer improvements will not provide water quality benefits.

Additional Notes/Information

Note that **Figures 28-36** show the inundation after all the improvements have been completed.

10.2 Post Road & Watford Way Improvements

Detailed Project Description

This improvement was focused on the Post Rd and Watford Way intersection. The upstream watershed includes Stewart Street, Watson Ave and portions of Kingsley Way. Water flows south along Watford Way, and in low flow conditions enter the water quality pond. During high flow conditions, there is a secondary bypass route that allows water to directly reach the outfall (bypassing the pond). Runoff that bypasses or discharges from the pond leaves the stormwater network at an outfall on the south side of Post Road where it enters the Jenni & Kyle Preserve, part of the Nine Springs Creek Recreation Area outside the City of Madison municipal limits. The contributing area is largely commercial and industrial.

Inundation along Stewart Street, Watford Way, and Post Road appeared in the modeling for the 100% AEP design storm event. City staff indicated this was an area of known flooding, but the extent that flooding impacted structures was unknown.

The existing pipe sizing starts as an 18” circular pipe along Stewart Street and becomes progressively larger as the pipe continues downstream. Further west along Stewart Street, the pipe is 21”, then transitions to 30” as it turns south along Watford Way, then to a 36” at the intersection of Watson Avenue, before transitioning to a 45” pipe at the southern portion of the intersection with Kingsley Way where it transitions to a 45”x29” horizontal ellipse until reaching the stormwater pond.

Proposed improvements for this area follow the existing storm sewer alignment, upsizing the pipes starting along Stewart Street, following the main trunkline the entirety of its length to the outfall south of Post Road. Improvements begin by upsizing the 18” & 21” circular pipes along Stewart Street to 36” circular pipes. Then, as the pipes turn south along Watford Way, they are proposed as 48”x76” elliptical pipes until south of Watson Ave where upsized 53x83” elliptical pipes are proposed. A 60”x96” box is proposed near the north end of the existing stormwater pond, continuing 205’ to the south as it transitions to a 60”x120” box along the southern portion of Watford Way, across Post Road to the outfall. Due to restricted elevation at the outfall, larger boxes and elliptical pipes are proposed to increase underground storage during higher intensity events. The improvement is intended to provide additional capacity without major intersection changes or reconstruction efforts that may adversely affect areas outside the City of Madison or worsen flood impacts during events compared to existing conditions.

Note that this improvement is sized for the 4% AEP design event. The primary goal of this improvement is to keep the streets passable for the 4% AEP event. A secondary benefit to this improvement includes reduced impacts to the surrounding buildings during the 1% AEP event.

Alternative Solutions Considered:

- Changing the pipe configuration around the existing pond and outfall was considered, including an option such as curb cutting along the south side of Post Road to alleviate overland flow from the street to enter the green space to the south. These options were deemed unfeasible due to the amount of permitting, road reconstruction efforts, and potential impacts to the City of Fitchburg.
- Keeping the pipes as circular pipes along the existing alignment but increasing their diameter was considered. Review of site topography and existing ground cover, as well as the elevation of the outfall and downstream low areas determined this would yield limited improvements, therefore transitioning pipes to boxes and ellipticals was preferred.
- A secondary outflow pipe and direction was considered for the pond to reduce or remove the "looped" system that currently exists between the pond and Watford Way storm sewer. The City did not prefer this location as it would be adding a new outfall location to land owned by Dane County Parks.
- Some maintenance activities were not modeled but should be considered. The pond outlet structure is often clogged with debris, and the pond itself is likely in need of sediment removal (dredging).

A map of the recommended storm sewer improvements for the Post Road and Watford Way Improvements are shown on **Figure 27-B**.

Associated Flood Reduction Benefits

As a result of the local storm sewer improvements, the City's flood control targets will be met as follows:

- **Target 1a**: The proposed solution reduces the flooding but does not eliminate all flooding within the street. The solution prevents seven (7) stormwater structures from flooding in the 10% AEP design storm.
- **Target 2a**: Inundation along the street centerline decreases with this recommended improvement, with all previously inundated street centerlines within this corridor (Stewart Street, Watford Way, Kingsley Way, and Post Road, totaling approximately 1,600 feet) no longer having 0.5-ft of water during the 4% AEP design storm event.
- **Target 3a**: Three buildings along Watford Way are no longer impacted by the 1% AEP design storm.
- **Target 3b**: There were no enclosed depressions within this corridor that were failing to meet the City's criteria during existing conditions.
- **Target 3c**: There are not any greenways within this area.
- **Target 4a**: One building is no longer impacted by the 0.2% AEP design storm.

Project Constraints/Considerations

This recommended solution is piped infrastructure and will be contained with the City right of way with some improvements planned at the outfall, but improvements will follow the existing pipe alignment.

This project will require coordination with the City of Fitchburg due to the proximity to the municipal boundary, as well with Dane County Parks due to the location of the outfall within the Jenni & Kyle Preserve.

Anticipated permits

Based on the planning level design, the following environmental permits would be needed:

- City of Madison Erosion Control
- WDNR Stormwater NOI (>1 acre disturbance)
- WDNR Water Quality Certification (if wetlands are present) *Note there are mapped wetlands near the outfall, and a wetland survey would likely be required due to the presence of wetland indicators and proximity to a mapped waterway*.
- Intake or Outfall Structure General Permit. *Note there are exceptions to this permit, but it depends on the final design*.

Water Quality Benefits

Local storm sewer improvements may provide additional water quality benefits in smaller rain events where additional runoff will be captured from the street rather than bypassed. Any improvements in water quality benefits would be minimal in larger events. The City may provide water quality benefits to this area by dredging or other improvements to the pond outside of the improvements proposed in this report.

Additional Notes/Information

Note that **Figures 28-36** show the inundation after all the improvements have been completed.

10.3 Applegate Bypass and Improvements

Detailed Project Description

The City is aware of flooding concerns in the area spanning from Index Road, Greenway Cross, Latham Drive, Jonathon Drive, Syene Road, and Applegate Road. Several sections of pipe along Applegate Road are privately owned and not maintained by the City. The City also describes the pipes along Applegate Road as significantly undersized, and several have experienced recent damage due to large flooding events. The corridor also includes a large, enclosed depression which adds an additional challenge to proposed improvements.

The corridor affected by the Applegate Bypass includes mostly commercial and industrial properties with large amounts of impervious area. Shallow inundation within the street was visible for small storm events beginning along Latham Drive and spilling from the right of way for the 100% AEP design event. Inundation worsens for larger events with most of Latham Drive, and large portions of Applegate Road and adjacent private property, experiencing significant inundation during larger events. Figure 2 shows the reported historical flooding in this area, with flooding often reported by the Latham Drive and Stewart Street intersection.

The currently proposed improvements include several upsized pipes following the existing pipe alignment and the removal of a pipe within private property north of Jonathon Drive. Pipes along Applegate Road are not planned to be updated as part of this proposed solution due to their ownership status (owned by the DOT or private landowners).

This improvement proposes adding a new section of 54” circular pipe along Jonathon Drive from Latham Drive to Perry Street as a bypass to provide additional capacity within the affected area and reducing conveyance within the existing undersized pipes along Applegate Road. The new pipe will connect existing infrastructure at the intersection of Latham Drive and Jonathon Drive to the existing pipe at Jonathon Drive and Perry Street. However, the pipe traveling north from the Perry Street connection will be removed in lieu of new pipe being installed to provide further connection to the east toward Syene Road, creating a secondary new run of 72” circular pipe that will connect further downstream before the existing outfall pipe system.

In addition to the new proposed infrastructure, several existing pipes will be upsized. Most of the existing alignment from Latham Drive to the new pipe along Jonathon Drive, and then the existing section of pipe from Perry Street to the new section of pipe to the east, would be upsized as part of this proposed solution.

The proposed improvement keeps the existing alignment intact from Greenway Cross to Latham Dr. However, if this improvement proceeds, an alternative alignment that removes pipes from private property and easements and instead follows the road right of way could be considered. Preliminary review of topography indicates this may be feasible; however, consideration would need to be made for other existing utilities in the right of way.

The inlets at the intersection of Perry St and Jonathon Dr spill under existing conditions, and under proposed conditions (albeit to a lesser extent). During the final design, this intersection should be carefully reviewed as minor changes to the piped system might manifest in surcharging at this location.

These proposed improvements are sized for the 4% AEP event and focused on reducing inundation within the streets and right of way. A secondary benefit to these improvements is reduced impact to structures for the 1% AEP event. This improvement is intended to be completed with **Recommended Solution 10.4 – Applegate Outfall**. Construction at the outfall will be limited by DOT projects. However, if improvements are to be made within the upstream area, the outlet will need to be upsized to provide more capacity and not shift flooding within the watershed.

A map of the recommended storm sewer improvements for the Applegate Bypass are shown on **Figure 27-C**.

Alternative Solutions Considered:

- Keeping the pipe connection to the north from Jonathon Drive, resulting in a secondary bidirectional flow location. This option was not favorable to the City, as they prefer to keep the City pipe system disconnected from the private pipe system.
- Continuing the piped flow from Jonathon Dr east, past Syene Rd and connecting directly the HWY 14 system. This improvement required less pipe length and improved conveyance (less bends in the system). The City indicated this alignment would likely be more efficient but did not want to secure a new easement or purchase land.

Associated Flood Reduction Benefits

This improvement is physically close to another Recommended Solution: Applegate Outfall (following section). Since the proposed conditions modeling was completed showing all the improvements collectively, it is not possible to attribute specific targets to one mitigation action. Therefore, the list of the City's flood control targets listed below is due to both improvements:

- **Target 1a**: This set of solutions prevents eight (8) publicly owned stormwater structures from flooding in the 10% AEP design storm.
- **Target 2a**: Inundation along the street centerline decreases with this set of recommended improvements, with 622-ft of additional centerline no longer having 0.5-ft of water during the 4% AEP design storm event. Improvements are on Latham Drive, Jonathon Drive, and Applegate Road.
- **Target 3a**: Five (5) buildings are no longer impacted by the 1% AEP design storm. These buildings are on Lathan Drive, Perry Street, and Syene Road.

- **Target 3b**: There were no enclosed depressions within this corridor that were failing to meet the City's criteria during existing conditions.
- **Target 3c**: There are not any greenways within this area.
- **Target 4a**: Three (3) buildings are no longer impacted by the 0.2% AEP design storm. These buildings are on Latham Drive and Perry Street.

Project Constraints/Considerations

This recommended solution is piped infrastructure and will be mostly contained with the City right of way; however some improvements will take place within easements along existing pipe alignments, and one new run of 72" circular pipe is proposed between Jonathon Drive and Syene Road that will run adjacent to an existing parking lot. One existing pipe adjacent to this new pipe will be removed. Coordination will be required with adjacent property owners to place new pipes and remove existing pipes outside the City right of way.

This project will require extensive coordination with the Wisconsin Department of Transportation due to state highway right of way. Coordination with the City of Fitchburg may also be required due to the proximity to the municipal boundary.

Anticipated permits

Based on the planning level design, the following environmental permits would be needed:

- City of Madison Erosion Control
- WDNR Stormwater NOI (>1 acre disturbance)
- Wisconsin DOT Highway Right of way Permit
- Intake or Outfall Structure General Permit. *Note there are exceptions to this permit, but it depends on the final design*.

Water Quality Benefits

Local storm sewer improvements will not provide water quality benefits.

Additional Notes/Information

Note that **Figures 28-36** show the inundation after all the improvements have been built. Reduced inundation in this area is also a result of recommended solutions in the Applegate Outfall.

10.4 Applegate Outfall

Detailed Project Description

The stormwater infrastructure around the Applegate Road corridor and surrounding areas end at an outfall along Highway 14 south of the Beltline/Hwy 14/Park Street interchange. In order to provide additional capacity for other upstream improvements, updates will be required at the outfall. The outfall is located along a state highway and will require additional coordination.

This improvement is intended to increase the outlet capacity for the outfall at the end of Applegate Road along Highway 14, providing more capacity for piped improvements in the upstream areas. There is limited vertical space for large pipes, and construction will be limited by DOT projects near the outfall. However, if improvements are to be made upstream to reduce flooding in the commercial and industrial areas, the outlets need to be upsized to provide more capacity and not shift flooding within the watershed.

The existing outlet pipe is a 54" circular pipe near the Fitchburg municipal boundary and within DOT right of way. Proposed improvements involve upsizing the existing 54" circular pipe to a 78" circular pipe along the existing alignment, as well as adding a new 36"x72" box across Highway 14. The new cross pipe will serve to provide additional capacity and reduce inundation across the highway where flooding currently occurs in the low area along the City of Fitchburg municipal boundary. The proposed outfall pipes are designed for the 1% AEP event.

A map of the recommended storm sewer improvements for the Applegate Outfall Improvements is shown on **Figure 27-D**.

Alternative Solutions Considered:

- Upsizing of existing infrastructure along the existing alignment was considered without the addition of the proposed cross pipe. However the cross-pipe is able to help reduce inundation escaping the ditch along the southeast corner of the interchange. This captures additional inundation within the pipe system and reduces the amount of inundation that leaves the City of Madison and travels into Fitchburg on Highway 14.

Associated Flood Reduction Benefits

This improvement is physically close and downstream from another Recommended Solution: Applegate Bypass and Improvements (**Section 10.3**) and is also downstream of an additional Recommended Solution: DOT Ponds at Beltline Interchange (**Section 10.5**). Since the proposed conditions modeling was completed showing all the improvements collectively, it is not possible to attribute specific targets to one mitigation action. Therefore, the list of the City's flood control targets listed below is due to each improvement:

- **Target 1a**: There are no publicly owned structures surcharging during existing conditions.

- **Target 2a**: There were no centerlines exceeding allowable inundation during the 4% AEP design storm during existing conditions.
- **Target 3a:** There were no buildings impacted by the 1% AEP design storm during existing conditions.
- **Target 3b**: There were no enclosed depressions within this corridor that were failing to meet the City's criteria during existing conditions.
- **Target 3c**: There are not any greenways within this area
- **Target 4a**: There were no buildings impacted by the 0.2% AEP design storm during existing conditions.

Project Constraints/Considerations

This recommended solution is piped infrastructure and will be contained primarily within the City right of way. Work will likely occur within DOT right of way and will depend on department coordination.

Anticipated permits

Based on the planning level design, the following environmental permits would be needed:

- City of Madison Erosion Control
- WDNR Stormwater NOI (>1 acre disturbance)
- Wisconsin DOT Highway Right of way Permit
- WDNR Water Quality Certification (if wetlands are present) Note there are mapped wetlands near the outfall, and a wetland survey would likely be required.
- Intake or Outfall Structure General Permit. Note there are exceptions to this permit, but it depends on the final design.

Water Quality Benefits

Local storm sewer improvements will not provide water quality benefits.

Additional Notes/Information

Note that **Figures 28-36** show the inundation after all the improvements have been built. Reduced inundation in this area is also a result of recommended solutions for the Applegate Bypass and DOT Ponds at Beltline Improvements.

10.5 DOT Ponds at Beltline Interchange

Detailed Project Description

The Park Street/Beltline/Hwy 14 interchange contains several ponds and drainage areas that convey stormwater from multiple areas within the watershed. There is known flooding beneath the beltline on Park St. Water can also overtop the S Park Street on-ramp to the westbound Beltline. Ultimately, water from this area is discharged to the south toward the City of Fitchburg.

The area of proposed improvement begins just south of W Badger Road along S Park Street and involves proposed new pipes as well as several upsized pipes across the Beltline toward Syene Road. These improvements will be affected by improvements described in the Applegate Outfall (Section 10.4) and targets will be evaluated based on both improvements being completed. While the City does not have jurisdiction to make most of the improvements around the DOT owned ponds, the City requested to be informed about potential changes and recommendations should the DOT begin planning for reconstruction of the intersection.

Under existing conditions, several pipes empty into a ditch that travels south along the east side of the Westbound Beltline on-ramp from S Park Street. Flows re-enter piped infrastructure underneath the on-ramp at a 30” pipe that travels into an existing DOT owned BMP which gathers water before re-entering a 24” pipe to the south beneath the Beltline. This pipe enters another DOT owned BMP on the southwest side of the Beltline cloverleaf and joins infrastructure from Syene and Applegate Roads. Currently there is a dual 36” pipe traveling south from the BMP which joins a larger 54” pipe that travels south/southeast toward the Applegate Outfall and the City of Fitchburg. The improvement area also includes existing pipes on the east side of S Park Street, both underneath the Beltline and between DOT BMPs. Currently these pipes are sized as 24” circular pipes.

It should be noted that during model construction, several pipe sizes could not be officially verified due to lack of existing data or plan sets available to the City. Many pipe sizes and inverts were inferred from the Digital Elevation Model (DEM), and these are noted at specific links within the XPSWMM model.

Proposed improvements follow the existing pipe alignment, with new pipes proposed along the on-ramp for the S Park Street to westbound Beltline which is currently an open ditch. A new pipe is also proposed beneath the existing BMP on the north side of the Beltline. Existing pipes will be changed to boxes and upsized to provide additional capacity.

A map of the recommended storm sewer improvements for the DOT Ponds at the Beltline Interchange Improvements are shown in **Figure 27-E**.

Alternative Solutions Considered:

- Maintaining and modifying the existing ditch adjacent to the on-ramp was considered, but the City did not think they would have enough access for mowing and maintenance equipment if converted to a wider greenway.
- Placement of a new BMP was evaluated in a vacant parcel along W Badger Road, east of S Park Street. The City noted this parcel was already slated for development, and therefore placing a pond here was impossible.

Associated Flood Reduction Benefits

This improvement is physically close to two other Recommended Solutions: Applegate Bypass and Improvements (Section 10.3) and the Applegate Outfall (Section 10.4). Recommendations in the area indicate improvements to the Outfall should happen before improvements to the DOT Ponds. Since the proposed conditions modeling was completed showing all the improvements collectively, it is not possible to attribute specific targets to one mitigation action. Therefore, the list of the City's flood control targets listed below is due to several improvements:

- **Target 1a**: This set of solutions prevents three (3) publicly owned stormwater structures from flooding in the 10% AEP design storm.
- **Target 2a**: Inundation along the street centerline decreases with this set of recommended improvements, with 300-ft of additional centerline no longer having 0.5-ft of water during the 4% AEP design storm event. Improvements are on S Park Street and the Westbound Beltline On-Ramp from S Park Street.
- **Target 3a**: One (1) building is no longer impacted by the 1% AEP design storm. This building is on Perry Street.
- **Target 3b**: There is one enclosed depression within the solution area that is failing to meet the City's criteria during both existing and proposed conditions. It is located along the Beltline's westbound on-ramp. While the proposed solutions improvements do improve the inundation in this depression, it continues to fail to meet the City's criteria for Target 3b.
- **Target 3c**: There are not any greenways within this area.
- **Target 4a**: Five buildings are impacted by the 0.2% AEP design storm during both existing proposed conditions.

Project Constraints/Considerations

This recommended solution is piped infrastructure. Many facets of the proposed solutions will be contained with the City right of way, however proposed improvements within the Beltline and Hwy 14 right of way will require DOT coordination and likely will not be feasible until the DOT reconstructs the interchange. Improvements within this proposed solution will be dependent on downstream improvements, including the proposed Applegate Outfall proposed solution.

Anticipated permits

- City of Madison Erosion Control
- WDNR Stormwater NOI (>1 acre disturbance)
- Wisconsin DOT Highway Right of way Permit
- WDNR Water Quality Certification (if wetlands are present) Note there are mapped wetlands near the outfall, and a wetland survey would likely be required.
- Intake or Outfall Structure General Permit. Note there are exceptions to this permit, but it depends on the final design.

Water Quality Benefits

Local storm sewer improvements will not provide water quality benefits directly. If the DOT makes modifications to the ponds in addition to the piped improvements, there is potential for additional water quality benefits in this area.

Additional Notes/Information

Note that **Figures 28-36** show the inundation after all the improvements have been built.

10.6 Engelhart Settlement Improvements

Detailed Project Description

The existing infrastructure along Warner Street, Diving Hawk Trail, Settlement Drive, and Engelhart Drive is reportedly undersized and insufficient to contain inundation during large events. While the inundation is mostly contained to the right of way, flooding reports in this area have indicated that street flooding is significant and can carry large debris (e.g. trash cans washed away during large events).

Under existing conditions, modeling predicted inundation within the Engelhart Drive right of way of greater than 6" at the centerline during the 25 year (4% AEP event). Existing infrastructure begins at the intersection of the Settlement Drive and Artesian Lane as a circular 18" pipe. Pipes continue to the south and then transition to 24" pipes at the intersection of Engelhart Drive and Settlement Drive where they travel west approximately 350 feet toward a city owned easement where the pipe transitions to a 36" pipe and discharges to the south toward Nine Springs Creek. The proposed recommendations include upsizing the existing pipe infrastructure as well as adding new pipes to the north of the existing infrastructure. New pipes are proposed to include the full length of Settlement Drive to the north, along Diving Hawk Trail to the east, and along portions of the southern portion of Warner Street.

Alternative Solutions Considered:

- This proposed solution was originally considered without the addition of new pipes along Diving Hawk Trail and Warner Street; however, higher inundation remained within the streets and street right of way, which can be reduced by the addition of new pipes.
- A secondary outlet (from Settlement Dr directly to the Nine Springs Greenway) was considered.

This proposed solution was designed with the 4% AEP event in mind. It focused primarily on removing inundation from the streets. A map of the recommended storm sewer improvements for the Engelhart Settlement Improvement is shown on **Figure 27-F.**

Associated Flood Reduction Benefits

- **Target 1a**: This set of solutions prevents two (2) stormwater structures from flooding in the 10% AEP design storm.
- **Target 2a**: Inundation along the street centerline decreases with this set of recommended improvements, with 560-ft of additional centerline no longer having 0.5-ft of water during the 4% AEP design storm event. Improvements are along Engelhart Drive.
- **Target 3a**: There were no buildings being impacted under existing conditions in this area.

- **Target 3b**: There is one enclosed depression with the recommendation area, however it was not flagged as a problem and therefore no improvements are required to be addressed.
- **Target 3c**: There are not any greenway crossings within this area.
- **Target 4a**: There are no buildings impacted during the 0.2% AEP Event under existing conditions.

Project Constraints/Considerations

This recommended solution is piped infrastructure and will be contained with the City right of way with some improvements planned at the outfall, but improvements will follow the existing pipe alignment.

This project may require coordination with the City of Fitchburg due to the proximity to the municipal boundary, but all of the improvements will be within the City of Madison.

Anticipated permits

Based on the planning level design, the following environmental permits would be needed:

- City of Madison Erosion Control
- WDNR Stormwater NOI (>1 acre disturbance)
- WDNR Water Quality Certification (if wetlands are present) *Note there are mapped wetlands at the outfall. A wetland survey will likely be required.*
- Intake or Outfall Structure General Permit. *Note there are exceptions to this permit, but it depends on the final design.*

Water Quality Benefits

Local storm sewer improvements will not provide water quality benefits.

Additional Notes/Information

Note that **Figures 28-36** show the inundation after all the improvements have been completed.

10.7 Fell Road Improvements

Detailed Project Description

The existing Fell Road storm system includes piped infrastructure located behind homes. Existing pipes travel from the area cul-de-sacs (Book Court, Arther Court, and Marcus Court) to the east into a pipe between properties and continues to the south. This area is adjacent to a portion of land previously part of the Town of Madison and was annexed into the City.

The City acknowledged previous flooding concerns in the area. The cul-de-sacs are graded so that water flows east (toward the existing homes) to be collected by a storm system at the back of the lots. Several flooding reports have indicated backyard flooding is common, and that the contributing flows from an adjacent condo complex overwhelms the piped infrastructure.

The proposed solution includes new pipes, upsized pipes, and one pipe removal. New 30” pipes are proposed along Fell Road, linking the existing pipes along Marcus Court to the existing pipes along Engelhart Drive to the south. New 30-36”” pipes from the condo complex (from approximately N Sunnyvale Lane to Engelhart Drive) will provide capacity relief for the existing storm system in the backyard easement. The existing connection from the condo complex will be removed. Finally, the pipes from Engelhart Dr to the outfall are also upsized to a 42” pipe.

The proposed solution is designed to remove inundation from the street and increase conveyance to the south during the 4% AEP event. The proposed solution also reduces inundation in backyard areas compared to existing conditions.

Alternative Solutions Considered:

- Upsizing of all pipes within the study area, without changing alignment, to increase capacity.
- Relocating and upsizing pipes out of the backyard private property to areas within public right of way was evaluated but deemed infeasible due to the existing grade on the cul-de-sacs. The City prefers adding capacity downstream, and from the private property to the east at Sunnyvale Lane.

A map of the recommended storm sewer improvements for the Fell Road Improvements is shown on **Figure 27-G.**

Associated Flood Reduction Benefits

- **Target 1a**: This set of solutions prevents eight (8) stormwater structures from flooding in the 10% AEP design storm.
- **Target 2a**: There were no sections of street centerline with 0.5-ft of water during the 4% AEP design storm event during existing conditions.

- **Target 3a**: One (1) building is no longer impacted by the 1% AEP design storm. This building is on Engelhart Drive.
- **Target 3b**: There were no enclosed depressions within this corridor that were failing to meet the City's criteria during existing conditions.
- **Target 3c**: There are not any greenway crossings within this area.
- **Target 4a**: One (1) building is no longer impacted by the 0.2% AEP design storm. This building is on Engelhart Drive.

Project Constraints/Considerations

This recommended solution is piped infrastructure. Some new pipes will be placed both within and outside the right of way. A single pipe outside the right of way will also be removed just north of S Sunnyvale Lane. Improvements are also planned at the outfall, but improvements south of Englehart Drive will follow the existing pipe alignment.

This project may require coordination with the City of Fitchburg due to the proximity to the municipal boundary, but all the improvements will be within the City of Madison.

Anticipated permits

Based on the planning level design, the following environmental permits would be needed:

- City of Madison Erosion Control
- WDNR Stormwater NOI (>1 acre disturbance)
- WDNR Water Quality Certification (if wetlands are present) *Note there are mapped wetlands south of the outfall. A wetland survey will likely be required to map the exact wetland boundary*.
- Intake or Outfall Structure General Permit. *Note there are exceptions to this permit, but it depends on the final design*.

Water Quality Benefits

Local storm sewer improvements will not provide water quality benefits.

Additional Notes/Information

Note that **Figures 28-36** show the inundation after all the improvements have been completed.

11 Areas where Flood Control Targets are Not Met

This portion of the City of Madison is fully developed. The remaining open space is existing park land or mapped wetlands which limit the potential flood mitigation solutions that are viable in the Nine Springs Watershed. Portions of the watershed area are also within surrounding municipalities and outside of the purview for improvements by Madison. Another compounding factor is the limited topography. Several areas of the watershed are within enclosed depressions in a relatively flat area, which restrict the depth pipes can be placed. Increasing the piped capacity upstream will have a limited effect on reducing inundation on the ground surface. Finally, all the recommended improvements within the watershed needed to ensure that flooding issues were not simply transferred from one location to another.

With all these limitations, the recommended improvements will reduce flooding in some areas of the watershed, but they will not remove the flooding entirely.

This section is included to see how much the recommended improvements reduced flooding with respect to each target, with the understanding that flooding will still occur within the watershed.

11.1 Target 1a: Flooding Storm Sewer (10% AEP)

No surcharging onto the street for up to the 10% AEP design storm; all water shall be contained within the pipes and structures.

This criterion was evaluated by comparing the rim elevations of the structures compared to the hydraulic grade line of the water in each structure. Structures where the hydraulic grade line was higher than the rim of the structure were flagged as surcharging and classified as a 'potential problem location'. Of the 152 modeled publicly owned access structures and inlets, 67 of them were classified as potential problem location (44%). Under the recommended conditions, 38 were within the study area and still classified as potential problem locations (25%).

11.2 Target 2a: Street Centerlines (4% AEP)

Centerline of street to remain passable during 4% AEP design storm with no more than 0.5 feet of water at the centerline.

This criterion was evaluated by using a road centerline dataset, split at 100-ft intervals and intersected with the 4% AEP inundation raster. Any segments with an average of 0.5-feet or more of water depth within the Study Area were classified as a 'potential problem location'. This study area has 21.6 miles of roads. Under existing conditions, 0.88 miles were classified as problem locations (4%). Under the recommended conditions, 0.26 miles were classified as problem locations (1.2%).

11.3 Target 3a: Homes and Businesses (1% AEP)

No homes or businesses will be flooded during the 1% Annual Exceedance Probability (AEP) design storm.

This criterion was evaluated by buffering all buildings by 5-ft and intersecting them with the 1% AEP inundation raster. Any buffered building with an inundation depth of 0.5-feet or greater was classified as a 'potential problem location'. *Note that this analysis does not account for modifications residents take to mitigate flooding on their own properties.* There are 1,202 buildings/structures within the study area. Under existing conditions, 16 buildings were classified as potentially impacted (1.3%). Under the recommended conditions, seven (7) structures would still be impacted by flooding during the 1% AEP design storm (0.5%).

11.4 Target 3b: Enclosed Depressions (1% AEP)

Enclosed depressions to be served to the 1% AEP design storm (which can include safe overland flow within street, easements, greenways or other public lands).

This criterion was evaluated by identifying all the enclosed depressions at least 0.25 acres in size, based on the 2017 LiDAR DEM. This was completed using the LiDAR processing GIS tool created by Dr. Qiusheng Wu (https://github.com/giswqs/lidar). All depressions were intersected with the 1% AEP inundation raster. Any depression that had a maximum depth of 1-foot or more and touched public land (e.g. street ROW, greenway or SWU lands, etc) was flagged for review. The public lands and private ponds were removed from this subset of enclosed depressions, to determine if the depression also encompassed a portion of privately owned land.

Any enclosed depression that touched public land, included at least 0.25 acres of private land, and had more than 1-foot of inundation depth during the 1% AEP event was classified as a potential problem area. There are 29 enclosed depressions within the watershed. Under the existing conditions, modeling predicts that the 1% AEP service levels are not achieved in two enclosed depressions classified as a potential problem location. Under the recommended conditions, the same two enclosed depressions are still classified as potential problem locations.

11.5 Target 3c: Greenways (1% AEP)

Greenway crossings at streets to be served to the 1% AEP design storm.

This criterion is evaluated by identifying all the locations where channelized overland flow enters the piped stormwater system at roadway. However, for the Nine Springs Watershed Study, there were no locations where greenways crossed roadways within the Study Area.

11.6 Target 4a: Safely Convey Stormwater (0.2% AEP)

No homes or businesses will be flooded during the 0.2% Annual Exceedance Probability (AEP) design storm.

This criterion was evaluated by buffering all buildings by 5-ft, and intersecting them with the 0.2% AEP inundation raster. Any buffered building with an inundation depth of 0.5-feet or greater was classified as a 'potential problem location'. Note that this analysis does not account for modifications residents take to mitigate flooding on their own properties. There are 1,202 buildings/structures within the watershed in the City of Madison in this watershed. Under existing conditions, 25 buildings were classified as potentially impacted (2%). Under the recommended conditions, 20 structures would still be impacted by flooding during the 0.2% AEP design storm (1.6%).

12 Climate Resilience Analysis

12.1 0.2% Chance Analysis

The following section describes anticipated changes in 0.2% AEP flooding between existing and recommended conditions.

As described in previous sections of the report, storm sewer capacity improvements are recommended along several locations around the watershed. Several trunk line improvements are proposed, including areas around Post Road, Watford Way, Steward Street, Greenway Cross, Lathan Drive, Jonathon Drive, South Park Street, areas around the Beltline/South Park Street/Highway 14 interchange, Engelhart and Settlement Drive, and Fell Road. Most of these proposed solutions are non-contiguous. These improvements were generally recommended with the intent of balancing storm sewer capacity along the main trunk storm sewer system serving the watershed with a target of providing sufficient capacity to convey 4% AEP peak flow rates. Even so, under 0.2% AEP event conditions, modeling predicts moderate improvements in flooding conditions along this corridor.

Westview Lane

- Upsizing the Westview Lane outfall for increased upstream capacity

Post Road/Watford Way

- Upsizing pipes and increasing capacity along Steward Street
- Upsizing pipes and increasing capacity along Watford Way
- Upsizing outfall culvert to a 60”x126” box culvert

Applegate Bypass

- Improvements to the upstream storm system
- Improved connectivity and capacity throughout Applegate Road corridor

Applegate Outfall

- Increased upstream capacity for Applegate Bypass and DOT Pond areas

DOT Ponds

- Increased upstream capacity along Park Street, Perry Road, Cypress Way, and Badger Road
- Increased connectivity and capacity around highway interchange

Engelhart Drive and Settlement Drive

- Increased upstream capacity along Warner Street
- Increased capacity along Diving Hawk Trail, Settlement Drive, and Engelhart Drive
- Increased capacity at the outfall draining design area

Fell Road

- Increased upstream capacity and the outfall draining design area
- Increased connectivity and capacity around residential buildings

Increasing the improvements to Nine Springs Creek is limited by topography and in some areas, by the downstream tailwater conditions. Increasing the pipe capacity beyond those values recommended in this report might provide marginally more underground storage but would not significantly increase conveyance. In fact, several alternatives were evaluated with larger pipes, which worsened problems elsewhere (e.g. surcharged pipes spilling water at inlets in downstream locations). Changes to pipe sizes to size for other events may require additional modeling and review.

Although the piped improvements to Nine Springs Creek are not sized to serve the 0.2% AEP design event, there are notable improvements for this large storm event.

- Inundation depths within the Watford Way right of way decreased ~0.6 ft
- Flooding depths within the enclosed depression along Applegate Road decreased ~1 ft
- Inundation depths along the pipe alignment in the private property between Syene Road and Perry Street decreased ~1.2 ft
- Inundation depths along the ditch on the north side of the Hwy 14 ramp to the east-bound Beltline on-ramp decreased ~0.6 ft
- Inundation depths along the westbound Beltline On-Ramp were decreased ~2.8 ft
- Inundation depths within the streets along Diving Hawk Trail and Settlement Drive decreased by ~0.2 ft
- Flooding in residential yards around the Fell Road improvement area decreased by up to ~0.5 ft

Across the watershed, regarding buildings at risk of 0.2% AEP event flooding, there is a significant improvement under recommended conditions. Under existing conditions, 25 buildings are anticipated to be affected by the 0.2% AEP event. Under full-watershed improved conditions, this number is anticipated to be reduced to 20. This analysis is assuming current conditions at the time of this report. The City has noted that several locations within the Study Area are proposed to be redeveloped, with some projects already underway. Keeping these proposed conditions in mind, future planning efforts could further reduce this number.

Figure 19 and **Figure 36** present a comparison of flooding conditions under 0.2% AEP (500-yr) conditions.

12.2 Infrastructure modifications

The Nine Springs Watershed is capacity limited for many of the outfalls. To meet the stormwater needs for the 0.2% AEP design storm, alternative solutions that were not recommended due to other concerns (e.g. cost, public feedback, etc.) need to be reconsidered. For example, placing large regional stormwater detention basins via property acquisition; this would require removing any development on the property and replacing it with a detention facility. This could retain water during large events and effectively delay the water from entering the piped system to reduce peak flows. Expanding the diameter of existing outlets could also be considered, but it would also require property acquisition and removal of existing development. Note that this might only have marginal flood reduction benefits in those areas where the outfall is submerged, as the upsized pipe would still be submerged. Both options could be reevaluated in the future, if the City's design targets change.

13 Cost Estimates

To help the City plan for future implementation, planning level cost estimates were developed for each of the stand-alone solutions outlined in **Chapter 10.** For each solution, cost estimates were prepared by creating a tabulated list of estimated quantities. Most of the recommended improvements in the study area were within the street right of way; however some new pipes are proposed outside the right of way, and some existing pipes outside the right of way are proposed to be removed. For some proposed solutions, the end of the project would likely fall into an easement on private land. It was assumed that the pipe replacements would require the entire street to be reconstructed (rather than simply replacing/repairing pavement areas impacted by selectively modifying just the stormwater system).

The 'main driver' for a project might be the stormwater project, but in many cases, the project would be completed when the roadway is already planned for reconstruction. The City requested that the costs associated with the street reconstruction **only** be incorporated into those recommended solutions where the stormwater improvements would be the 'main driver' in the project. However for the Nine Springs Watershed Study, there are no projects where replacing the storm sewer will be the main driver of street reconstruction. All proposed improvements are slated to occur when the streets are planned to be reconstructed for other reasons.

The City provided average unit costs for typical stormwater bid items, specifically for pipe materials. The costs of the piped improvements were added together to calculate an estimated cost for each of the recommended projects.

Standard unit costs were adjusted by MSA based on specific project conditions that may result in higher or lower than average unit costs. In these cases, a note was added to justify the rationale for the cost revision. Initial cost estimates were provided to the City for review prior to finalizing them in the report.

The total cost estimate for each of the stand-alone projects is provided in **Table 13-1.** A detailed breakdown for each cost estimate, with quantities, average unit costs, and adjustments is provided in **Appendix G.**

Table 13-1: Stand-Alone Project Cost Estimates for Nine Springs Watershed

Project	Estimated Cost
Westview Lane	$0.03 M
Post Road/Watford Way	$2.84 M
Applegate Bypass*	$4.02 M
Applegate Outfall	$1.18 M
DOT Ponds & Improvements*	$1.64 M
Engelhart & Settlement Drive	$0.94 M
Fell Road	$0.62 M

**only to be constructed if the Applegate Outfall project is completed.*

14 Recommended Implementation Order

14.1 Technical Implementation Needs

Implementing an improvement in one area of the watershed can impact other parts of the study area. For example, increasing the pipe capacity upstream can negatively impact downstream areas without adequate capacity to handle the increase in peak flows. Within the study area, there are known limitations for implementation order that should be considered prior to advancing any of the recommended solutions. The following guidelines are recommended for implementation.

1. In general, improvements should be implemented from downstream end, progressing towards the upstream projects. In this vein, the Applegate Outfall improvements should occur first, with improvements to the Applegate Bypass and the DOT ponds taking place later.

14.2 Citywide Implementation Prioritization

The City is conducting similar studies for all the watersheds in the City, all of which will have numerous recommendations. The City has developed a process to rank and prioritize the order in which the solutions might be implemented if/when funding and public support are obtained. The process includes an extensive process to score projects based on feasibility, constructability, cost, projected benefits, and racial equity and social justice parameters. This working database of projects is updated as each study is completed and reevaluated at least annually as part of the Storm Water Utility budgeting process.

15 Next Steps

At this point, the next steps in the watershed study are to disseminate the findings, for both the existing conditions modeling and the recommended solutions with interested parties. This includes coordinating with City design staff, presenting the information to City Boards, committees, commissions, City Council and other applicable City Agencies. Results can also be presented to stakeholders, including local Friends Groups, Neighborhood Organizations, interested Developers and neighborhood residents.

Each individual recommended potential project identified in this study will go through full design and public information process prior to construction; including resident and stakeholder engagement.

Figures

Figure 1. Watershed Area

Figure 2. Historic Flooding

Figure 3. Adjacent Watersheds

Figure 4. Land Use

Figure 5. Impervious Areas

Figure 6. Soils

Figure 7. Gage Locations

Figure 8. Model Network

Figure 9. Surface Roughness

Figure 10. 2D Land Use

Figure 11. 50% AEP Inundation

Figure 12. 20% AEP Inundation

Figure 13. 10% AEP Inundation

Figure 14. 4% AEP Inundation

Figure 15. 2% AEP Inundation

Figure 16. 1% AEP Inundation

Figure 17. Long 1% AEP Inundation

Figure 18. 0.5% AEP Inundation

Figure 19. 0.2% AEP Inundation

Figure 20. Target 1a, Eliminate flooding from storm sewer in 10% AEP design storm

Figure 21. Target 2a, Streets passable in 4% AEP design storm

Figure 22. Target 3a, No homes/businesses flooded in 1% AEP design storm

Figure 23. Target 3b, Enclosed depressions served to 1% AEP design storm

Figure 24. Target 3c, Greenway crossings at streets served to 1% AEP design storm

Figure 25. Target 4a, No homes/businesses flooded in 0.2% AEP design storm

Figure 26. Recommended Solutions Index

Figure 27. Recommended Solutions

Figure 28. 50% AEP Inundation Recommended Conditions

Figure 29. 20% AEP Inundation Recommended Conditions

Figure 30. 10% AEP Inundation Recommended Conditions

Figure 31. 4% AEP Inundation Recommended Conditions

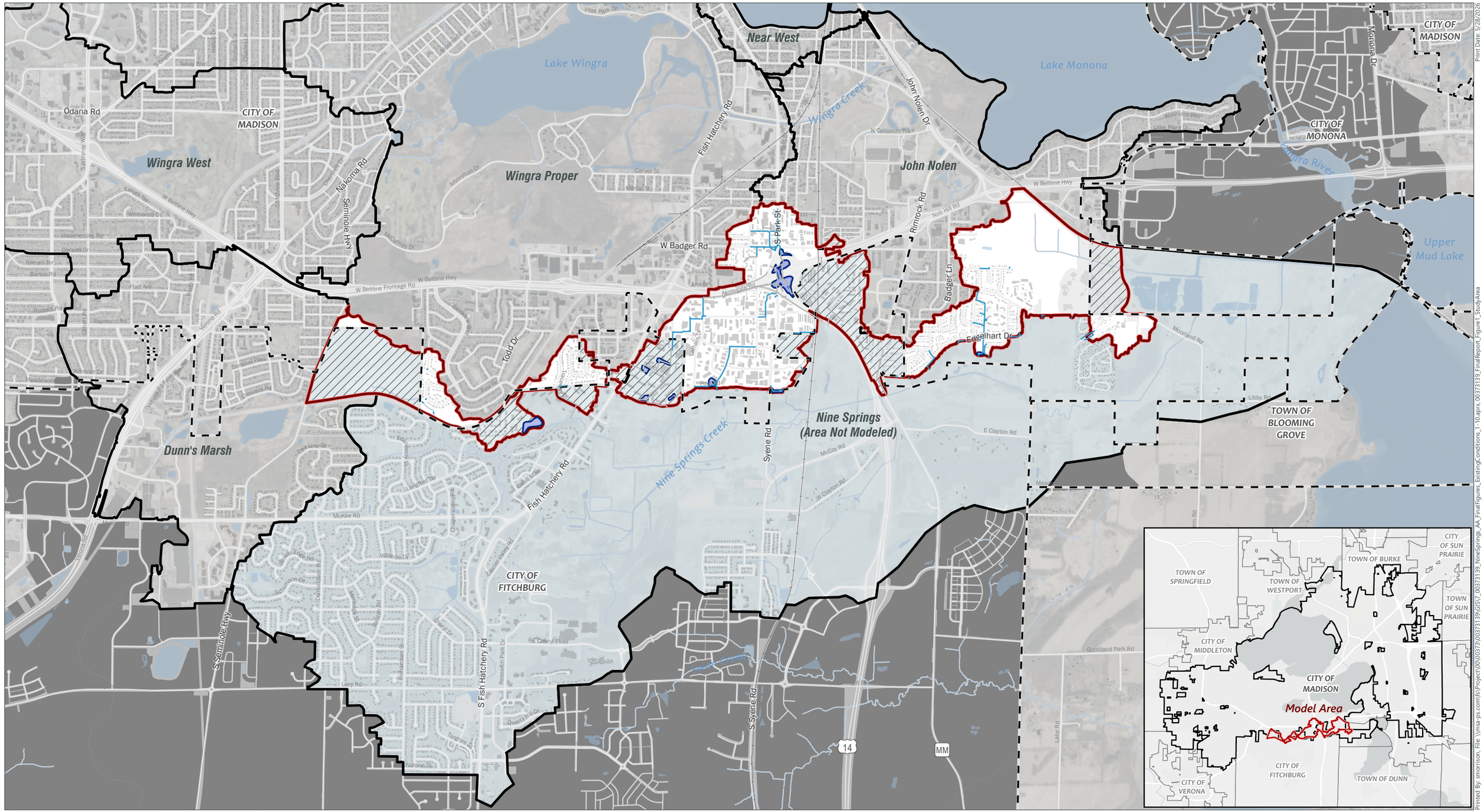
Figure 32. 2% AEP Inundation Recommended Conditions

Figure 33. 1% AEP Inundation Recommended Conditions

Figure 34. Long 1% AEP Inundation Recommended Conditions

Figure 35. 0.5% AEP Inundation Recommended Conditions

Figure 36. 0.2% AEP Inundation Recommended Conditions



MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

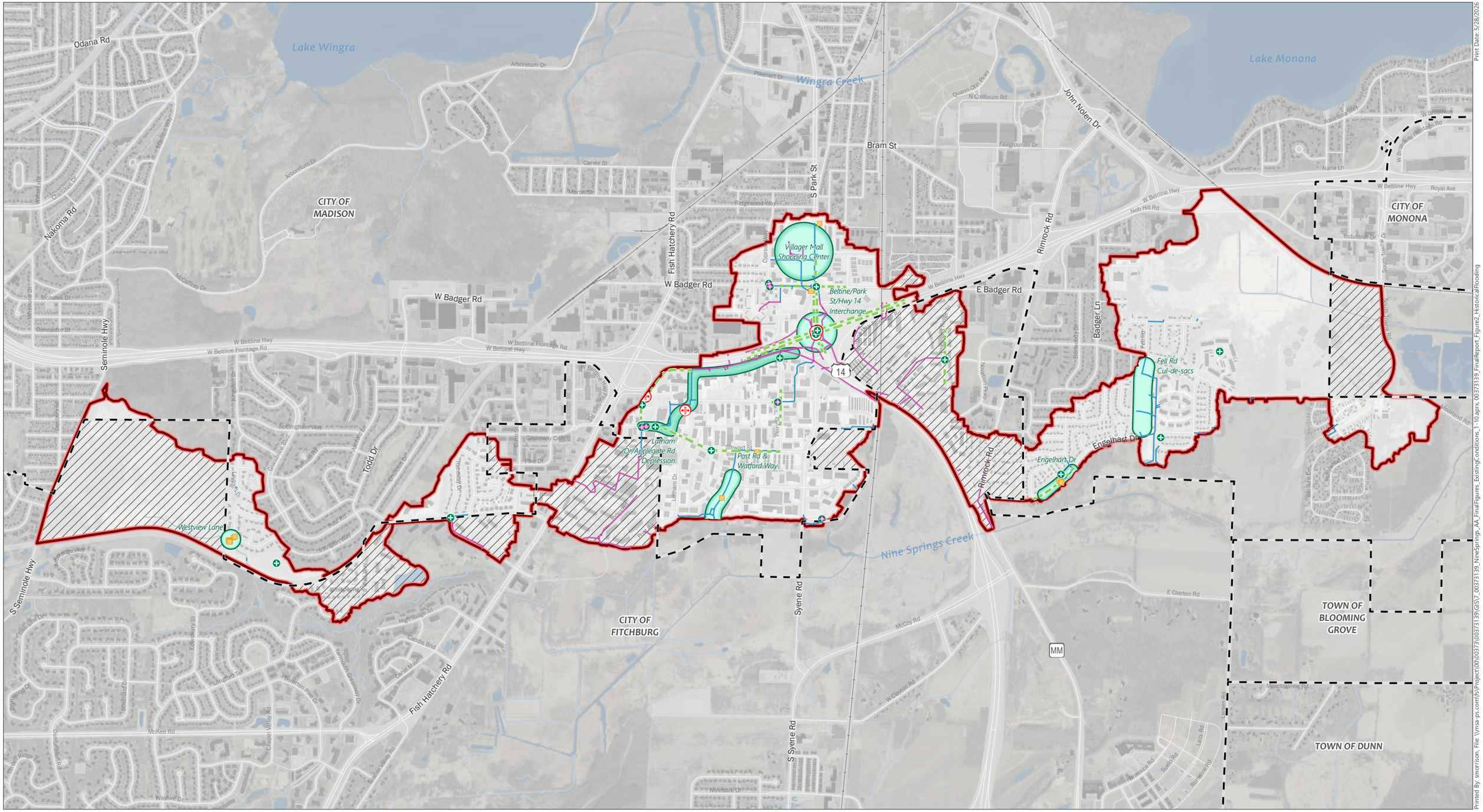
- Model Area
- Adjacent Watershed Boundary
- Nine Springs Watershed Boundary (Outside Madison)
- Municipal Boundary
- Building Footprint
- Rivers and Streams
- Lakes and Ponds
- Unmodeled Watersheds
- Model Area Outside Madison
- Modeled Pond/Inactive Area
- Modeled City Owned Pipe
- Modeled Non-City Owned Pipe

Study Area

FIGURE 1
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

Print Date: 5/28/2026
Printed By: smorrison, File: \\msa-ps.com\fs\Project\000\00373\003731339\GIS\7_003731339_NineSprings_AA_FinalFigures_ExistingConditions_1-10.aprx, 003731339_FinalReport_Figure1_StudyArea



MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

- Model Area
- Municipal Boundary
- Building Footprint
- Rivers and Streams
- Lakes and Ponds
- Modeled City Owned Pipe
- Modeled Non-City Owned Pipe
- Priority Inlets
- Historic/Observed Flooding Points
- Operations Flooding Points
- Business Flooding Points
- Water Rescue Locations
- Historic Street Flooding
- Observations by City Staff

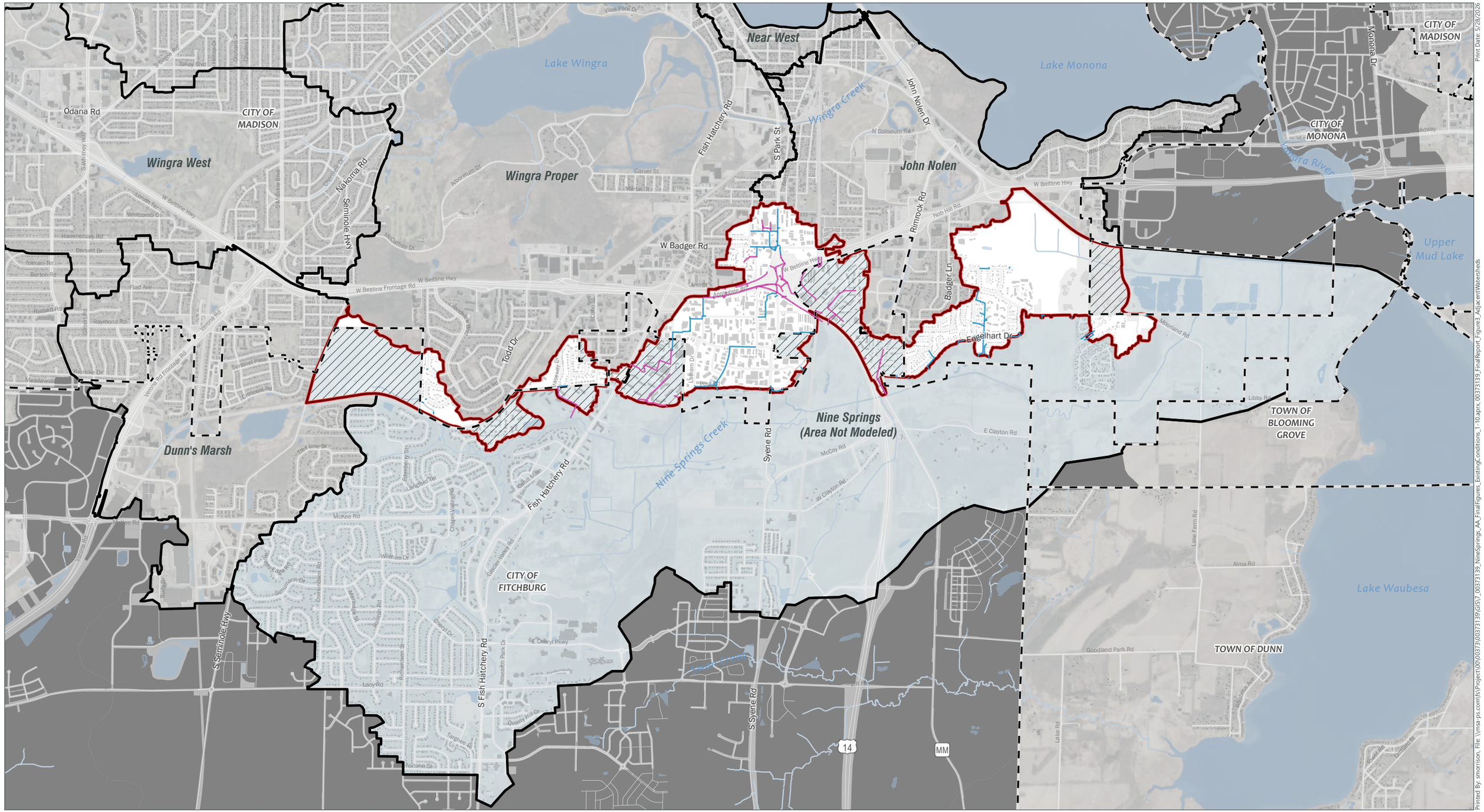
Historical Flooding

FIGURE 2
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

Print Date: 5/28/2026

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MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

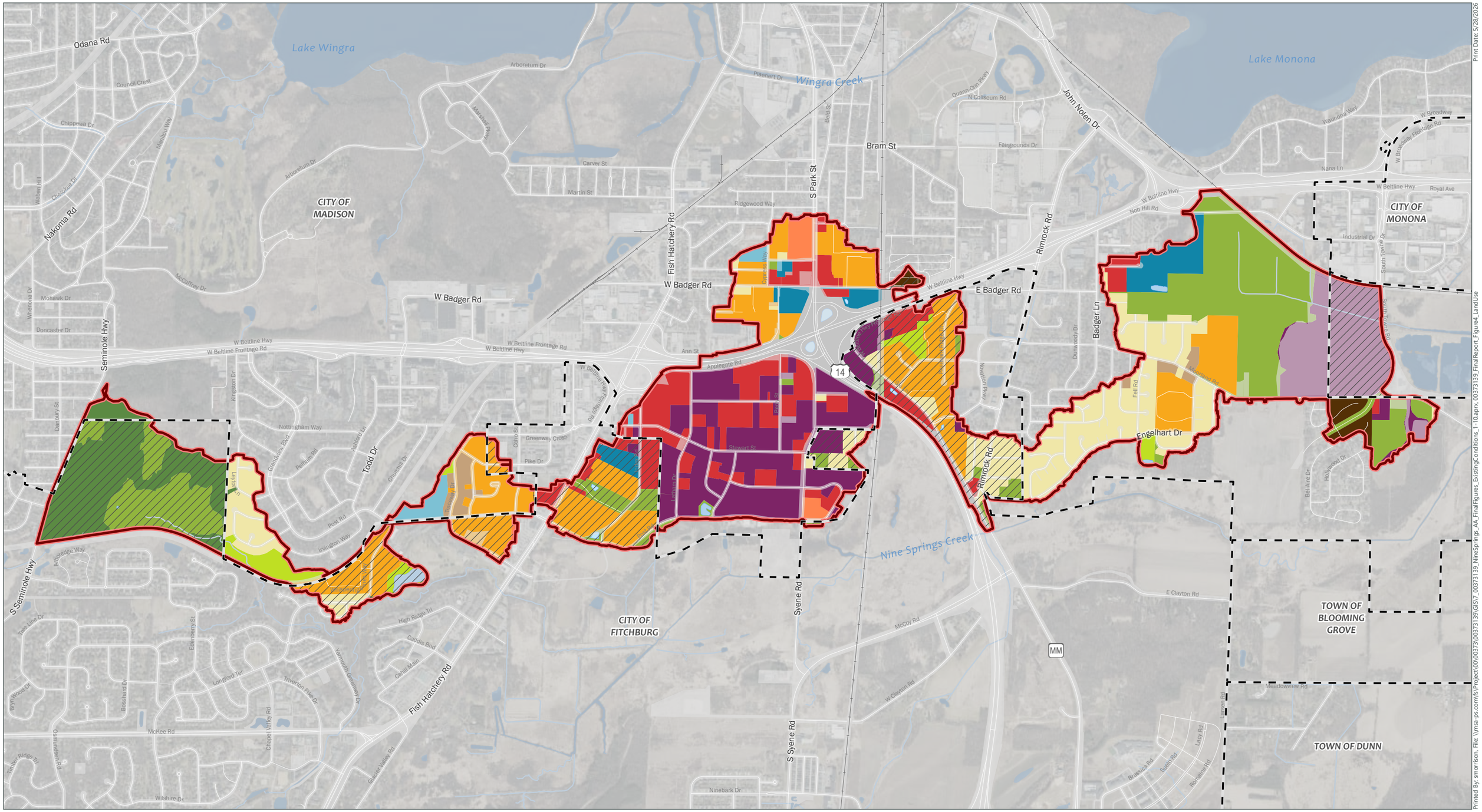
- Model Area
- Adjacent Watershed Boundary
- Nine Springs Watershed Boundary (Outside Madison)
- Municipal Boundary
- Building Footprint
- Rivers and Streams
- Lakes and Ponds
- Unmodeled Watersheds
- Model Area Outside Madison
- City of Madison Structure
- Structure Owned by Other Entity
- Modeled City Owned Pipe
- Modeled Non-City Owned Pipe

Adjacent Watersheds

FIGURE 3
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

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MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

N

0 0.25 0.5 Miles

- Model Area
- Municipal Boundary
- Model Area Outside Madison
- Rivers and Streams
- Lakes and Ponds

Existing Land Use

- Commercial, Shopping Center
- Commercial, Strip
- Highway
- Industrial, Light
- Institutional, Misc
- Institutional, School
- Open Space
- Park
- Residential, Low Density
- Residential, Medium Density without alley
- Residential, Duplex
- Residential, Mobile Homes
- Residential, MultiFamily
- Water
- Wooded

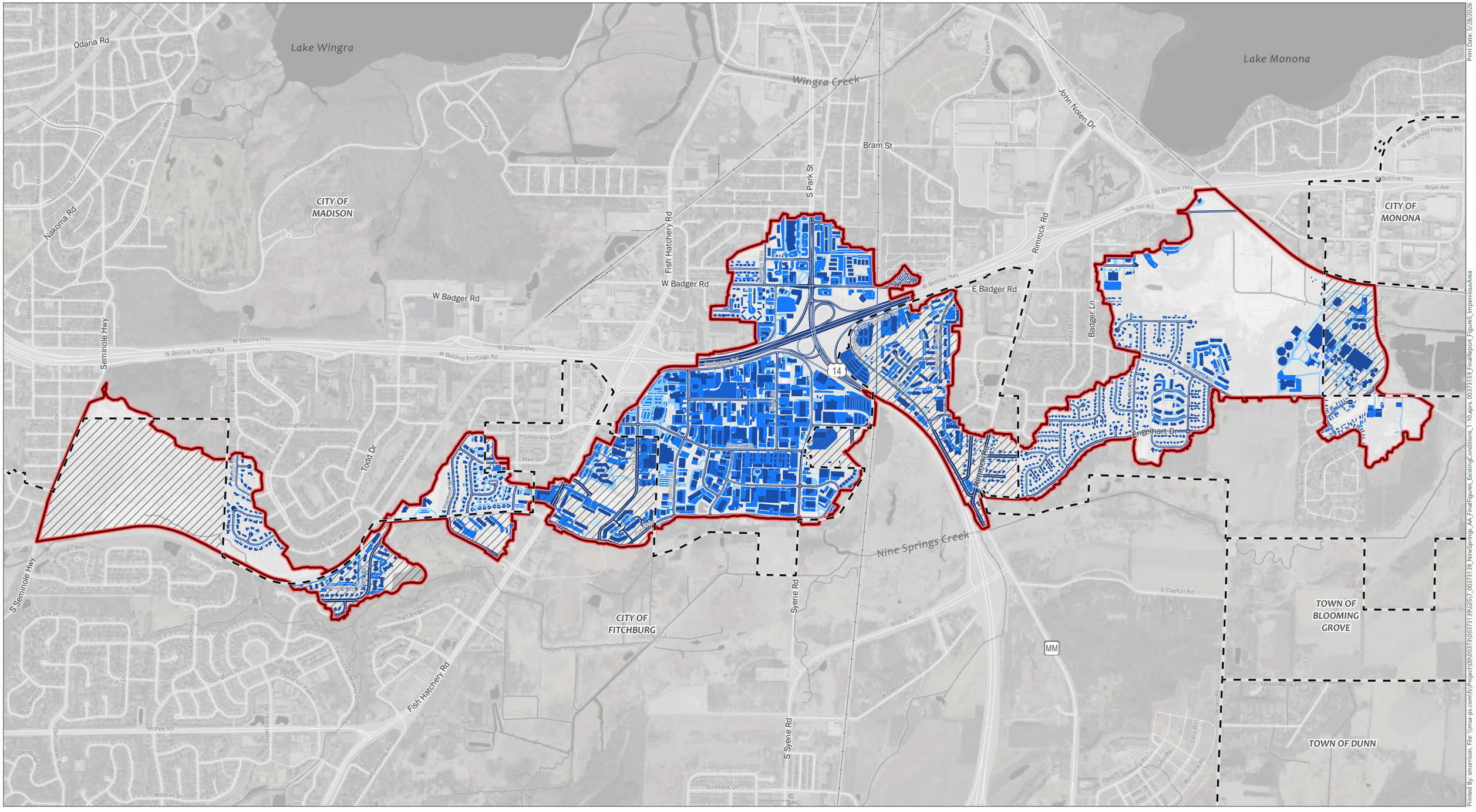
Land Use

FIGURE 4
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

Print Date: 5/28/2026

Printed By: smorrison, File: \\msa-ps.com\fs\Project\00\00373\003731\39\GIS\7_003731\39_NineSprings_AA_FinalFigure_ExistingConditions_1-10.aprx, 003731\39_FinalReport_Figure4_LandUse



MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

Model Area
Municipal Boundary
Model Area Outside Madison

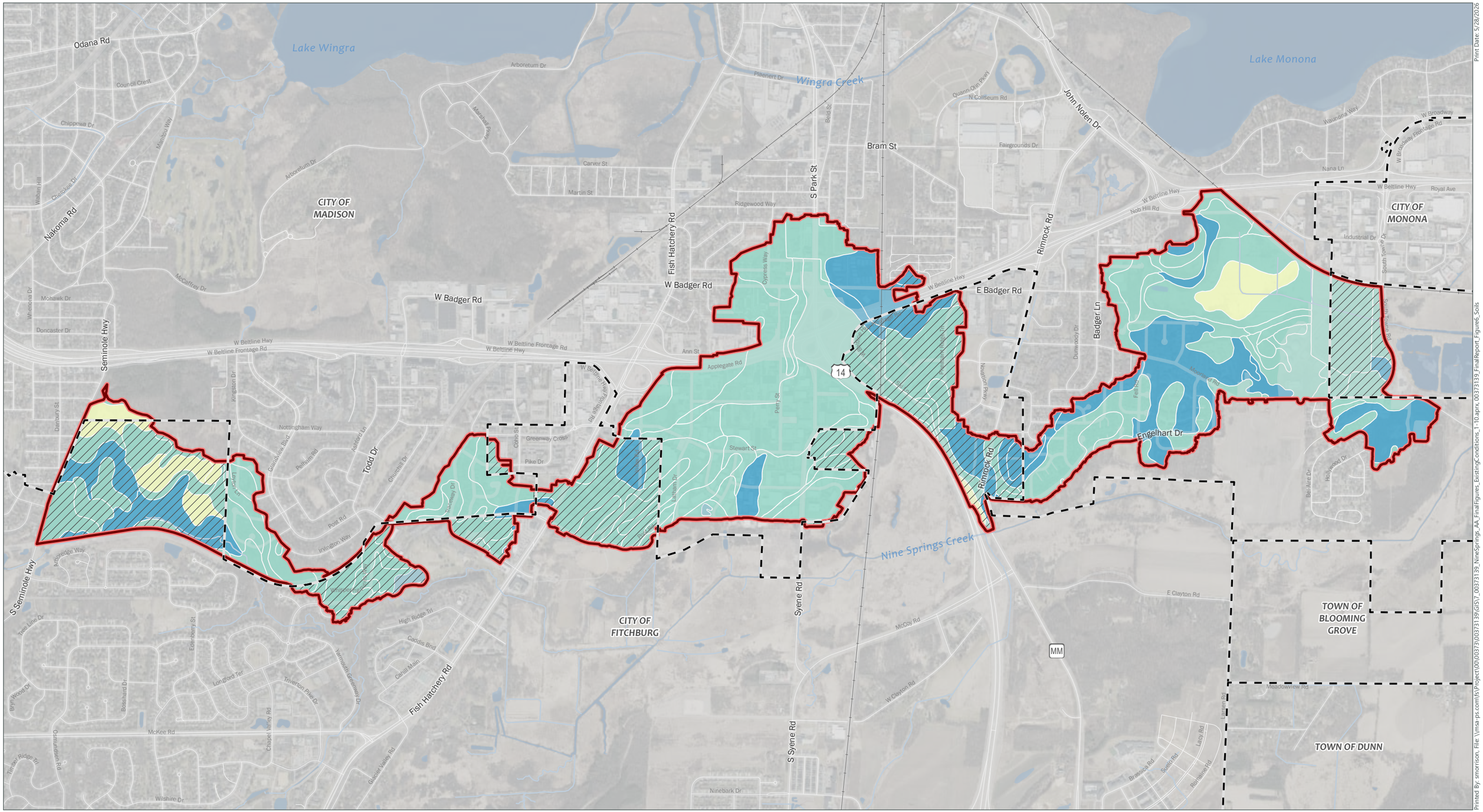
Impervious Type
Sidewalk
Driveway
Gravel Driveway
Parking
Gravel Parking
Roof
Street

Impervious Area

FIGURE 5
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

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MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

Model Area

Municipal Boundary

Model Area Outside Madison

Hydrologic Soil Group

A

B

C

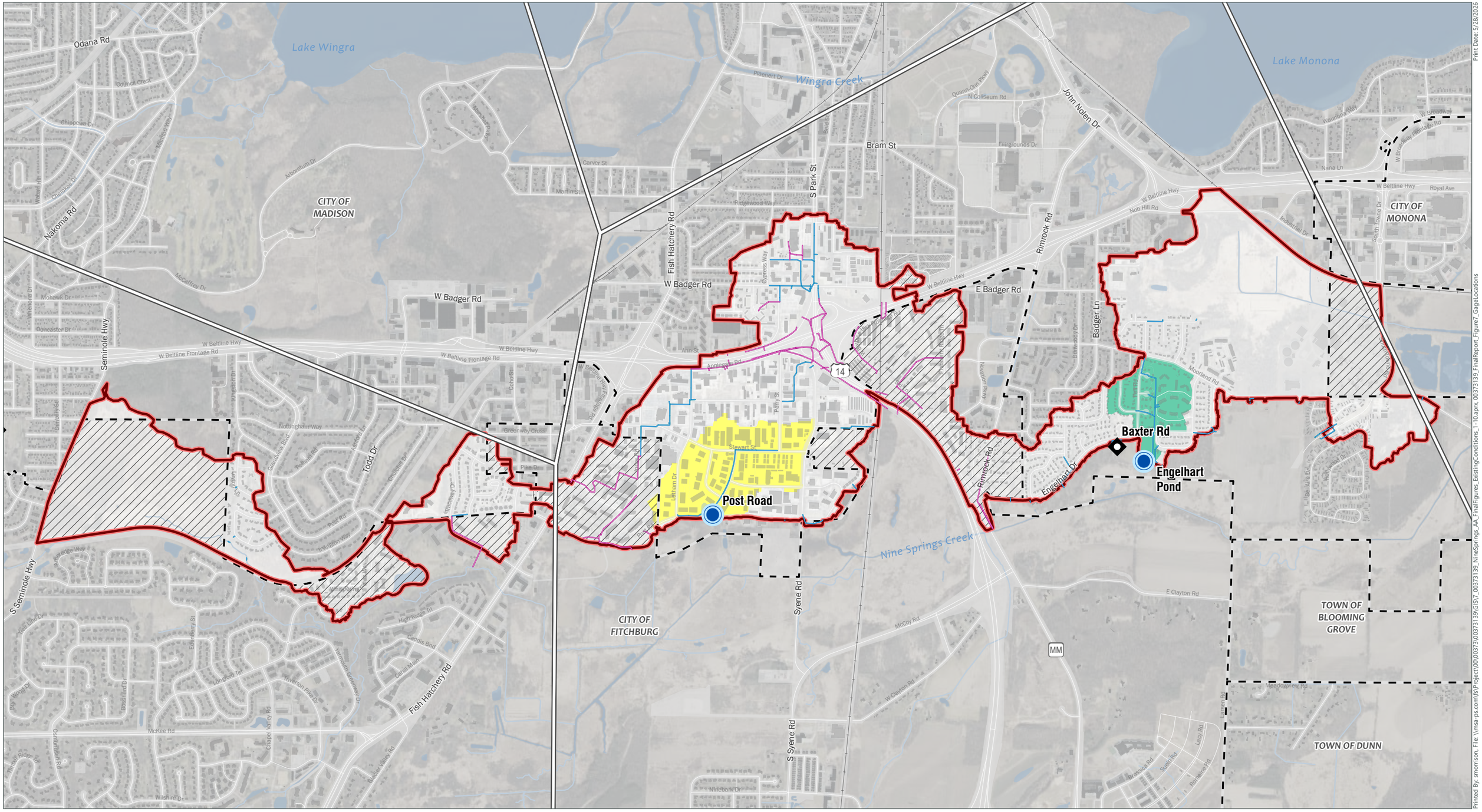
Soils

FIGURE 6
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

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MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

- Model Area
- Municipal Boundary
- Model Area Outside Madison
- Thiessen Polygons for Rain Gages
- Modeled City Owned Pipe
- Modeled Non-City Owned Pipe

MonitoringType
- Rain Gage
- Water Level

Metershed
- Engelhart Pond
- Post Road

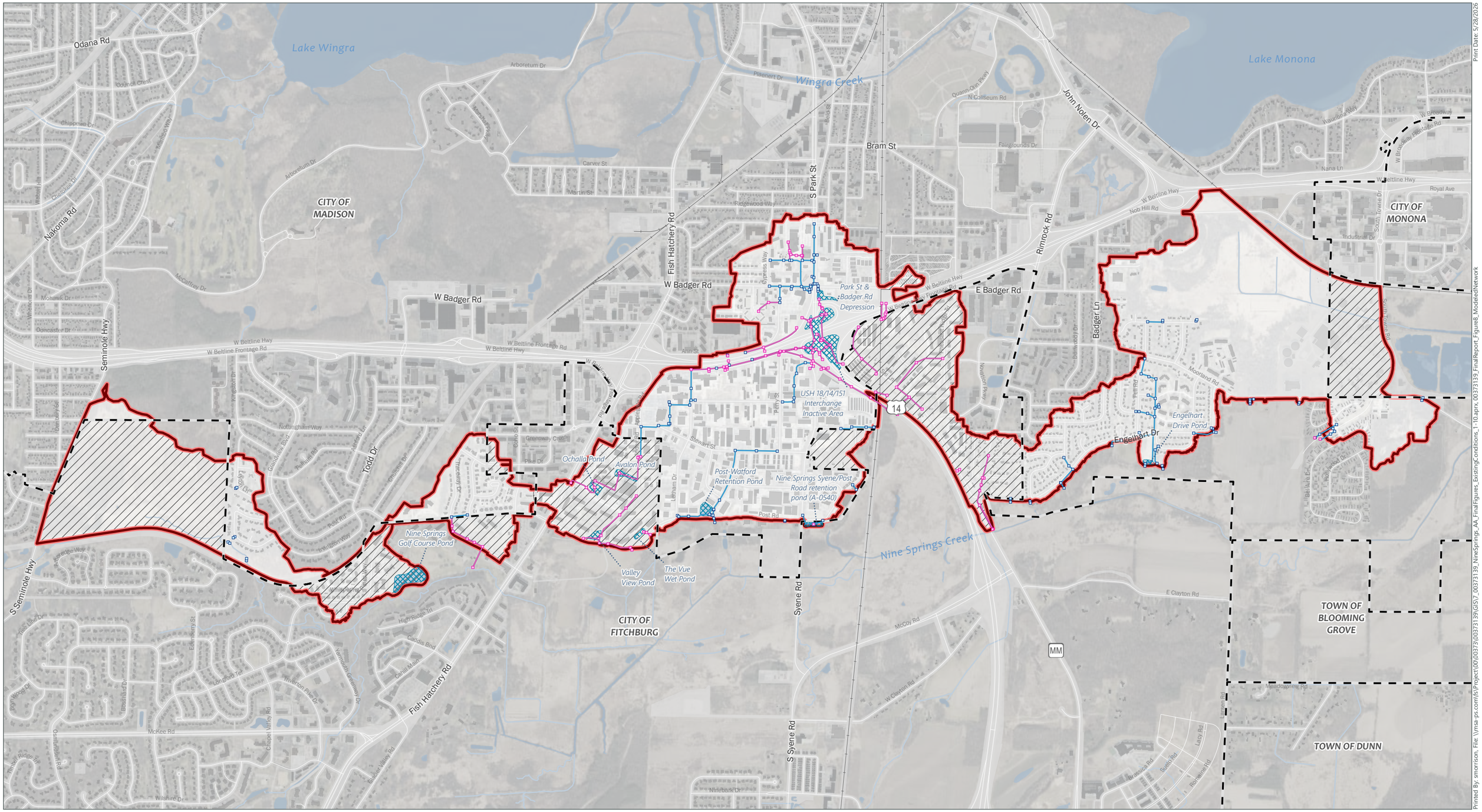
Gage Locations

FIGURE 7
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

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MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

- Model Area
- Municipal Boundary
- Model Area Outside Madison
- Building Footprint
- Rivers and Streams
- Lakes and Ponds
- City of Madison Structure
- Structure Owned by Other Entity
- Modeled City Owned Pipe
- Modeled Non-City Owned Pipe; Private
- Modeled Pond

Modeled Network

FIGURE 8
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

*Mannings Roughness (n)	
Classification	**Roughness**
Buildings	*Inactive*
Impervious, Other *(Strets, Sidewalk, Driveway, Parking)*	*0.016*
Turf Grass	0.03
Wooded	0.03
Gravel	0.02

MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

Model Area
Municipal Boundary
Model Area Outside Madison

Surface Roughness (Manning's n)*
Streets, Sidewalk, Driveway, Parking
Buildings
Wooded
Turf Grass

Surface Roughness

FIGURE 9
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

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MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

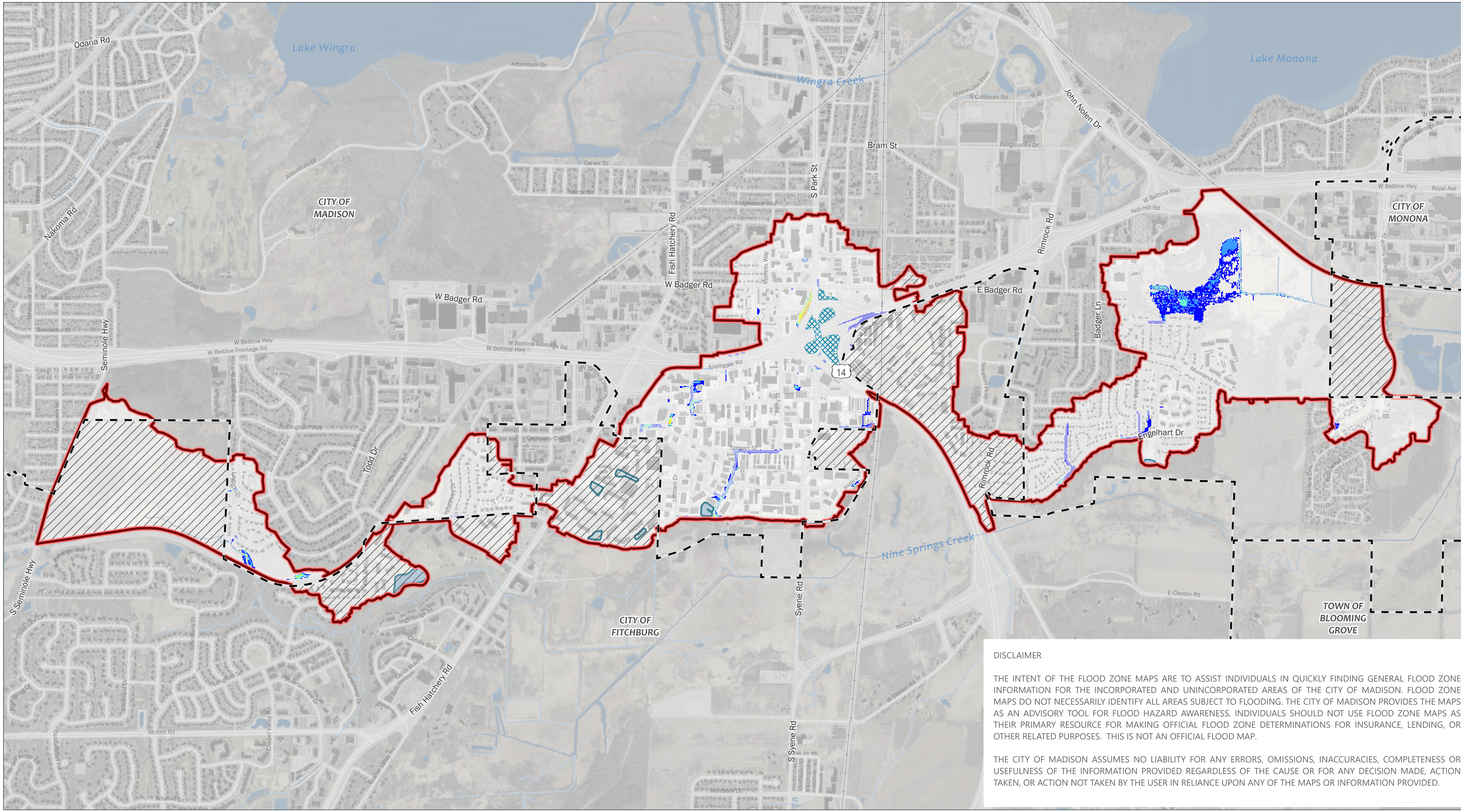
Model Area
Municipal Boundary
Model Area Outside Madison
Impervious Area
Turf Grass

2D Land Use

FIGURE 10
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

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Print Date: 5/28/2026



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MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

N
0 | 0.25 | 0.5 Miles

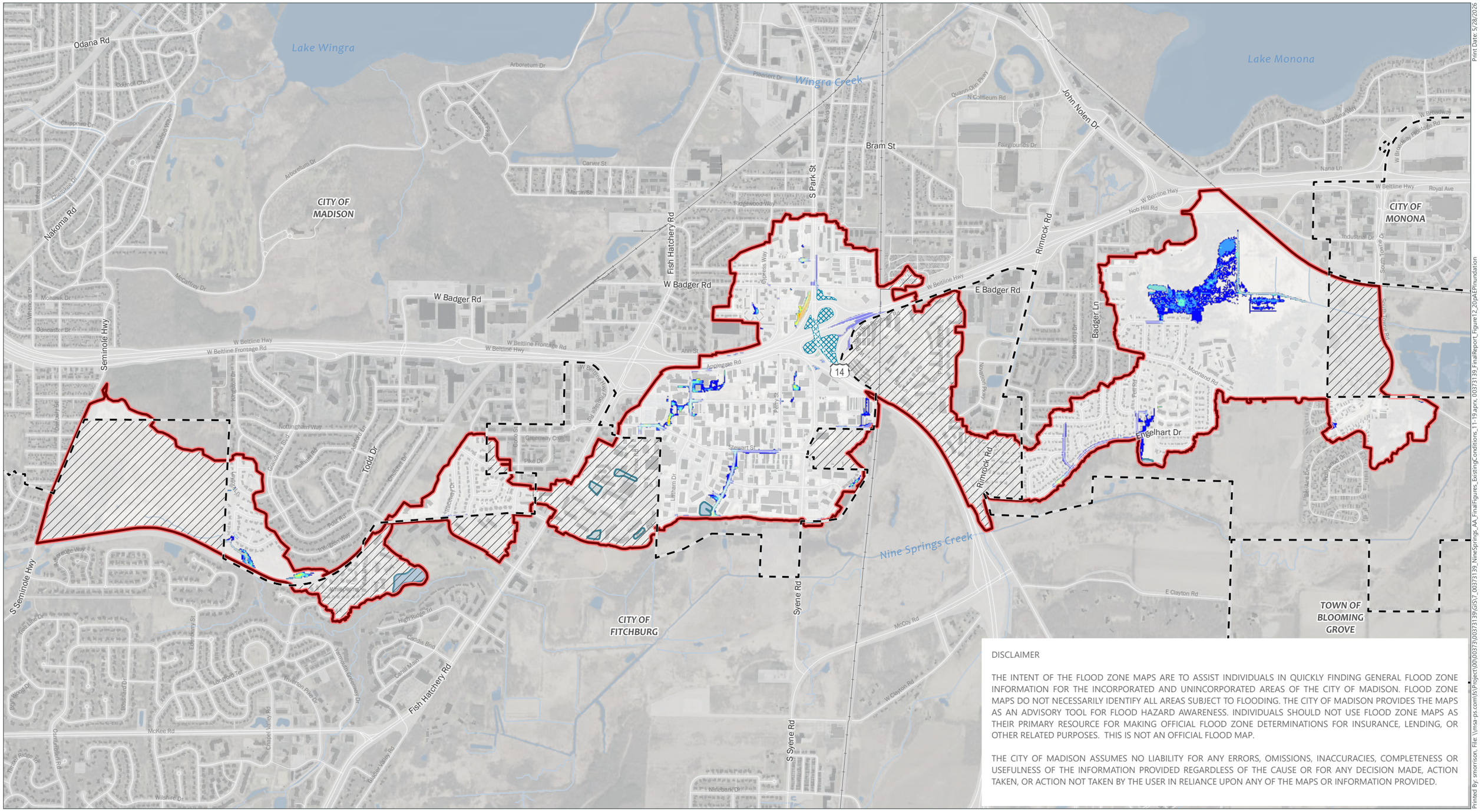
Model Area
Municipal Boundary
Model Area Outside Madison
Building Footprint
Rivers and Streams
Lakes and Ponds
Modeled Inactive Area
Modeled Stormwater Pond

Flood Event Inundation Depth
0.1 - 0.3
0.3 - 0.5
0.6 - 1
1.1 - 3
3.1 - 6
6.1+

50% AEP Inundation

FIGURE 11
Nine Springs Watershed Study Report

City of Madison
Dane County, WI



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MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

- Model Area
- Municipal Boundary
- Model Area Outside Madison
- Building Footprint
- Rivers and Streams
- Lakes and Ponds
- Modeled Inactive Area
- Modeled Stormwater Pond

Flood Event Inundation Depth

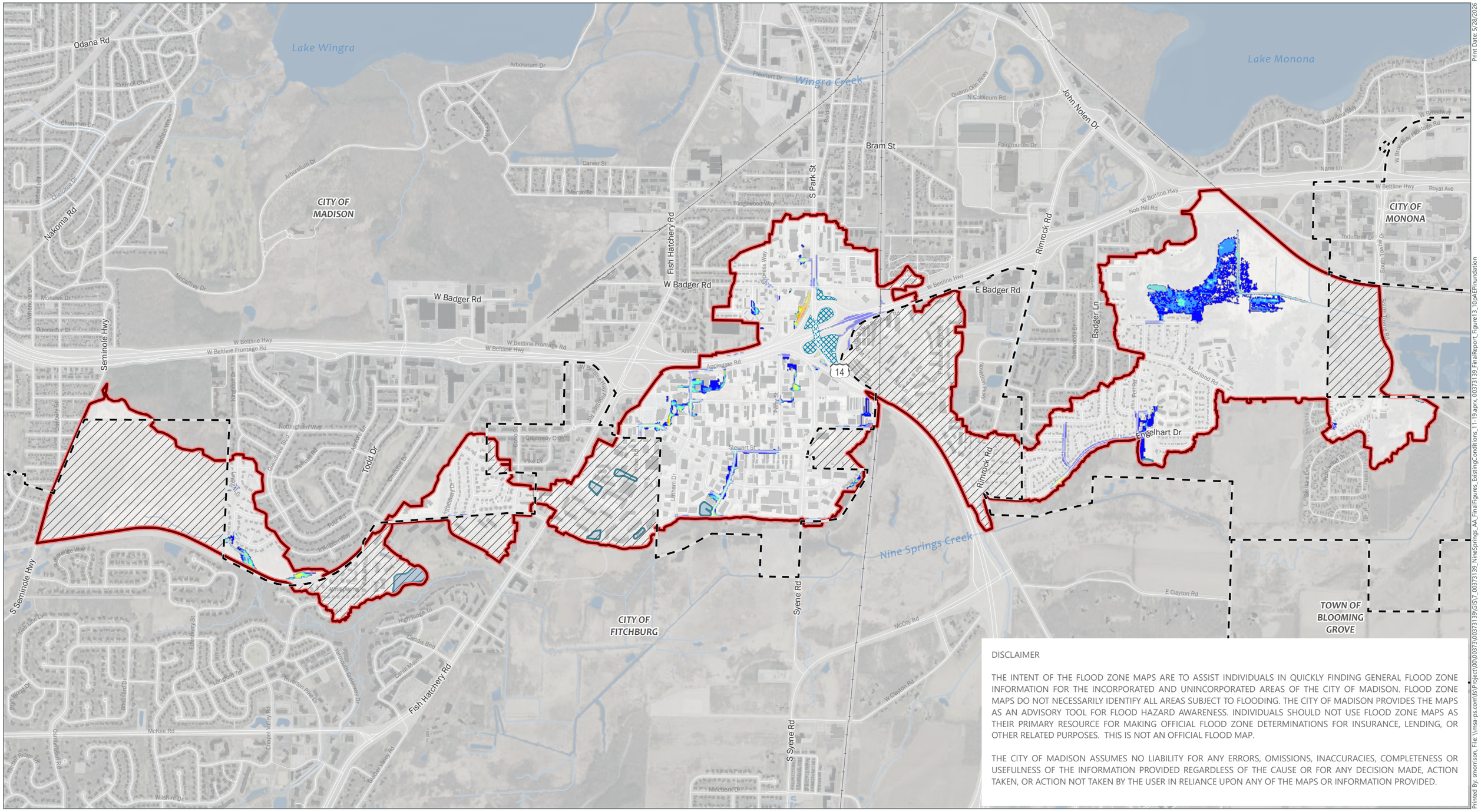
- 0.1 - 0.3
- 0.3 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 6
- 6.1+

20% AEP Inundation

FIGURE 12
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

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MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

- Model Area
- Municipal Boundary
- Model Area Outside Madison
- Building Footprint
- Rivers and Streams
- Lakes and Ponds
- Modeled Inactive Area
- Modeled Stormwater Pond

Flood Event Inundation Depth

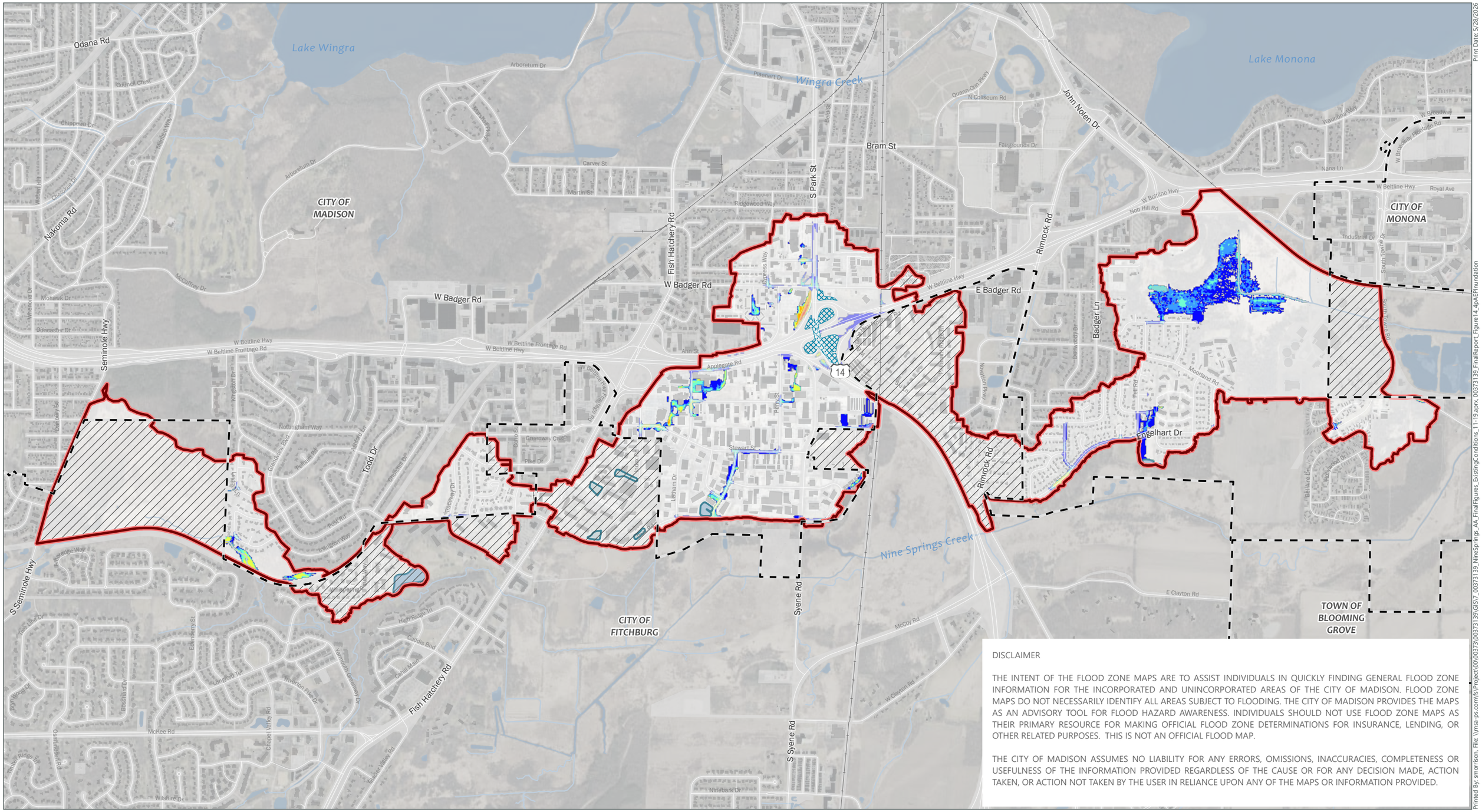
- 0.1 - 0.3
- 0.3 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 6
- 6.1+

10% AEP Inundation

FIGURE 13
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

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MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

- Model Area
- Municipal Boundary
- Model Area Outside Madison
- Building Footprint
- Rivers and Streams
- Lakes and Ponds
- Modeled Inactive Area
- Modeled Stormwater Pond

Flood Event Inundation Depth

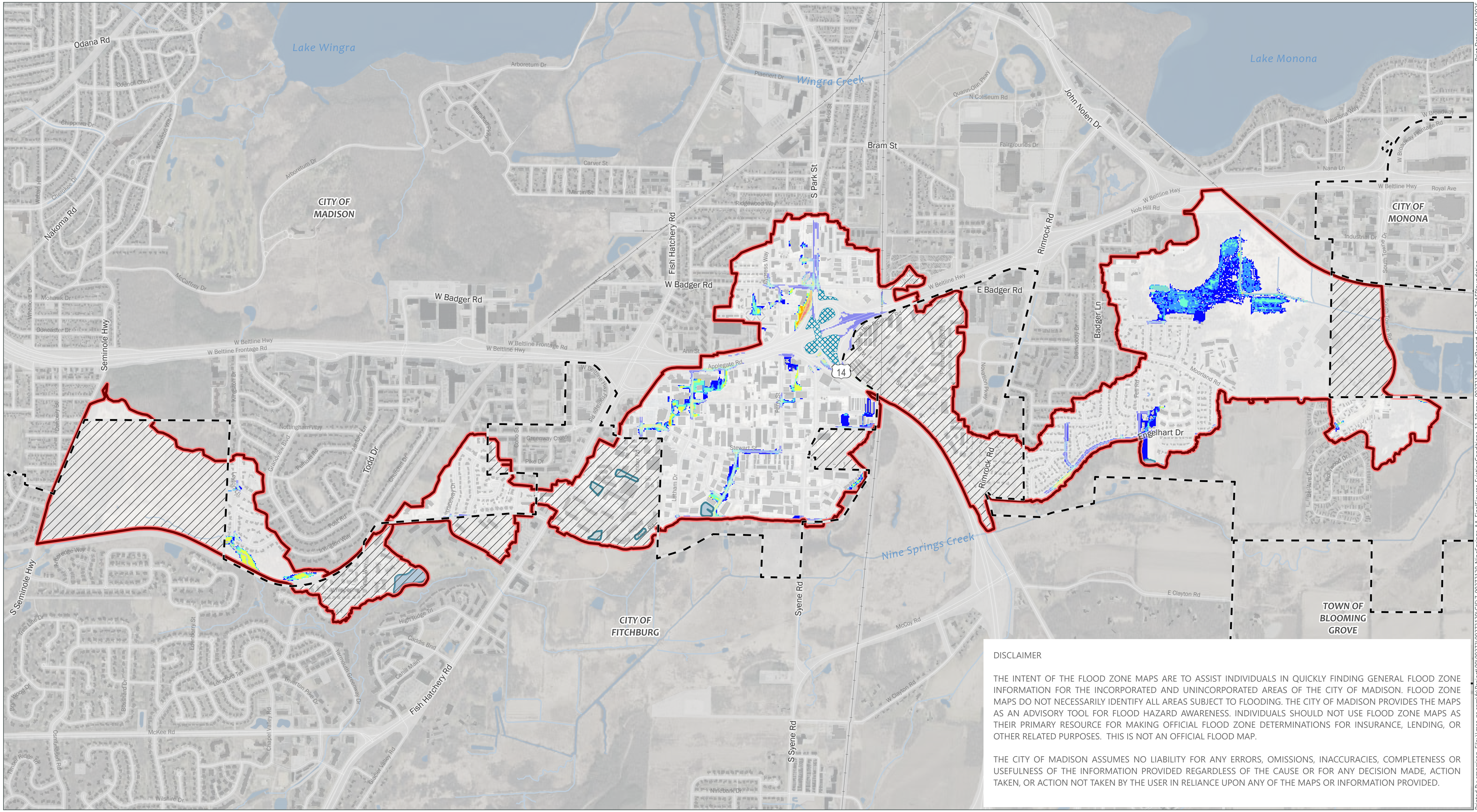
- 0.1 - 0.3
- 0.3 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 6
- 6.1+

4% AEP Inundation

FIGURE 14
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

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MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

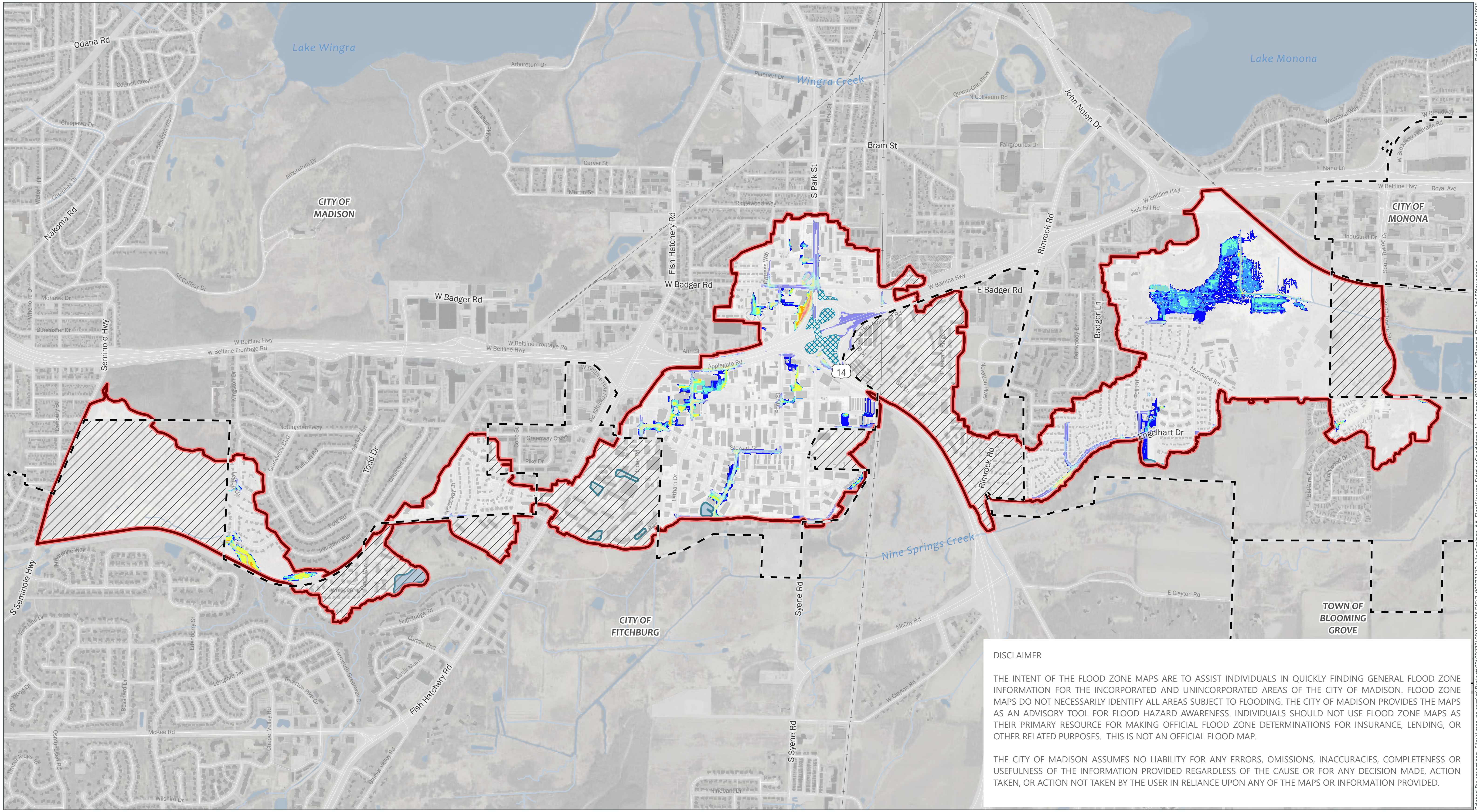
Model Area
Municipal Boundary
Model Area Outside Madison
Building Footprint
Rivers and Streams
Lakes and Ponds
Modeled Inactive Area
Modeled Stormwater Pond

Flood Event Inundation Depth
0.1 - 0.3
0.3 - 0.5
0.6 - 1
1.1 - 3
3.1 - 6
6.1+

2% AEP Inundation

FIGURE 15
Nine Springs Watershed Study Report

City of Madison
Dane County, WI



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MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

N 0 0.25 0.5 Miles

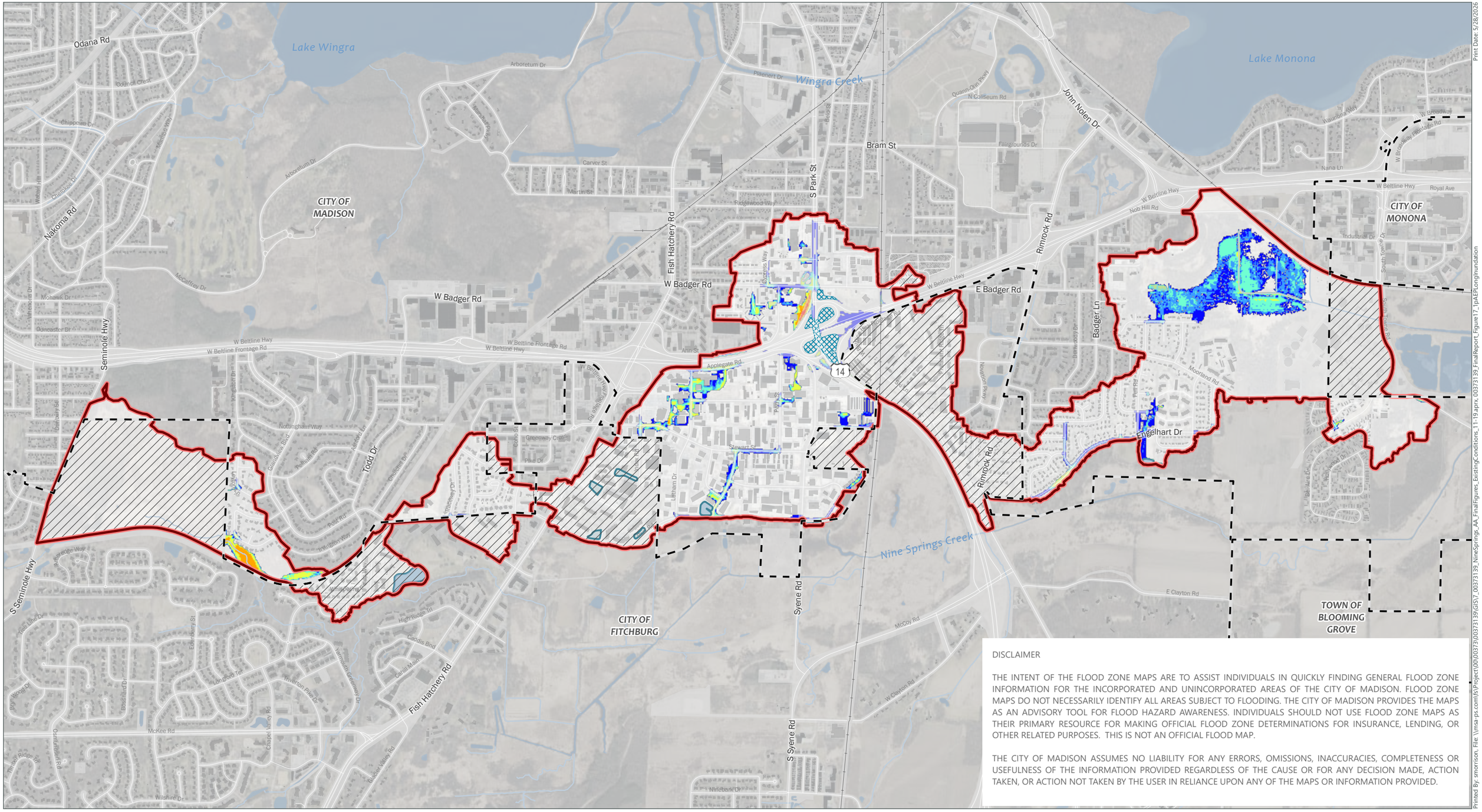
- Model Area
- Municipal Boundary
- Model Area Outside Madison
- Building Footprint
- Rivers and Streams
- Lakes and Ponds
- Modeled Inactive Area
- Modeled Stormwater Pond

Flood Event Inundation Depth
- 0.1 - 0.3
- 0.3 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 6
- 6.1+

1% AEP Inundation

FIGURE 16
Nine Springs Watershed Study Report

City of Madison
Dane County, WI



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MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

- Model Area
- Municipal Boundary
- Model Area Outside Madison
- Building Footprint
- Rivers and Streams
- Lakes and Ponds
- Modeled Inactive Area
- Modeled Stormwater Pond

Flood Event Inundation Depth

- 0.1 - 0.3
- 0.3 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 6
- 6.1+

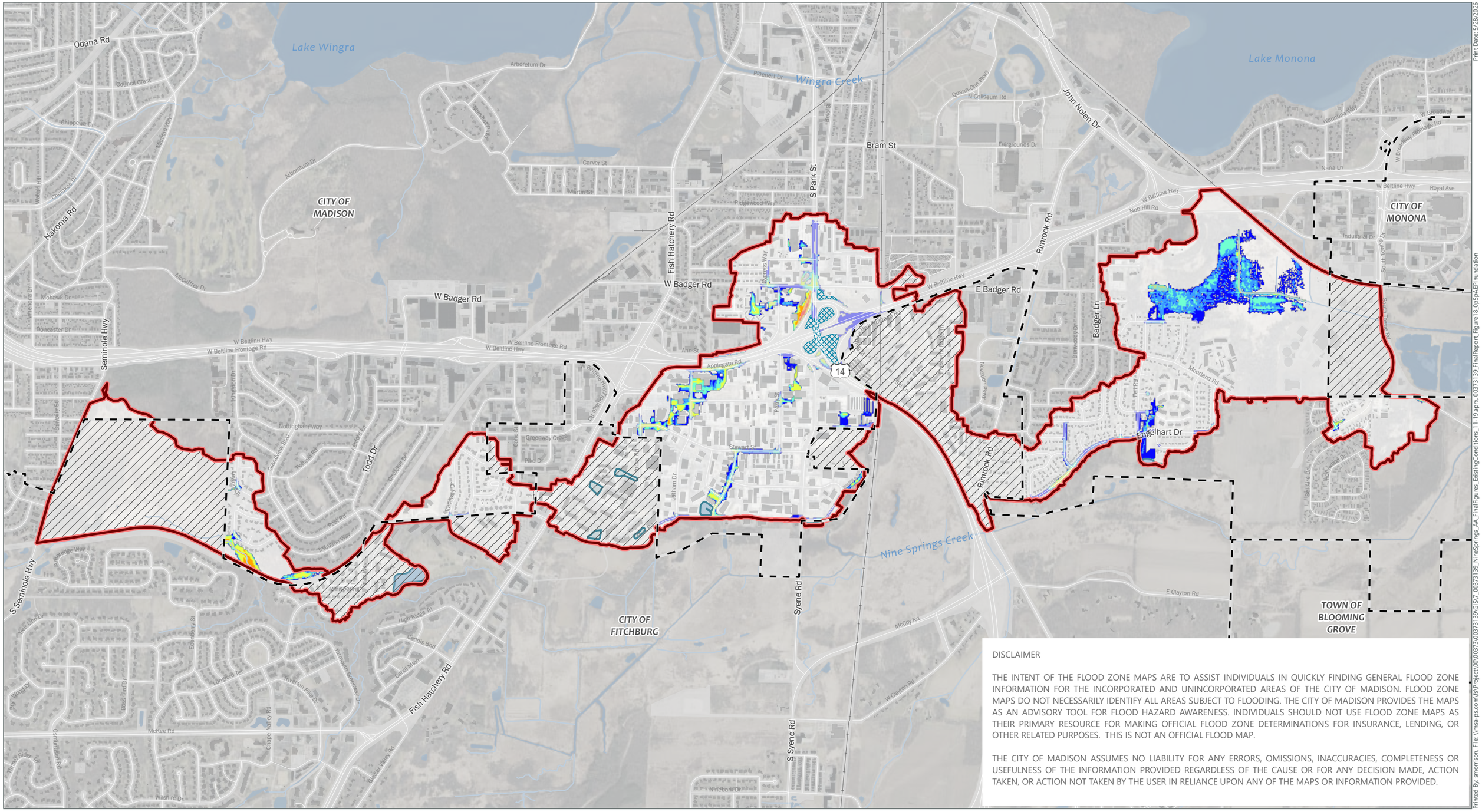
1% AEP Long Inundation

FIGURE 17
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

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THE CITY OF MADISON ASSUMES NO LIABILITY FOR ANY ERRORS, OMISSIONS, INACCURACIES, COMPLETENESS OR USEFULNESS OF THE INFORMATION PROVIDED REGARDLESS OF THE CAUSE OR FOR ANY DECISION MADE, ACTION TAKEN, OR ACTION NOT TAKEN BY THE USER IN RELIANCE UPON ANY OF THE MAPS OR INFORMATION PROVIDED.

MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

- Model Area
- Municipal Boundary
- Model Area Outside Madison
- Building Footprint
- Rivers and Streams
- Lakes and Ponds
- Modeled Inactive Area
- Modeled Stormwater Pond

Flood Event Inundation Depth

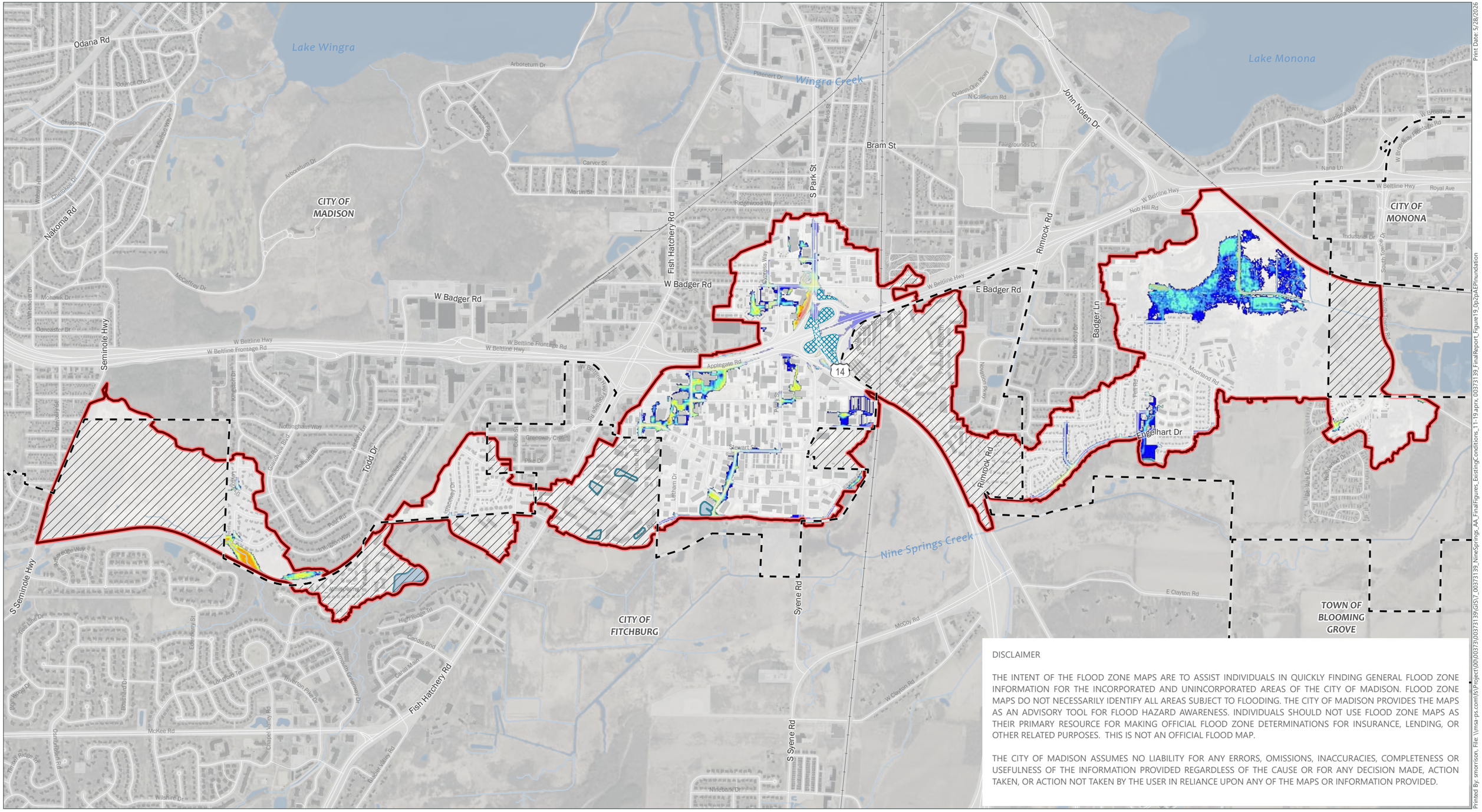
- 0.1 - 0.3
- 0.3 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 6
- 6.1+

0.5% AEP Inundation

FIGURE 18
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

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DISCLAIMER

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MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

- Model Area
- Municipal Boundary
- Model Area Outside Madison
- Building Footprint
- Rivers and Streams
- Lakes and Ponds
- Modeled Inactive Area
- Modeled Stormwater Pond

Flood Event Inundation Depth

- 0.1 - 0.3
- 0.3 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 6
- 6.1+

0.2% AEP Inundation

FIGURE 19
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

Print Date: 5/28/2026

Eliminate flooding from the storm sewer system for the 10% AEP design storm; all water shall be contained within the system, except at low points.

Lake Wingra

Wingra Creek

CITY OF MADISON

CITY OF MONONA

CITY OF FITCHBURG

TOWN OF BLOOMING GROVE

TOWN OF DUNN

Nine Springs Creek

S Park St

W Badger Rd

Syene Rd

Moorland Rd

Fell Rd

Latham Dr

Tracceway Dr

Stewart St

Point St

Pheasant Ridge Dr

Whitney Way

Wisconsin State Hwy 19

14

Print Date: 5/28/2026

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MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

- Model Area
- Municipal Boundary
- Model Area Outside Madison
- Rivers and Streams
- Lakes and Ponds
- City of Madison Structure
- Structure Owned by Other Entity
- Modeled City Owned Pipe
- Modeled Non-City Owned Pipe
- Street Surcharging at City Owned modeled node (67)

Flood Event Inundation Depth

- Inundation Extent, 10% AEP Event

Target 1a

FIGURE 20
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

City Owned Streets to remain passable during 4% AEP design storm with no more than 0.5-ft of water at the centerline.

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MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

N 0 0.25 0.5 Miles

- Model Area
- Municipal Boundary
- Model Area Outside Madison
- Rivers and Streams
- Lakes and Ponds
- City of Madison Structure
- Structure Owned by Other Entity
- Modeled City Owned Pipe
- Modeled Non-City Owned Pipe
- 0.5' or Greater Inundation at Centerline

Target 2a

FIGURE 21
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

No home or business will be flooded during the 1% AEP design storm.

Lake Wingra

Wingra Creek

CITY OF MADISON

CITY OF MONONA

CITY OF FITCHBURG

TOWN OF BLOOMING GROVE

TOWN OF DUNN

Nine Springs Creek

W Badger Rd

W Beltline Hwy

Applegate Rd

Stewart St

Syene Rd

Moorland Rd

14

MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

- Model Area
- Municipal Boundary
- Model Area Outside Madison
- SWU Lands & Parks Within Study Area
- City of Madison Structure
- Structure Owned by Other Entity
- Modeled City Owned Pipe
- Modeled Non-City Owned Pipe; Private
- Building Footprint
- 1% AEP Storm
- Inundation >0.5 ft

Target 3a

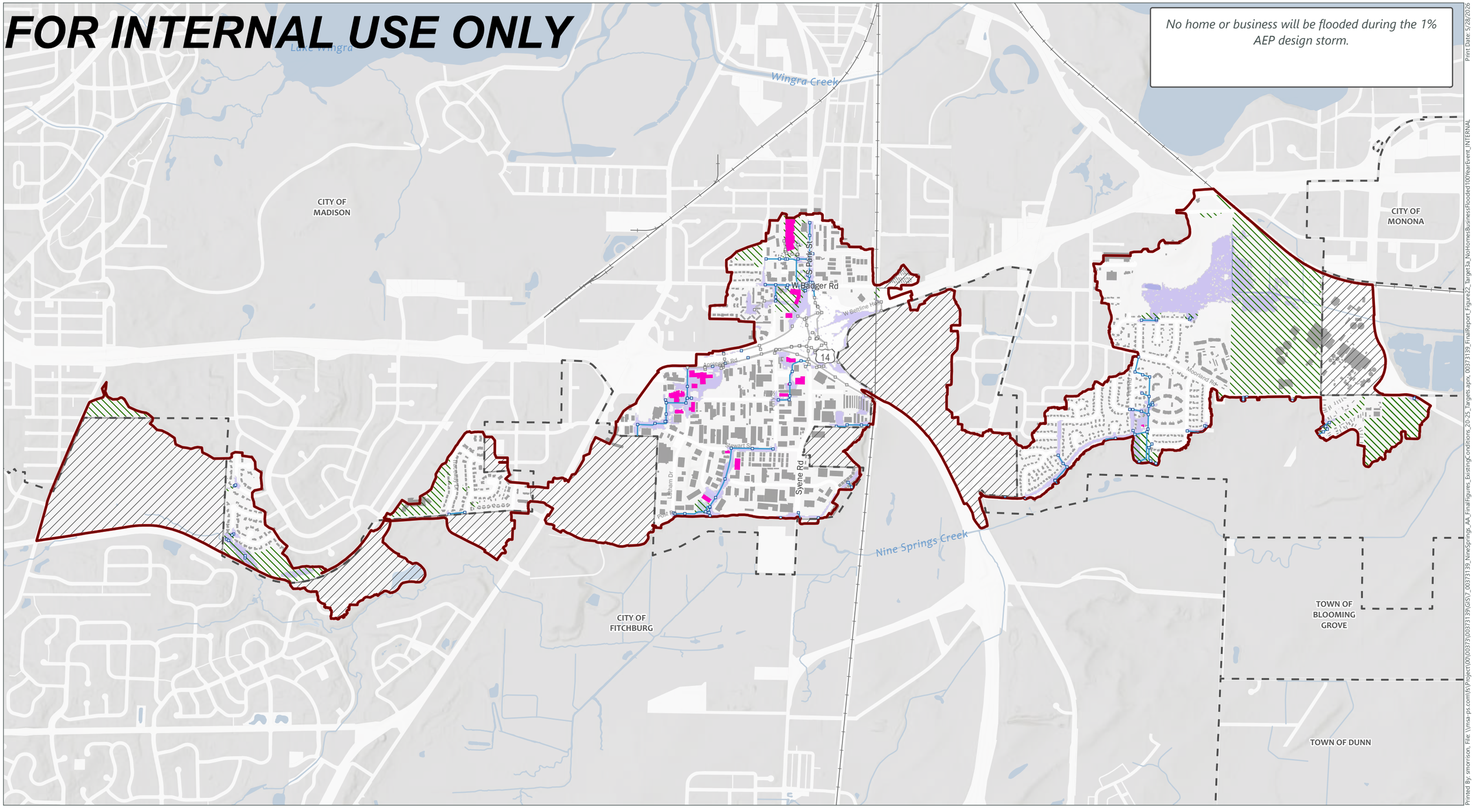
FIGURE 22
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

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FOR INTERNAL USE ONLY

No home or business will be flooded during the 1% AEP design storm.



MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

- Model Area
- Municipal Boundary
- Model Area Outside Madison
- SWU Lands & Parks Within Study Area
- City of Madison Structure
- Structure Owned by Other Entity
- Modeled City Owned Pipe
- Modeled Non-City Owned Pipe; Private
- Building Footprint
- Impacted Building (1% AEP Event) (16)

1% AEP Storm

- Inundation >0.5 ft

Target 3a

FIGURE 22
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

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Enclosed depressions to be served to the 100-year design storm
(which can include safe overland flow within street, easements, greenways or other public lands).

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MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

- Model Area
- Municipal Boundary
- Model Area Outside Madison
- Rivers and Streams
- Lakes and Ponds
- Modeled Inactive Area
- Modeled Stormwater Pond
- SWU Lands & Parks Within Study Area
- City of Madison Structure
- Structure Owned by Other Entity
- Modeled City Owned Pipe
- Modeled Non-City Owned Pipe; Private
- Enclosed Depression Not Meeting Criteria* Within City Limits
- Enclosed Depression

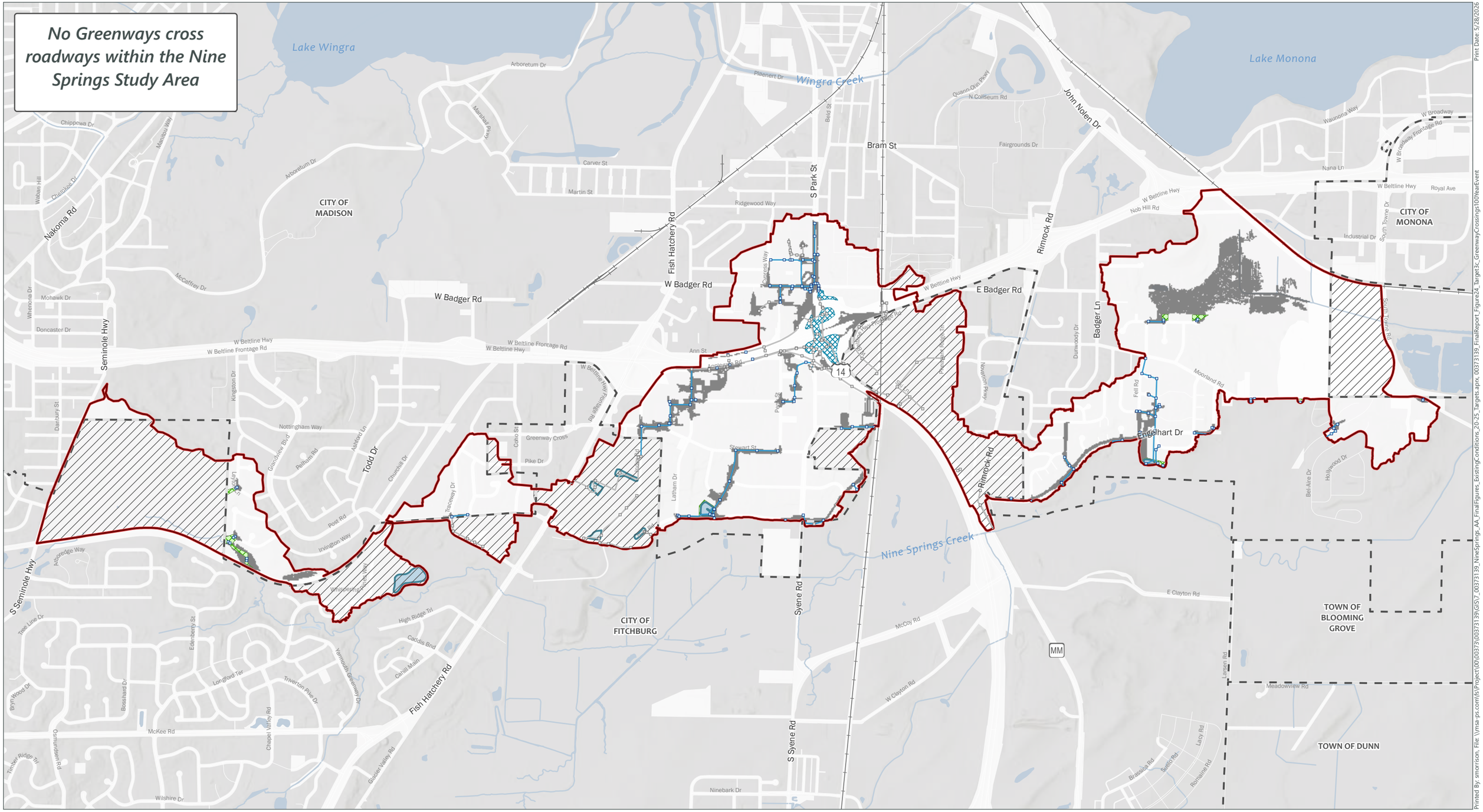
Flood Event Inundation Depth
- 0.1 - 0.3
- 0.3 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 6
- 6.1+

Target 3b

FIGURE 23
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

No Greenways cross roadways within the Nine Springs Study Area



MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

- Model Area
- Municipal Boundary
- Model Area Outside Madison
- Modeled Inactive Area
- Modeled Stormwater Pond
- Other Pond/Greenway
- City of Madison Structure
- Structure Owned by Other Entity
- Modeled City Owned Pipe
- Modeled Non-City Owned Pipe; Private

Flood Event Inundation Depth

- Inundation Extent, 1% AEP Event

Target 3c

FIGURE 24
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

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Safely convey stormwater with limited impact on private property during the 0.2% AEP design storm.

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MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

- Model Area
- Municipal Boundary
- Model Area Outside Madison
- SWU Lands & Parks Within Study Area
- City of Madison Structure
- Structure Owned by Other Entity
- Modeled City Owned Pipe
- Modeled Non-City Owned Pipe; Private
- Building Footprint

0.2% AEP Storm

- Inundation > 0.5 ft

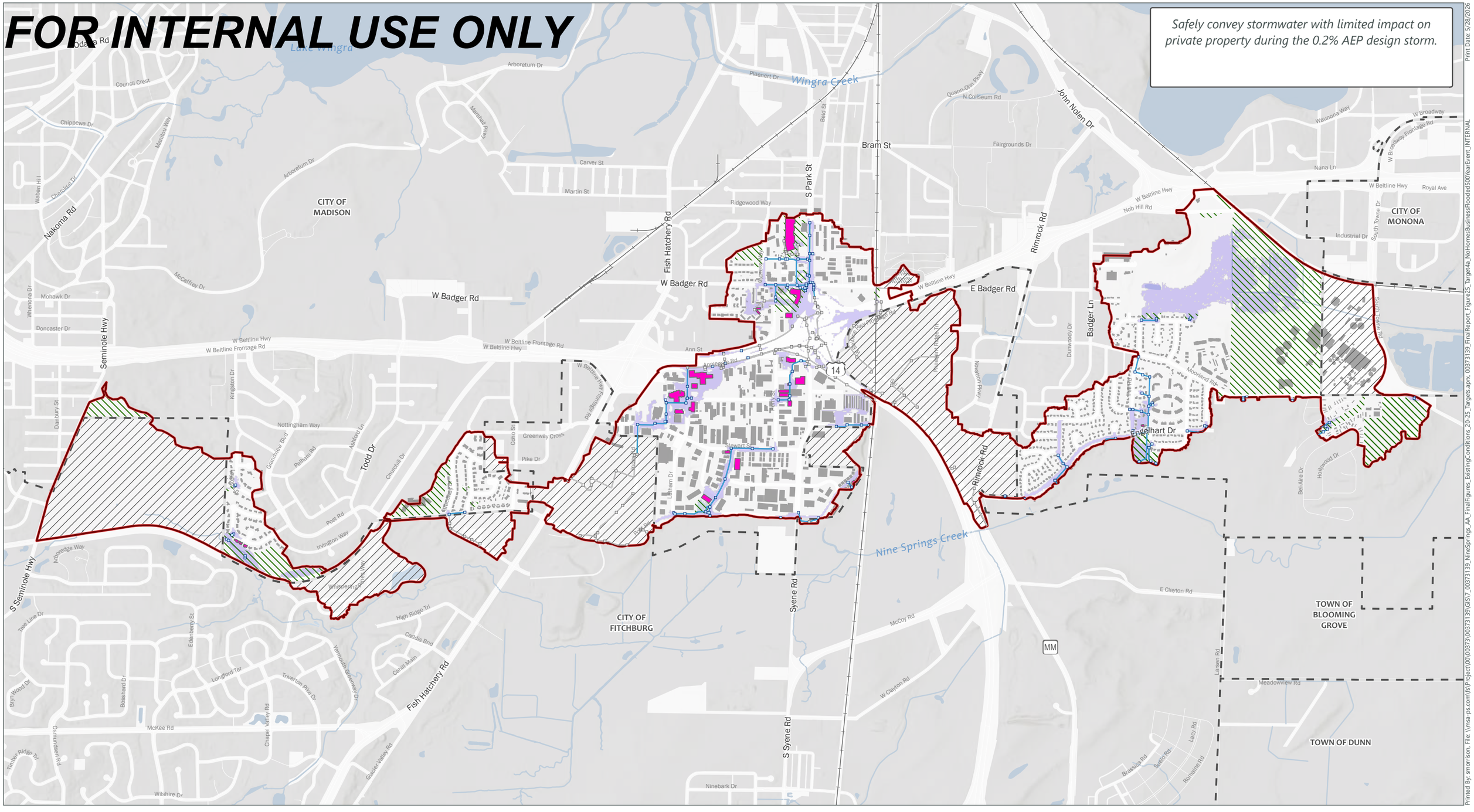
Target 4a

FIGURE 25
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

FOR INTERNAL USE ONLY

Safely convey stormwater with limited impact on private property during the 0.2% AEP design storm.



MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

- Model Area
- Municipal Boundary
- Model Area Outside Madison
- SWU Lands & Parks Within Study Area
- City of Madison Structure
- Structure Owned by Other Entity
- Modeled City Owned Pipe
- Modeled Non-City Owned Pipe; Private
- Building Footprint
- Impacted Building (0.2% AEP Event) (25)

0.2% AEP Storm

- Inundation > 0.5 ft

Target 4a

FIGURE 25
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

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Recommended Solutions Index

Figure 26

Nine Springs Watershed Study
City of Madison

- Map Extents (Figures 27A - G)
- Model Area
- Municipal Boundary
- Model Area Outside Madison
- Improvement Area of Interest

Proposed Storm Improvement

- Upsize
- New
- Removal

0 700 1,400 2,800 Feet

CITY OF MADISON
CITY OF MONONA
CITY OF FITCHBURG
TOWN OF BLOOMING GROVE
TOWN OF DUNN

Lake Wingra
Lake Monona
Wingra Creek
Nine Springs Creek
Swan Creek

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Storm System Improvements

Westview Lane

Figure 27 - A

City of Madison,
Dane County, Wisconsin

N

Sandwood Way

Westview Ln

Westview Ln

Knollwood Ct

Knollwood Way

Upsize to 19''x30'' Elliptical Pipe
Length: 35'
U/S IE: 930.12'
D/S IE: 929'

Stormwater System
- Storm Pipe
- Inlet
- Apron End
- Access

Water System
- Water Main/Service
- Valve
- Hydrant

Sanitary System
- Access
- Sanitary Main
- Lateral
- MMSD Access
- MMSD Main

- Model Area Outside Madison
- Railroad
- Park
- City of Madison Ponds/Greenways
- Waterbody

Proposed Storm Improvement
- Upsize

0 20 40 80 Feet

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Storm System Improvements

Post Rd/Watford Way

Figure 27 - B

City of Madison,
Dane County, Wisconsin

Upsize to 36'' Pipe
Length: 396'
U/S IE: 873'
D/S IE: 865'

Upsize to 36'' Pipe
Length: 388'
U/S IE: 878'
D/S IE: 873'

Upsize to 48''x76'' Elliptical Pipe
Length: 591'
U/S IE: 864'
D/S IE: 855.5'

Upsize to 60''x96'' Box
Length: 205'
U/S IE: 852'
D/S IE: 850.5'

Upsize to 53''x83'' Elliptical Pipe
Length: 393'
U/S IE: 855'
D/S IE: 853'

Upsize to 60''x96'' Box
Length: 50'
U/S IE: 850.5'
D/S IE: 850'

Upsize to 60''x120'' Box
Length: 104'
U/S IE: 851.5'
D/S IE: 851'

Upsize to 60''x120'' Box
Length: 60'
U/S IE: 851'
D/S IE: 850.5'

Upsize to 60''x120'' Box
Length: 80'
U/S IE: 850.5'
D/S IE: 850.25'

Upsize to 60''x120'' Box
Length: 24'
U/S IE: 852'
D/S IE: 851.53'

Stewart St
Latham Dr
Kingsley Way
Watford Way
Perry St
Watson Ave
Post Rd

N

Stormwater System
- Storm Pipe
- Inlet
- Bend
- Apron End
- Access
- Private Stormwater Structure
- Private Stormwater Pipe

Water System
- Water Main/Service
- Valve
- Hydrant

Sanitary System
- Access
- Sanitary Main
- Lateral

- Model Area Outside Madison
- Railroad
- Park
- City of Madison Ponds/Greenways
- Waterbody

Proposed Storm Improvement
- Upsize

0 45 90 180 Feet

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Storm System Improvements

Applegate Bypass

Figure 27 - C

City of Madison,
Dane County, Wisconsin

N

W Fiedler Ln
Petra Pl
Emil St
Ann St
Damon Rd
W Beltline Hwy
Perry St
S Park St
W Beltline Hwy
Fish Hatchery Rd
Applegate Rd
Applegate Ct
Ann St
W Beltline Hwy
Applegate Rd
W Beltline Hwy Frontage Rd
14
Jonathon Dr
Greenway Cross
Index Rd
Perry St
Rolfsmeyer Dr
Stewart St
Stewart St
Syene Rd
Area Dr
Kingsley Way
Watford Way
Watson Ave

New 72" Pipe
Length: 35'
U/S IE: 861.78'
D/S IE: 861.6'

New 72" Pipe
Length: 193'
U/S IE: 861.6'
D/S IE: 861'

New 30" Pipe
Length: 10'
U/S IE: 864.71'
D/S IE: 864.5'

New 72" Pipe
Length: 379'
U/S IE: 861'
D/S IE: 860.25'

New 72" Pipe
Length: 23'
U/S IE: 860.25'
D/S IE: 860'

New 24" Pipe
Length: 67'
U/S IE: 871.94'
D/S IE: 868'

New 72" Pipe
Length: 229'
U/S IE: 863.15'
D/S IE: 861.78'

New 72" Pipe
Length: 315'
U/S IE: 864.51'
D/S IE: 863.15'

New 72" Pipe
Length: 122'
U/S IE: 864.9'
D/S IE: 864.51'

New 72" Pipe
Length: 409'
U/S IE: 867.68'
D/S IE: 864.9'

Upsize to 72" Pipe
Length: 206'
U/S IE: 869.41'
D/S IE: 867.68'

Upsize to 54" Pipe
Length: 112'
U/S IE: 881.35'
D/S IE: 880.77'

Upsize to 54" Pipe
Length: 78'
U/S IE: 880.5'
D/S IE: 880.77'

New 54" Pipe
Length: 1629'
U/S IE: 880.5'
D/S IE: 870.91'

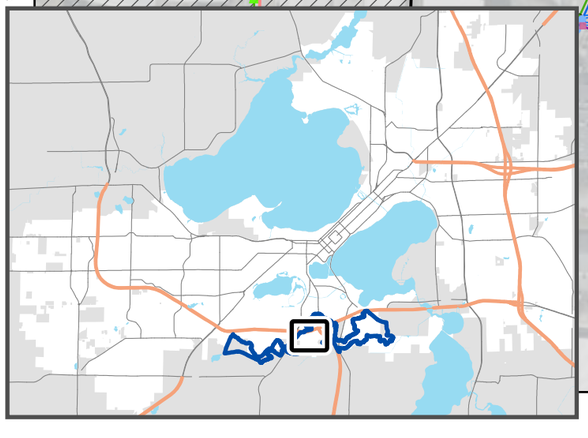
Upsize to 54" Pipe
Length: 212'
U/S IE: 882.85'
D/S IE: 882.27'

Upsize to 54" Pipe
Length: 339'
U/S IE: 885.63'
D/S IE: 883.77'

Upsize to 54" Pipe
Length: 371'
U/S IE: 882.27'
D/S IE: 881.35'

Upsize to 54" Pipe
Length: 140'
U/S IE: 883.18'
D/S IE: 882.85'

Upsize to 54" Pipe
Length: 249'
U/S IE: 883.77'
D/S IE: 883.18'



Stormwater System
- Storm Pipe
- Abandoned Storm Pipe
- Inlet
- Bend
- Apron End
- Access
- Private Stormwater Structure
- Private Stormwater Pipe

Water System
- Water Main/Service
- Valve
- Hydrant

Sanitary System
- Access
- Sanitary Main
- Lateral
- MMSD Access
- MMSD Main

- Model Area Outside Madison
- Railroad
- Park
- City of Madison Ponds/Greenways
- Waterbody

Proposed Storm Improvement
- Upsize
- New
- Removal

0 100 200 400 Feet

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Storm System Improvements

Applegate Outfall

Figure 27 - D

City of Madison,
Dane County, Wisconsin

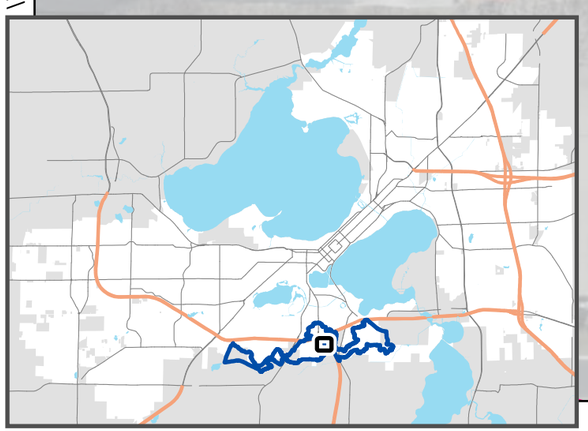
N

Upsize to 78'' Pipe
Length: 260'
U/S IE: 859.5'
D/S IE: 857.42'

Upsize to 78'' Pipe
Length: 414'
U/S IE: 857.42'
D/S IE: 854.11'

Upsize to 78'' Pipe
Length: 378'
U/S IE: 854.11'
D/S IE: 851.09'

New 36''x72'' Box
Length: 138'
U/S IE: 855.74'
D/S IE: 855.28'



Stormwater System
- Storm Pipe
- Inlet
- Bend
- Apron End
- Access

Water System
- Water Main/Service
- Valve
- Hydrant

Sanitary System
- Access
- Sanitary Main
- Lateral
- MMSD Access
- MMSD Main

- Model Area Outside Madison
- Railroad
- Park
- City of Madison Ponds/Greenways
- Waterbody

Proposed Storm Improvement
- Upsize
- New

0 30 60 120 Feet

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Storm System Improvements

DOT Ponds

Figure 27 - E

City of Madison,
Dane County, Wisconsin

W Badger Rd
Cypress Way
Parker Pl
Perry St
S Park St
Badger Pkwy
W Beltline Hwy
W Beltline Hwy Frontage Rd
Ann St
Skyline
Syene Rd
14

New 48"x76" Elliptical Pipe
Length: 507'
U/S IE: 871.1'
D/S IE: 870.22'

Upsize to 48"x72" Box
Length: 140'
U/S IE: 870.22'
D/S IE: 869.21'

New 24" Pipe
Length: 214'
U/S IE: 876.93'
D/S IE: 872.22'

Upsize to 36" Pipe
Length: 326'
U/S IE: 867'
D/S IE: 866'

New 48"x72" Box
Length: 122'
U/S IE: 869.21'
D/S IE: 868'

Upsize to 48"x72" Box
Length: 253'
U/S IE: 868'
D/S IE: 866'

Upsize to 36"x60" Box
Length: 122'
U/S IE: 865'
D/S IE: 864'

Upsize to 36"x72" Box
Length: 149'
U/S IE: 866'
D/S IE: 864.28'

N

Stormwater System
- Storm Pipe
- Abandoned Storm Pipe
- Inlet
- Bend
- Apron End
- Access
- Private Stormwater Structure
- Private Stormwater Pipe

Water System
- Water Main/Service
- Valve
- Hydrant

Sanitary System
- Access
- Sanitary Main
- Lateral
- MMSD Access
- MMSD Main

- Model Area Outside Madison
- Railroad
- Park
- City of Madison Ponds/Greenways
- Waterbody

Proposed Storm Improvement
- Upsize
- New

0 55 110 220 Feet

CITY OF MADISON ENGINEERING

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Storm System Improvements

Engelhart Settlement

Figure 27 - F

City of Madison,
Dane County, Wisconsin

N

Seven Nations Dr
Salem Dr
Rimrock Rd
Maloney Dr
Diving Hawk Trl
Lone Eagle Dr
Warner St
Warner Ln
Fell Rd
Engelhart Dr
Spear Cir
Settlement Dr
Geronimo Cir
Artesian Ln
Burroughs Dr
Braeger Dr

New 18" Pipe
Length: 321'
U/S IE: 888.5'
D/S IE: 878.75'

New 15" Pipe
Length: 197'
U/S IE: 895'
D/S IE: 888.75'

New 12" Pipe
Length: 369'
U/S IE: 907'
D/S IE: 895.25'

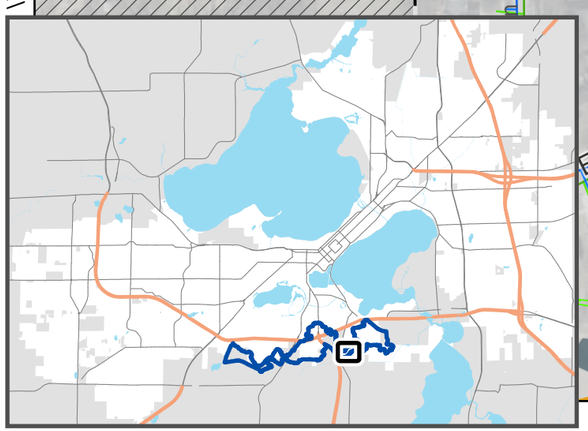
New 27" Pipe
Length: 643'
U/S IE: 878'
D/S IE: 867.7'

Upsize to 36" Pipe
Length: 180'
U/S IE: 866.95'
D/S IE: 861.1'

Upsize to 36" Pipe
Length: 98'
U/S IE: 861.1'
D/S IE: 859.1'

Upsize to 38"x60" Elliptical Pipe
Length: 339'
U/S IE: 859.1'
D/S IE: 857.32'

Upsize to 38"x60" Elliptical Pipe
Length: 113'
U/S IE: 857.32'
D/S IE: 857.04'



Stormwater System
- Storm Pipe
- Abandoned Storm Pipe
- Inlet
- Apron End
- Access

Water System
- Water Main/Service
- Valve
- Hydrant

Sanitary System
- Access
- Sanitary Main
- Lateral
- MMSD Access
- MMSD Main

- Model Area Outside Madison
- Railroad
- Park
- City of Madison Ponds/Greenways
- Waterbody

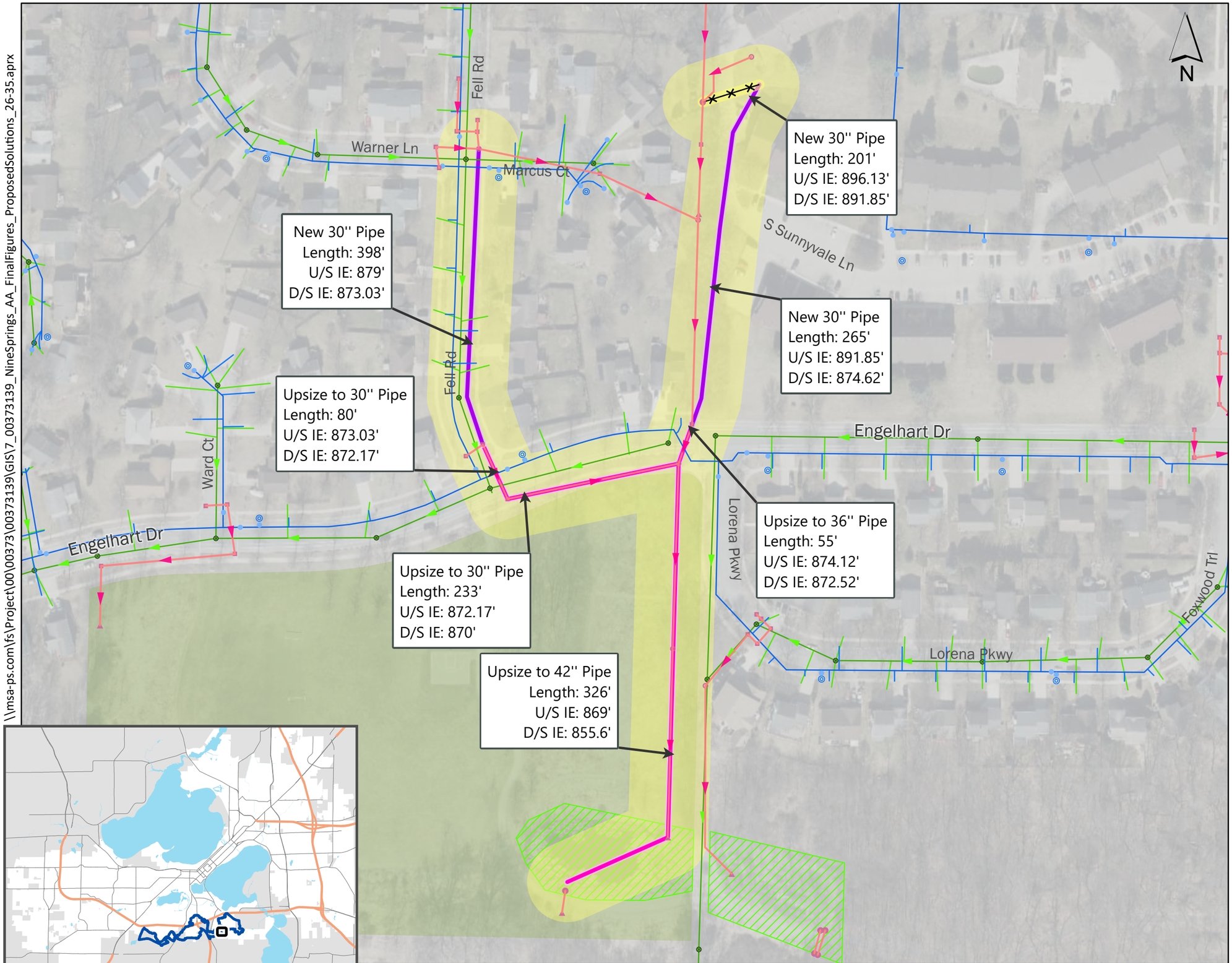
Proposed Storm Improvement
- Upsize
- New

0 55 110 220 Feet

CITY OF MADISON ENGINEERING

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Storm System Improvements

Fell Road

Figure 27 - G

City of Madison,
Dane County, Wisconsin

Stormwater System
- Storm Pipe
- Inlet
- Bend
- Apron End
- Access

Water System
- Water Main/Service
- Valve
- Hydrant

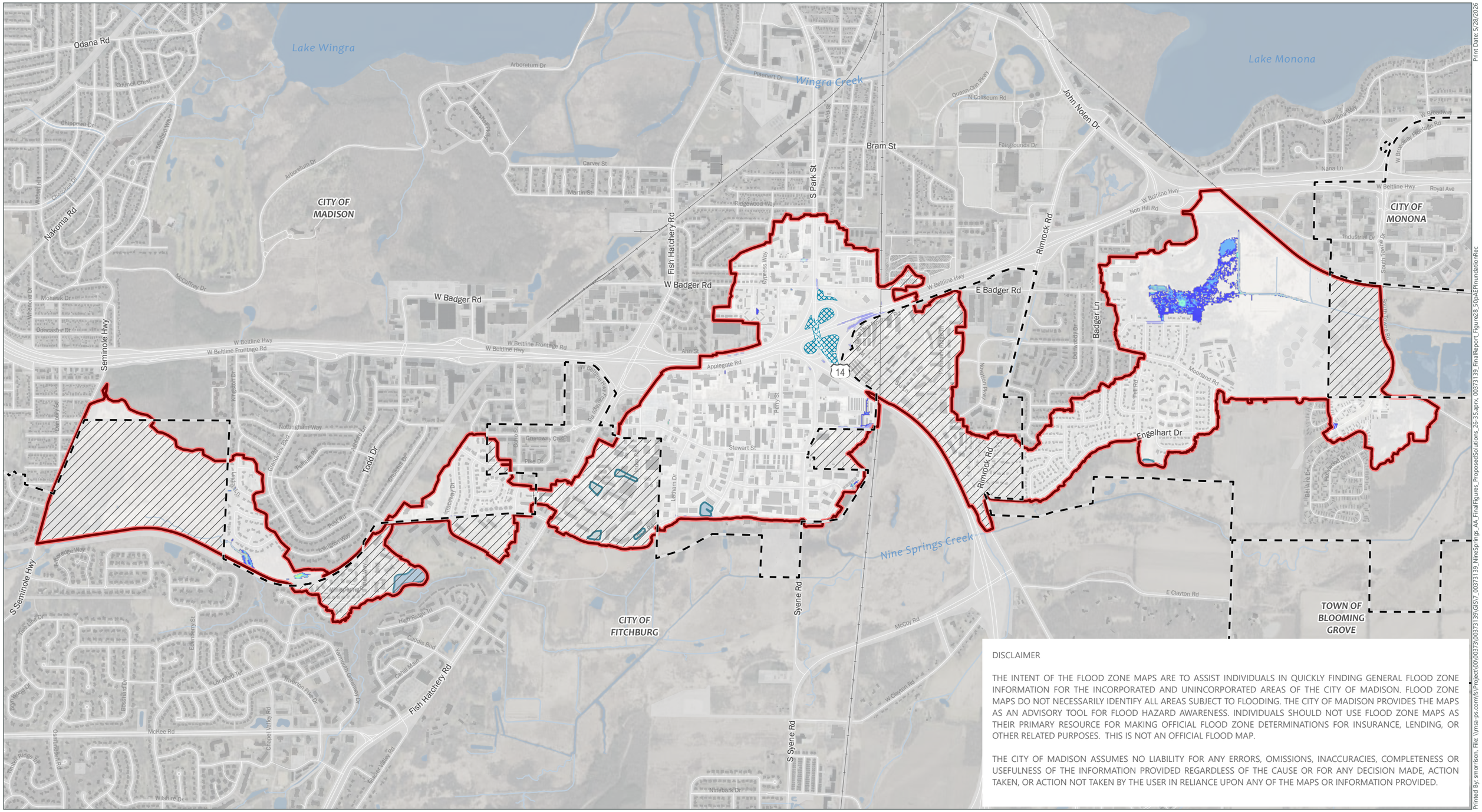
Sanitary System
- Access
- Sanitary Main
- Lateral

- Model Area Outside Madison
- Railroad
- Park
- City of Madison Ponds/Greenways
- Waterbody

Proposed Storm Improvement
- Upsize
- New
- Removal

0 30 60 120 Feet

CITY OF MADISON ENGINEERING



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MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

- Model Area
- Municipal Boundary
- Model Area Outside Madison
- Building Footprint
- Rivers and Streams
- Lakes and Ponds
- Modeled Inactive Area
- Modeled Stormwater Pond

Flood Event Inundation Depth

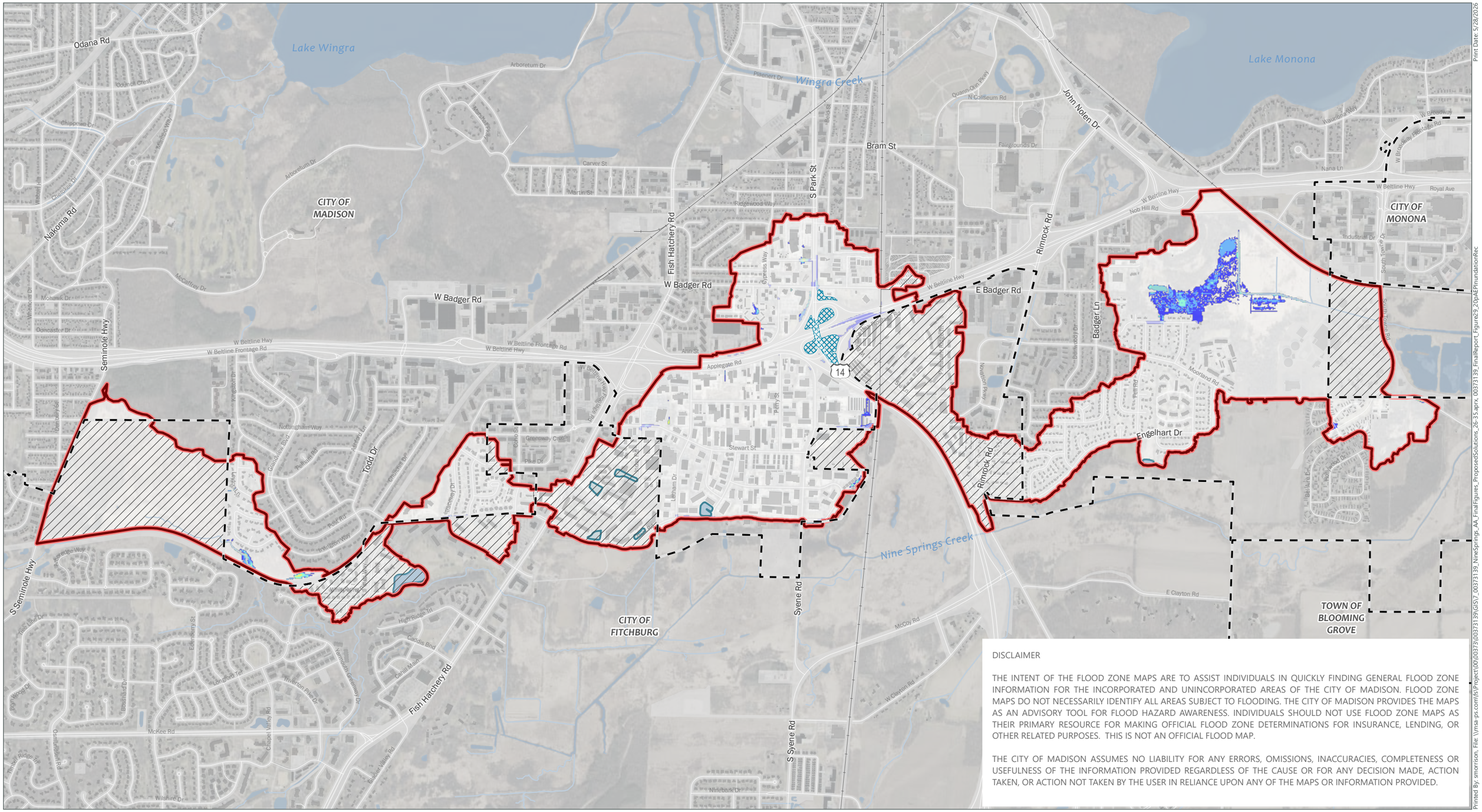
- 0.1 - 0.3
- 0.3 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 6
- 6.1+

50% AEP Inundation - Recommended Conditions

FIGURE 28
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

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MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

- Model Area
- Municipal Boundary
- Model Area Outside Madison
- Building Footprint
- Rivers and Streams
- Lakes and Ponds
- Modeled Inactive Area
- Modeled Stormwater Pond

Flood Event Inundation Depth

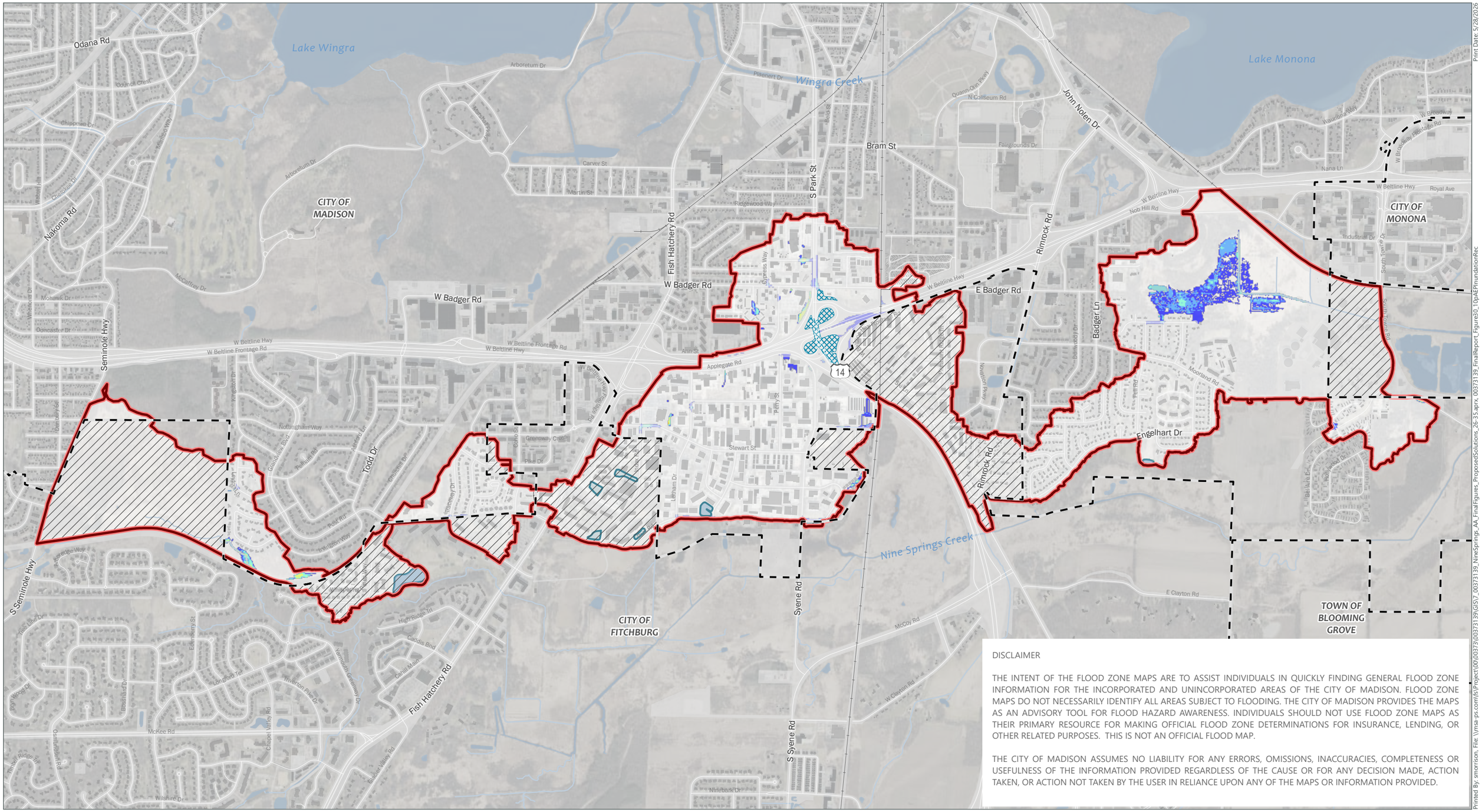
- 0.1 - 0.3
- 0.3 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 6
- 6.1+

20% AEP Inundation - Recommended Conditions

FIGURE 29
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

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MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

- Model Area
- Municipal Boundary
- Model Area Outside Madison
- Building Footprint
- Rivers and Streams
- Lakes and Ponds
- Modeled Inactive Area
- Modeled Stormwater Pond

Flood Event Inundation Depth

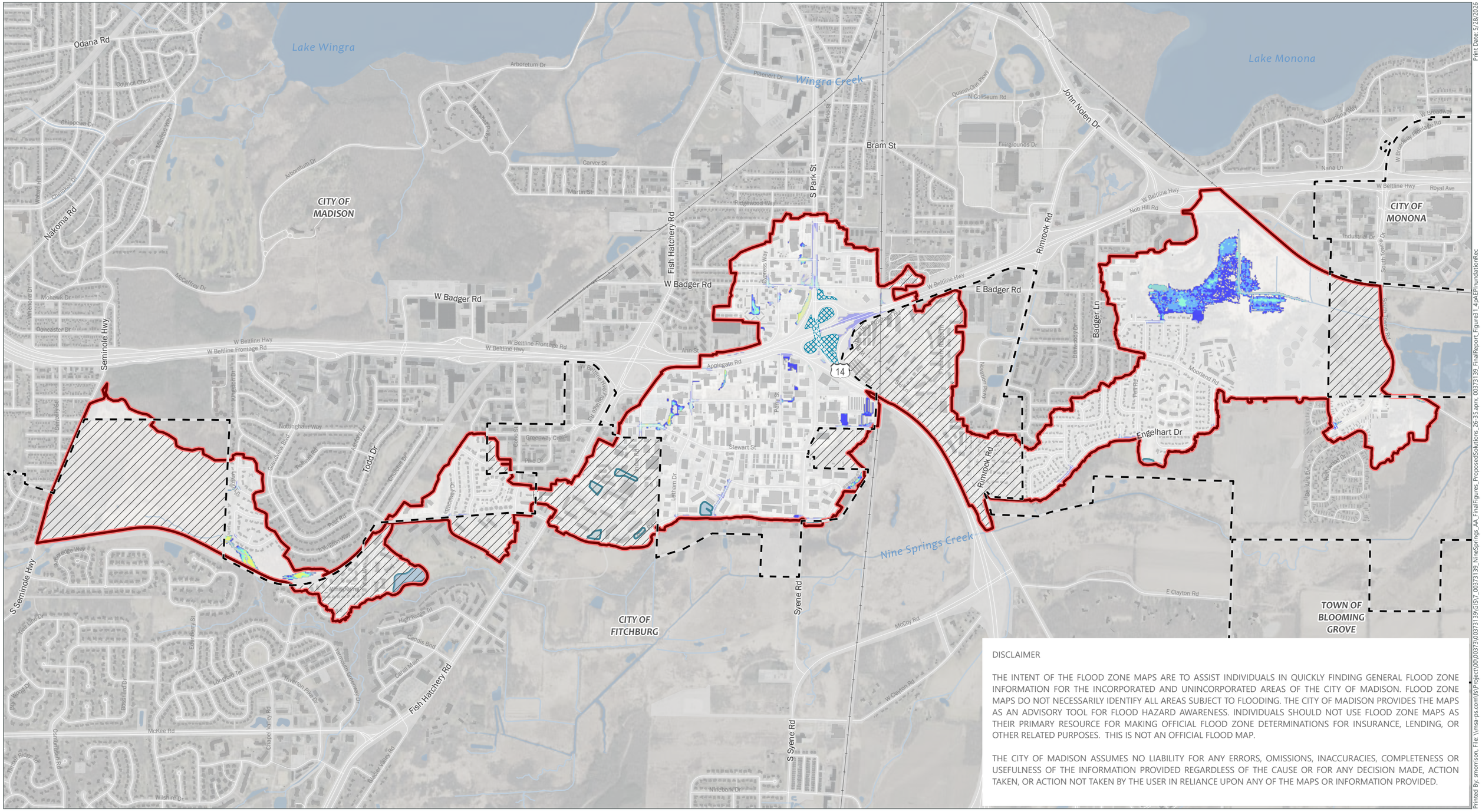
- 0.1 - 0.3
- 0.3 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 6
- 6.1+

10% AEP Inundation - Recommended Conditions

FIGURE 30
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

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MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

- Model Area
- Municipal Boundary
- Model Area Outside Madison
- Building Footprint
- Rivers and Streams
- Lakes and Ponds
- Modeled Inactive Area
- Modeled Stormwater Pond

Flood Event Inundation Depth

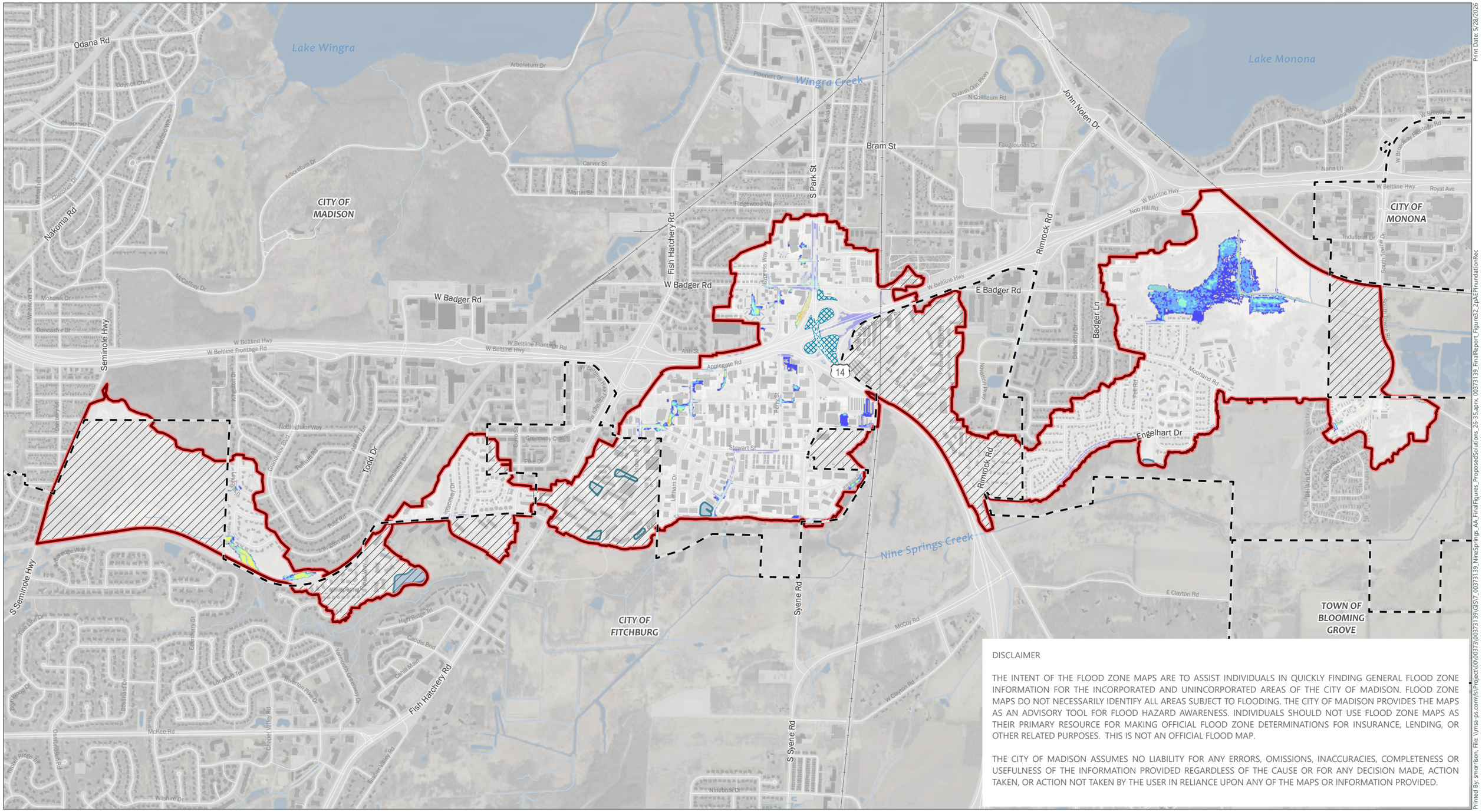
- 0.1 - 0.3
- 0.3 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 6
- 6.1+

4% AEP Inundation - Recommended Conditions

FIGURE 31
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

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MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

- Model Area
- Municipal Boundary
- Model Area Outside Madison
- Building Footprint
- Rivers and Streams
- Lakes and Ponds
- Modeled Inactive Area
- Modeled Stormwater Pond

Flood Event Inundation Depth

- 0.1 - 0.3
- 0.3 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 6
- 6.1+

2% AEP Inundation - Recommended Conditions

FIGURE 32
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

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Lake Wingra
Lake Monona
Wingra Creek
Nine Springs Creek
CITY OF MADISON
CITY OF MONONA
CITY OF FITCHBURG
TOWN OF BLOOMING GROVE
Odana Rd
Arboretum Dr
Carver St
Martin St
Ridgewood Way
Bram St
S Park St
Fish Hatchery Rd
W Badger Rd
E Badger Rd
Badger Ln
Rimrock Rd
John Nolen Dr
N Coliseum Rd
Fairgrounds Dr
W Beltline Hwy
W Beltline Frontage Rd
Nob Hill Rd
Nakoma Rd
Seminole Hwy
McCaffrey Dr
Mohawk Dr
Doncaster Dr
Kingston Dr
Nottingham Way
Todd Dr
Greenway Cross
Pike Dr
Stewart St
Applegate Rd
Ann St
Odana Hills Rd
Oxbow Way
Engelhart Dr
Moorland Rd
Industrial Dr
Royal Ave
Nana Ln
Waunona Way
W Broadway
W Broadway Frontage Rd
Novation Pkwy
Didier Way Dr
Pflaum Rd
Post Rd
Todd Dr
Ellis St
Echo St
Patty St
Bold St
Quann Gun Pkwy
Plaenert Dr
Marshall Pkwy
Council Crest
Chippewa Dr
Wexford Way
Wexford Hill
Chamokasa Dr
Whitehall Dr
Dorothy Ct
Kenwood Dr
Jamestown Rd
Greenbush Blvd
Whitcomb Dr
Inkstone Way
Whitcomb Ct
Tillicum Dr
Latham Dr
Rimrock Rd
Syene Rd
S Syene Rd
E Clayton Rd
W Clayton Rd
McCoy Rd
Nine Springs Trail
Ninebark Dr
S Seminole Hwy
Tree Line Dr
Edenbury St
Bent Wood Dr
Brookland Dr
Longford Ter
Riverton Pike Dr
Yarmouth Greenway Dr
Cahill Main
Gaddis Bnd
High Ridge Trl
Timber Ridge Trl
Osmundson Rd
Chapel Valley Rd
Badura Valley Rd
McKee Rd
Wilshire Dr
Whitcomb Ct
Ivy Ln
Ivy Rd
Hollywood Dr
Ibis Ln
Ibis Ct
Ibis Dr
Sunset Terrace Rd
South Towne Dr
Oxbow Way
Quann Gun Pkwy
Novation Pkwy
Didier Way Dr
Pflaum Rd
Post Rd
Todd Dr
Ellis St
Echo St
Patty St
Bold St
Quann Gun Pkwy
Plaenert Dr
Marshall Pkwy
Council Crest
Chippewa Dr
Wexford Way
Wexford Hill
Chamokasa Dr
Whitehall Dr
Dorothy Ct
Kenwood Dr
Jamestown Rd
Greenbush Blvd
Whitcomb Dr
Inkstone Way
Whitcomb Ct
Tillicum Dr
Latham Dr
Rimrock Rd
Syene Rd
S Syene Rd
E Clayton Rd
W Clayton Rd
McCoy Rd
Nine Springs Trail
Ninebark Dr
S Seminole Hwy
Tree Line Dr
Edenbury St
Bent Wood Dr
Brookland Dr
Longford Ter
Riverton Pike Dr
Yarmouth Greenway Dr
Cahill Main
Gaddis Bnd
High Ridge Trl
Timber Ridge Trl
Osmundson Rd
Chapel Valley Rd
Badura Valley Rd
McKee Rd
Wilshire Dr
Whitcomb Ct
Ivy Ln
Ivy Rd
Hollywood Dr
Ibis Ln
Ibis Ct
Ibis Dr
Sunset Terrace Rd
South Towne Dr
14

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MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

- Model Area
- Municipal Boundary
- Model Area Outside Madison
- Building Footprint
- Rivers and Streams
- Lakes and Ponds
- Modeled Inactive Area
- Modeled Stormwater Pond

Flood Event Inundation Depth
- 0.1 - 0.3
- 0.3 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 6
- 6.1+

1% AEP Inundation - Recommended Conditions

FIGURE 33
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

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MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

- Model Area
- Municipal Boundary
- Model Area Outside Madison
- Building Footprint
- Rivers and Streams
- Lakes and Ponds
- Modeled Inactive Area
- Modeled Stormwater Pond

Flood Event Inundation Depth

- 0.1 - 0.3
- 0.3 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 6
- 6.1+

1% AEP Long Inundation - Recommended Conditions

FIGURE 34
Nine Springs Watershed Study Report

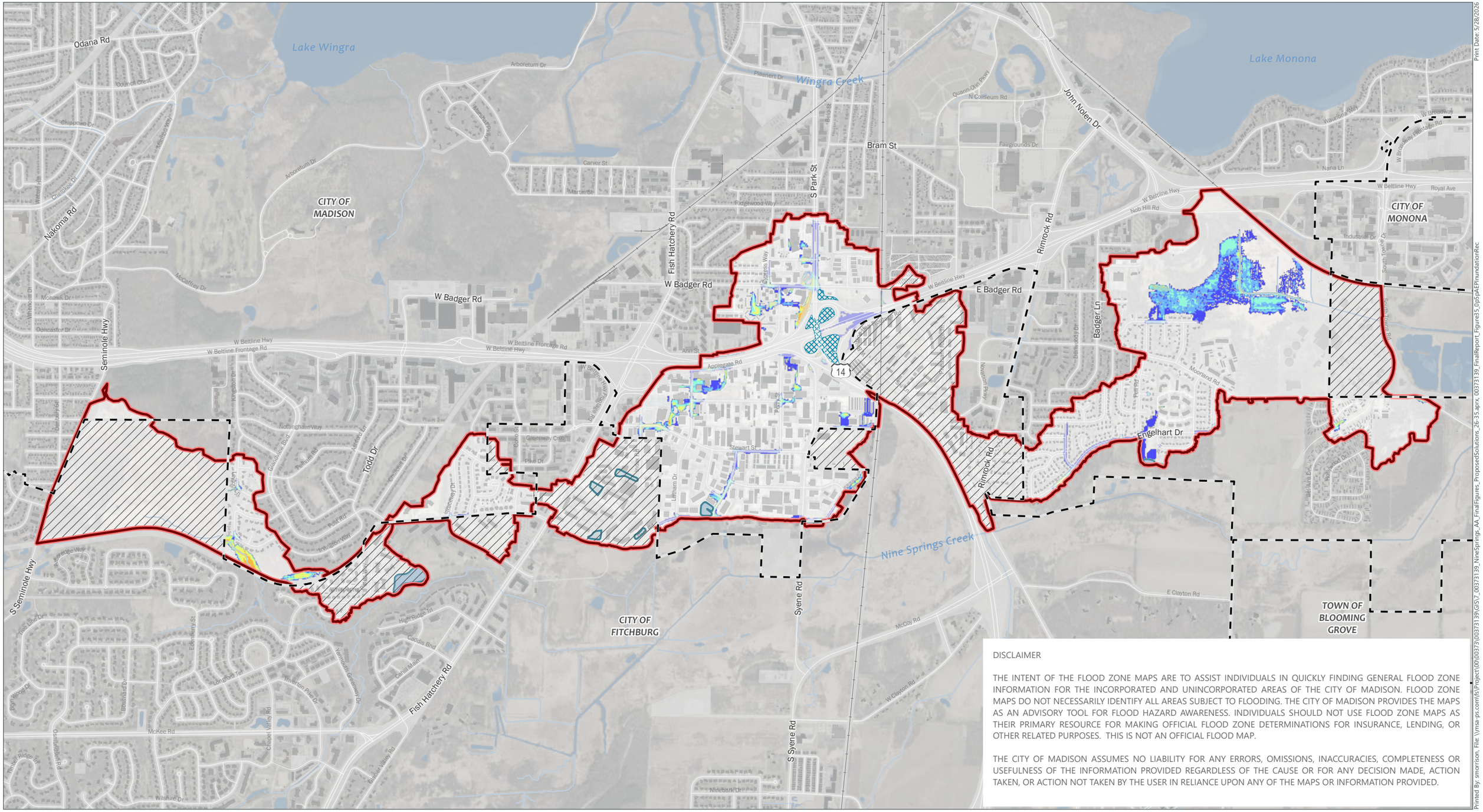
City of Madison
Dane County, WI

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MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

- Model Area
- Municipal Boundary
- Model Area Outside Madison
- Building Footprint
- Rivers and Streams
- Lakes and Ponds
- Modeled Inactive Area
- Modeled Stormwater Pond

Flood Event Inundation Depth

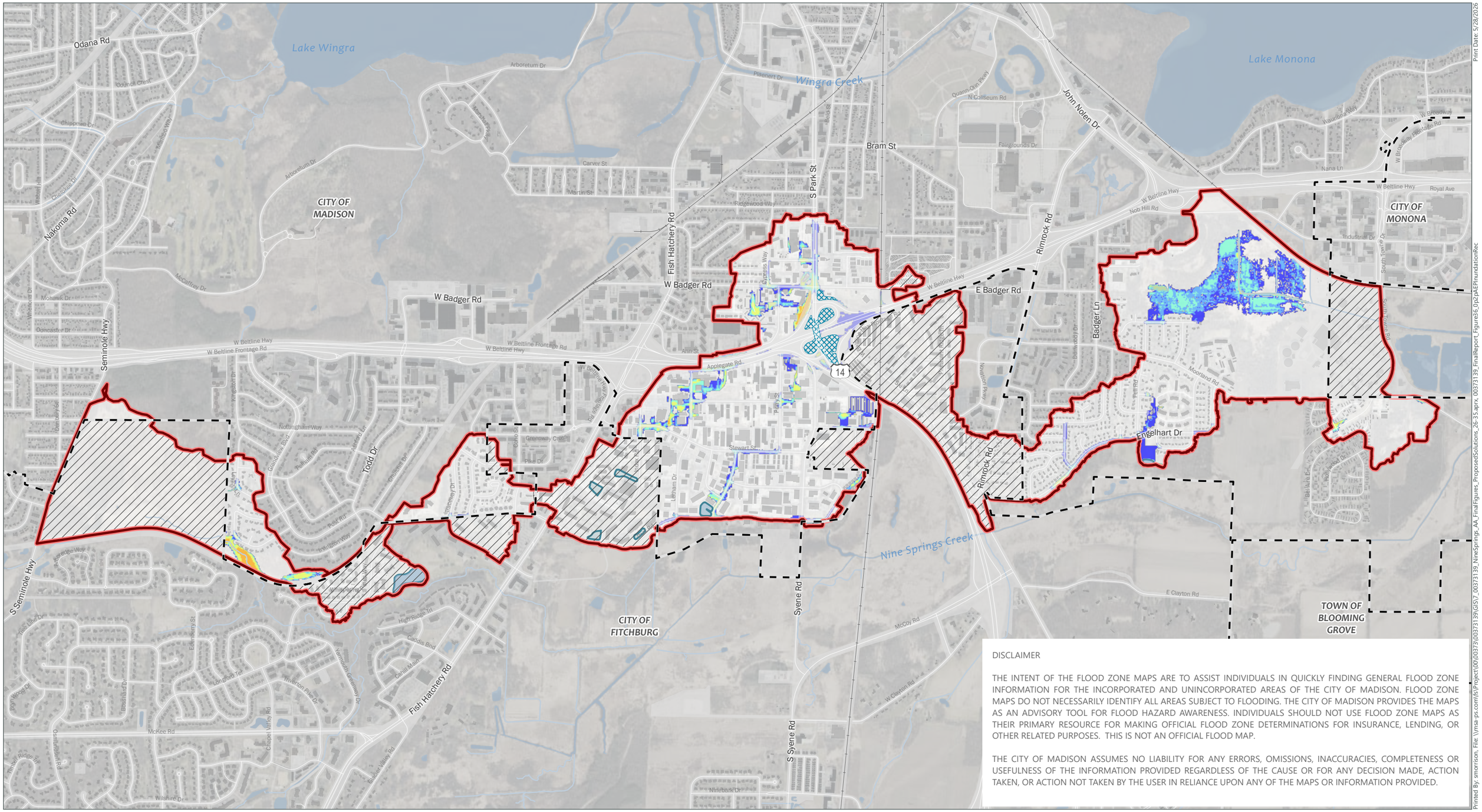
- 0.1 - 0.3
- 0.3 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 6
- 6.1+

0.5% AEP Inundation - Recommended Conditions

FIGURE 35
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

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MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

0 0.25 0.5 Miles

- Model Area
- Municipal Boundary
- Model Area Outside Madison
- Building Footprint
- Rivers and Streams
- Lakes and Ponds
- Modeled Inactive Area
- Modeled Stormwater Pond

Flood Event Inundation Depth

- 0.1 - 0.3
- 0.3 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 6
- 6.1+

0.2% AEP Inundation - Recommended Conditions

FIGURE 36
Nine Springs Watershed Study Report

City of Madison
Dane County, WI

Print Date: 5/28/2026
Printed By: smorrison; File: \\msa-ps.com\fs\Project\00\00373\003731139\GIS\Y_003731139_NineSprings_AA_FinalFigures_ProposedSolutions_26-35.aprx, 003731139_FinalReport_Figure36_0p2pAEPInundationRec

Appendix A. Modeling Guidance

MODELING GUIDANCE

Version 2024_02_19 (DRAFT)

Version Revision	Purpose	Changes	Author
V2024_02_19	Issued round 7 RFP (Nine Springs)	Added Item 10.c. under "Modeling Parameters"	RSS

Round 7 Watershed Studies

The City recognizes that an important aspect of modeling is professional judgement; and it will be up to the Consultant to appropriately define parameters, variables, and methodology. However, it is in the City's best interest to have relative uniformity amongst City models. This guidance document was developed to provide uniformity. Where inputs and assumptions differ from those outlined in this document, the Consultant will be expected to justify and document the differences and reasons for the differences.

The purpose of the watershed modeling is to construct planning-level models of the watershed to identify locations with significant conveyance system deficiencies. The identified solutions will be conceptual solutions, not design-level solutions.

City of Madison Flooding Level of Service Goals

1. 10-year design storm event:
    a. No surcharging onto the street for up to the 10-year design storm; water shall be contained within the pipes and structures.
        i. When using rain-on-grid hydrology, the goal is met if there is less than 0.25' of curb depth using the FHA method.
    b. There are locations within the City where low points exist that pond water; these low points are excluded from this goal and will be addressed as streets are redesigned.
    c. For locations limited by known inlet capacity, allow no more than 0.5 feet of water above storm sewer inlet rim.
2. 25-year design storm event:
    a. Street to remain passable for emergency vehicles during 25-year design storm.
        i. This is defined as no more than 0.5 feet of water on the centerline of the street for a length of 100-feet using the depth raster.
        ii. To define the centerline of street, the County's centerline data (Dane County SDE – GISdw.DCL.RoadCenterline) should be used.
    b. Note that the Watershed Study modeling approach will not explicitly account for cross flow conditions where more gutter flow on one side of the street can overtop the crown.
3. 100-year design storm event:
    a. No home or business will be flooded during the 100-year design storm.
        i. This is defined as no more than 0.5 feet of water at the 5-foot buffer around a structure.
    b. Enclosed depressions to be served to the 100-year design storm (which can include safe overland flow within street, easements, greenways or other public lands).
        i. For purposes of the watershed studies, enclosed depressions are defined as depressions in public right-of-way where stormwater needs to reach private property to overflow from the depression.
        ii. Solutions will also be developed for enclosed depressions where the stormwater collected is solely from private property. In these cases, the solutions may be implemented thru public-private cooperation or solely by the private property owners.
    c. Greenway crossings at streets to be served to the 100-year design storm.
4. 500-year design storm event:
    a. Safely convey stormwater; i.e. limited impact on private property.

    b. Limited impact is defined as no more than 0.5 feet of water at the 5-foot buffer around a structure.
5. Provide flooding solutions that do not negatively impact downstream properties.

Due to the inherent variability and complexity of stormwater conveyance systems, it is understand it may not be practical to meet the above level of service goals in all areas of the City.

Guidance for Solutions

1. For the purpose of the watershed studies "deficiencies" in the system shall be defined as existing infrastructure, drainage capacity, or system limitations that fail to meet the goals stated in 1-5 above.
2. Watershed deficiencies will be reviewed, and solutions will be provided up to, the 100-yr design storm.
3. In areas where flooding occurs in events exceeding the 100-year storm, those areas will not be prioritized for engineering solutions, but will be identified in existing conditions model for 500-year event storms.
4. Proposed solutions will be identified for only the publicly owned drainage system.
5. Drainage issues that are private (water from the public infrastructure such as streets, greenways, ponds and/or easements is not the cause of the drainage issue) will not require modeling solutions but should be noted, where possible, in the existing conditions analysis so staff may work with property owners if necessary. (See Also Hydraulics section of Modeling Guidance for discussion on private system existing conditions modeling.)

Emergency Vehicle Allowable Flood Depths (email from Fleet on 5/12/2020)

1. SUVs – up to 6-inches
2. Large Trucks – up to 3-feet
3. Ambulances, vans, and pick-up trucks – between 6-inches and 3-feet

MODELING PARAMETERS:

Initial model parameters are the following items:

1. Include storm sewers and culvert segments for the trunk line drainage system and major conveyance to that system. Additional conveyance components may be included if felt necessary by the modeler to understand the conveyance system drainage.
2. Inlet capacity will not be included in the model. It is assumed that sufficient inlets are present accommodate stormwater. In areas where there is known chronic flooding that has been reported to Engineering, additional detail may be requested.
3. Incorporate significant existing storm water management facilities (public and private) into the model.
4. Subdivide provided outfall basins into smaller watersheds as needed in order to properly execute the model.
5. Coordinate System and Vertical Datum
    a. Horizontal Coordinate System: NAD 1983 HARN WISCRS Dane County Feet (WKID 103412).
    b. Vertical Datum: NAVD88 (pre 2007 adjustment) ft (City of Madison Datum + 845.6)
    c. Various data sources have different horizontal and vertical datums, check datum for each data source prior to use.
    d. When setting up PC-SWMM Models, the default coordinate system that looks like it matches the City's preferred coordinate system is not the same. PC-SWMM's default coordinate system is State Plane and the exact coordinate system the City uses is not in PC-SWMM's database. To create a PC-SWMM model with the same coordinate system:
        i. Open up a new, blank model.
        ii. Add one of the City's shapefiles with the preferred coordinate system.
        iii. Then, in PC-SWMM, select that coordinate system as the default.
6. Monitoring Data Time Zone: Different sources of monitoring data use different time zones. Also,

some adjust for daylight savings time whereas others do not. When using the monitoring data, check both the time zone and if the data is adjusted for daylight savings time.

7. Monitoring Data Review: Familiarize yourself with the location of the monitoring gage at each site. Also, visit the monitoring site following a rain event to review the site conditions for things that would impact the measurements. For example, is there debris clogging anything?
8. Naming convention
    a. Names are limited to 20 characters where possible. Both PC-SWMM and XP-SWMM can take lengthy names but both indicate shorter is better for avoiding truncating names.
    b. Subcatchments:
        i. Begin with Subcatchments naming convention provided by the City in the Outfall Basin feature class.
            1. Add a three-digit designator to the end of the name, beginning with 000
            2. As subcatchments are subdivided, increase the added designator by 1.
            3. Example: ME04-A-0014-H *(Provided by City)* → ME04-A-0014-H-MAD-C-000 *(For the original basin)* → ME04-A-0014-H-001 *(For first subdivision)*
        ii. Final outfall basin feature class file, including supporting files used to compute runoff timing and volume parameters shall be part of the deliverables provided to the City of Madison.
        iii. Note first downstream stormwater control practice as attribute in subcatchment feature class.
    c. Structures and Junctions:
        i. Node (Junction/Storage/Outfall) names for existing structures shall retain the asset identification provided by the City.
        ii. Proposed Structure names are to be determined by the Consultant but shall be given a “logical” name that reflects general location, function, or other.
        iii. For junctions that need to be added that are storm sewer tees as constructed, use the downstream manhole / structure with “_01” added in increasing order moving from downstream to upstream. For example, the first junction added for a tee upstream of MI3350-001 would be MI3350-001_01
    d. Pipes:
        i. Conduit names for existing pipes shall retain the asset identification provided by the City, except that:
            1. The first two letters (i.e AE, IN, etc) can be removed
            2. Leads with an asset ID that takes up all 20 characters can be shortened to the corresponding assigned ID. For example, IN3350-032_AS3350-007_3350-001 can be changed to 3350-032_3350-001_001
        ii. Proposed Pipe names are to be determined by the Consultant but shall be named in a manner similar to the City pipe naming convention, which includes the upstream and downstream structure names.
    e. Channel/Street Flow Segments:
        i. Conduit names for drainage-ways shall be named in a manner that identifies the greenway segment it represents by Greenway Node Number and the distance from the upstream end. Example: GR7541-062_125 would represent a channel segment that begins 125 feet into the North Door Creek Greenway – Sprecher Road Section.
        ii. Conduit names for streets shall be named with “Rd_”[US_Node_Name]_[DS_Node_Name] and remove the first two letters in the node name similar to how pipes are named.
    f. Natural Channels:
        i. Natural channel transects shall be named with the same ID as the conduit name.
        ii. Street models as natural channels shall be named in a manner that is easily identifiable for the street or street type it represents.
        iii. A shapefile shall be created documenting where natural channel transects are cut.
    g. Other SWMM Features (Weirs, orifices, etc)
        i. Other SWMM features shall have readily identifiable names corresponding to the type of feature they are trying to model. For example, an orifice for a detention

pond should have an ID that is "<Detention Pond ID>_ORIF_01", keeping within a 20 character limit.

h. Ponds
    i. Use the pond name identifier from GT-Viewer combined with a common name. For example, the ponds at Odana Hills Golf Course would be "PD3461-001_OdanaHills"
    ii. Use abbreviation of name if unofficial full name creates a model name longer than 20 characters.

i. Non-City owned infrastructure
    i. Consultant may choose name if consistent naming convention is not created by entity that owns infrastructure
    ii. If Consultant chooses name, all infrastructure owned by another entity shall start with the same few characters. For example, DOT infrastructure could all start with "DOT-" or Fitchburg owned infrastructure could start with "Fit-"

9. Data Notation

The GIS data describing the conveyance system is not complete. In some instances the modeler will be able to make assumptions based on available data. In other locations, the data will require survey. The City is tracking the accuracy of the data with the ultimate goal of having a complete record.

When the modeling is creating the GIS data describing the structures and pipes, they shall create a new attribute in their GIS data and categorize the data as the following:

a. Structures:
    - Source_IE
    - Source_Rim

b. Pipes:
    - Source_ToIE
    - Source_FromIE

c. Private:
    - Notes

d. Source –enter Number and text in bold in attribute
    0. **Converted:** legacy EI's taken from the structure, all EI's received the structures outgoing EI by default when converted in 2020. *This does not mean this data is ****better***** than the survey data, if it looks suspect, you should investigate and try to clarify the source (especially for pre-2005 data, or structures/pipes within ponds/gwys)*
    1. **Survey:** Survey data (current)
    2. **AsBuilt >2004:** As-Builts (2005-present) since City used GPS-Survey Grade to set control improving consistency citywide
    3. **AsBuilt pre-2005:** As-Builts (pre-2005)
    4. **ConstPlan**: Construction plans
    5. **GTV**: GTV in-line text, no plans to support
    6. **Interpolate:** interpolated (saddled structure had inverts on either side and interpolated—should eventually be surveyed)
    7. **Inferred:** best guess, (can't get survey now or is pulled from LiDAR, but should eventually be surveyed)
    8. **No data:** Needs survey (searched and unable to find—should eventually be surveyed, but a higher priority)

e. When creating a model, Engineers will verify/update:
    i. Structures:
        - Source_IE
        - Source_Rim
        - Project_No
    ii. Pipes:
        - Source_ToIE
        - Source_FromIE
        - Project_No

iii. Private:
- Notes
  - PLP_address
  - GTV
  - Survey (survey will need to confirm all fields)

10. Rainfall
    a. MSE4 24-hour Distribution and NOAA Atlas 14 Depths

Recurrence Interval (years)	Rainfall Depth (inches)
1	2.49
2	2.84
5	3.45
10	4.09
25	5.02
50	5.74
100	6.66
200	7.53
500	8.94

    b. Long-Duration Storm – Two 24-hour, 100-year MSE4 storm events with the time between peak rainfalls shorted from 24 hours to 12 hours.
    c. When using the MSE Rainfall distribution the timestep used for representing the distribution within the model shall be 0.1 hours (or 6 minutes).

11. Hydrology (SWMM Method with Horton Infiltration) (References: A, B, C, J, L)
- Parameters listed are default parameters and may need to be adjusted based on calibration data.

    a. Subcatchment Detail for Street Drainage
        i. Contributing area to the existing storm sewer system that is to be modeled (Determined on a watershed by watershed basis)
    b. SWMM Routing Parameters (if calibration is not available to adjust parameters)
        i. Percent Impervious:
            1. In areas where impervious areas are delineated:
                a. Use impervious/Pervious areas from City provided feature class.
            2. In areas where Impervious areas are not delineated:
                a. Use City provided WinSLAMM land use file and the "HowTo_CalculateCN" Document.
                b. Areas not delineated in City Provided WinSLAMM land use file shall defer to Dane County Land Use Map.
                c. Match WinSLAMM land uses with Dane County Land Use.
            3. Note: The City had a set of surface cover data built off the 2018 ortho image. The deliverables from Task 4 are the easiest to utilize in models. The impervious type is defined in a domain and to use it you may need to "Export a table to include domain descriptions and coded values"
        ii. DCIA
            1. In areas where impervious areas are delineated:
                a. Use impervious/Pervious areas from City provided feature class.
            2. In areas where Impervious areas are not delineated:
                a. Reference WinSLAMM Standard Land Use DCIA Spreadsheet
        iii. Width – Estimated based on subcatchment shape. Estimation methodology shall be documented.
        A single width shall be calculated for the entire subcatchment and used for all three sub-areas.

It is expected Width is one of the first calibration parameters for peak flow.

iv. Slope – Computed manually or estimated based on LiDAR. Computation or estimation methodology shall be documented.

v. In XP-SWMM, each subcatchment is to be split into area of (1) DCIA, (2) non-DCIA, and (3) pervious area. Within the model, the non-DCIA shall be routed to the pervious area.

vi. In PC-SWMM, indicate the percent being routed to pervious in the subcatchment attribute.

c. Horton Infiltration

i. For typical urban pervious area (Based on range of values for different soil types, moisture conditions, and vegetation conditions found in Reference A):

HSG Group[a]	Max Infil. Rate (in/hr)	Min Infil. Rate (in/hr)	Decay Rate (1/hr)	Dry Days[b]	Maximum Infiltration Volume (in)
A	4.0	1.0	4.0	3.1	
B	2.0	0.5	4.0	4.4	
C	1.0	0.2	4.0	7.0	
D	0.5	0.1	4.0	9.9	
Water	0	0	0	0	

[a]For HSG listed as A/D, B/D, C/D, the default approach will be to assume the HSG associated with the lower infiltration rate (HSG D).

[b]Use equation 4-12, pg 99, SWMM Reference Manual Volume 1 – Hydrology (Revised), January 2016

ii. Impervious Manning's n – 0.016

iii. Pervious Manning's n – 0.20

iv. Depression Storage for Impervious – 0.05 inches

v. Depression Storage for Pervious – 0.15 inches

vi. Zero Depression Storage – 25 percent

vii. Factors for adjusting (L)

1. Forest – Multiply max and min infiltration rates by 2.
2. Farmland (row crops) – Multiply max and min infiltration rates by 1.2.
3. Farmland (close crops) - Multiply max and min infiltration rates by 1.8.
4. Other land uses – discuss with City staff

viii. Area-weight the Horton Infiltration parameters for each subcatchment based on the area of each soil type within a subcatchment. Remove impervious area from area-weighting.

ix. It is understood the NRCS/SCS updates the soil mapping at various times. The project teams will identify a date the soils data will be downloaded and that will be the data used for the duration of the project.

d. Evaporation: Turn off evaporation from calibration and design storm event runs.

12. Hydrology (SCS CN Hydrology – ONLY USE WHERE DESIGNATED BY CITY) (References B, K)

a. Runoff Curve number, Percent Impervious, Directly Connected impervious Area

i. In areas where impervious areas are delineated:

1. Use impervious/Pervious areas from City provided shapefile.
2. Impervious areas shall use a runoff curve number of 98.
3. Urban pervious areas that are mowed and maintained can assume the area is Open Space in good condition listed in Table 4-9 of Reference B.
4. All other pervious land uses shall match descriptions listed in Table 4-9 of Reference B.
5. Create a composite subbasin runoff curve number that incorporates both impervious and pervious areas.

ii. In areas where Impervious areas are not delineated:

1. Use City provided WinSLAMM land use file and the "HowTo_CalculateCN" Document.
2. Areas not delineated in City Provided WinSLAMM land use file shall defer

to Dane County Land Use Map.
3. Match WinSLAMM land uses with Dane County Land Use and repeat item "i." of this section.
4. Impervious areas shall use a runoff curve number of 98.
5. Urban pervious areas that are mowed and maintained can assume Open Space in good condition listed in Table 4-9 of Reference B.
6. All other pervious land uses shall match descriptions listed in Table 4-9 of Reference B.
7. Create a composite subbasin runoff curve number that incorporates both impervious and pervious areas.

b. Routing Parameters
   i. Width - In PC-SWMM only, Estimated based on subbasin shape. Estimation methodology shall be documented. It is expected that width is one of the first calibration parameters to be adjust for peak flow.
   ii. Slope - In PC-SWMM only, computed manually or estimated based on LiDAR. Computation or estimation methodology shall be documented.
   iii. Time of Concentration - In XP-SWMM only, calculate each watershed time of concentration based on equations listed in SCS Urban Hydrology for Small Watershed, 2nd Ed., (TR-55), June 1986 (Reference K). The max flow length for sheet flow is 75 feet in urban areas and 150 feet in agricultural/natural areas.
   iv. In XP-SWMM and PC-SWMM, the percent impervious shall be zero and the composite runoff curve number shall incorporate impervious and pervious areas.

13. 1D Hydraulics (References: A, B, D, E, F, G)
- Dynamic mode with constant / variable timestep sufficient to model system accurately.
- Conduit lengthening shall not be used unless prior approval from City on reason.
- Parameters are default parameters and may need to be adjusted based on calibration data.
- This list is not intended to be exhaustive.

a. System to be Modeled
   i. Public
      1. Standard: Trunk line and major conveyance components to trunk line.
      2. Process for Exceptions: Provide justification for conveyance components not included.
      3. Use engineering judgement for inclusion of additional detail beyond this standard.
   ii. Private
      1. Standard: Not included
      2. Process for requiring inclusion of private pipes:
         a. Stormwater management detention facilities providing significant detention.
         b. When necessary to understand the functioning of the public system. For example, the West Towne Mall parking lot drainage system.
   iii. Greenways and major surface drainages
   iv. Significant stormwater detention facilities (public and private).
      1. Private systems may be simplified if serving a single site.
      2. Provide justification for detention facilities not included.

b. Loss Coefficients (see drawing at end of document)
   i. Entry
      1. Culverts – Select Inlet Type based on the Help File or HEC-RAS Hydraulic Reference Manual
      2. Storm Sewer (internal at MHs) = 0.05
      3. Storm Drainage Structures (MH) at 45 degree bend = 0.25
      4. Storm Drainage Structures (MH) at 90 degree bend = 0.5
      5. For culverts and entrances to storm sewer from an open channel or pond, both the energy loss coefficient and the inlet control (culvert code) shall be

used.

ii. Exit
    1. Culverts –
        a. Exit closed conduit to open channel = 0.5
        b. Exit closed conduit to lake or pond = 1.0
    2. Storm Sewer (internal at MHs) = 0.05
    3. Storm Drainage Structures (MH) at 45 degree bend = 0.25
    4. Storm Drainage Structures (MH) at 90 degree bend = 0.5

c. Coefficient of Discharge
    i. Weirs
        1. Sharp Crested – 3.0
        2. Roadway embankment – 2.6
        3. Flatter overflow – Use engineering judgment
    ii. Orifices
        1. 0.6

d. Manning's n
    i. Pipes
        1. Concrete Pipe: 0.013
        2. Other n values shall be chosen within generally acceptable ranges.
    ii. Channels
        1. Use Chow's Open Channel Hydraulics, Reference E
    iii. Bank Flow, including developed urban areas
        1. Use Chow's Open Channel Hydraulics, Reference E

e. Transect Placement and Modifiers
    i. Splitting long open channels
        1. Changes in cross section
        2. Significant changes in slope and roughness
        3. Overflow points
    ii. Segment Lengths
    iii. Channel Geometry
    iv. Provide shapefile where natural channel transects are selected along with XS Identifier

f. Tailwater Conditions:
    i. Lake Mendota: one foot over Summer Maximum – 851.10
    ii. Lake Monona: TBD
    iii. Lake Wingra (100-year WSE): 848.0
    iv. Yahara River between Lakes Mendota and Monona: TBD

g. Inlet Clogging Factors
    i. Continuous Slopes
        1. Street slope < 1% - 25% Clogging
        2. Street slope >= 1% - No Clogging
    ii. Sags – 50% Clogging

14. 2D Data (References: A, G, H, I)
    a. Surface Roughness – The average Manning's n may vary by land cover / land use. Referencing TR-55, the following roughness can be used for sheet flow conditions. Choose based on professional judgement and document in the report.
        i. Impervious areas - 0.1
        ii. Turf grass areas - 0.24
        iii. Wooded – 0.4
        iv. Prairie – 0.15
        v. Other – reference TR-55
    b. Channel Roughness - Where the 2D surface experiences channel flow, rather than sheet flow, utilize the Manning's n values for open channels
    c. Impervious Area/Inactive Areas - The City had a set of surface cover data built off the 2018 ortho image. The deliverables from Task 4 are the easiest to utilize in models. The

impervious type is defined in a domain and to use it you may need to "Export a table to include domain descriptions and coded values"

i. Average the roughness within the ROW based impervious and pervious area.

d. Blocked Obstructions – enter roofs as Inactive Areas in XP-SWMM and Obstructions in PC-SWMM
   i. Non-residential – use City impervious area data for roofs
   ii. Residential – use Dane County roof layer
e. Grid cell/mesh size: Use size that balances model run time and sufficient 2D overland flow detail.
f. Grid/mesh orientation: Where possible, align grid/mesh with major channel flow direction. If not practical, then use orientation that minimizes run time.

15. Rain-on-Grid Analysis (Do not use without discussion with City)
    a. Hydrology
    For a full study area Rain-on-Grid model, no nodes or pipes should be active within the Runoff Mode.
       i. Rainfall - All runoff is generated using Rainfall / Flow Area layers. Individual layers shall be created for each rainfall event, with only the applicable one active during each scenario. Rainfall distributions stated above in Section 9 shall be used.
       ii. Landuse – Layers for the following land uses must be created: Buildings, Impervious, Turf Grass, Wooded, Prairie, Water and any other applicable layers. Land use layers for Turf Grass, Wooded, Prairie, and any other pervious land coverage, shall be additionally divided up into Hydrologic Soil Groups A, B, C, and D. These layers should cover the entire study area. Under the Land use data tab, inputs for Manning's Roughness, Rainfall Abstraction, and Infiltration must be completed.
          1. Manning's Roughness:
             a. Buildings – Variable roughness must be used. A Depth-Roughness relationship as follows is appropriate:

Depth (ft)	Roughness
0.00	0.01
0.30	0.01
0.31	0.1
10.0	0.3

             b. Impervious – A constant roughness of 0.016
             c. Turf Grass, Prairie, Wooded, and other Pervious – Variable roughness must be used to account for sheet flow at low flow depths. The consultant shall use roughness coefficients stated above in Sections 10.c and 12.a to develop these roughness curves.
             d. Water – A constant roughness of 0.01.
          2. Rainfall Abstraction:
             a. Buildings and Impervious – Initial Abstraction of 0.04 inches (XP-SWMM Default). Continuing loss should remain 0.0.
             b. Pervious - This shall remain unchecked, as Initial and Continuing losses will be accounted for via the Horton Infiltration parameters.
          3. Infiltration:
             a. Buildings and Impervious – This shall remain unchecked
             b. Pervious – Horton Infiltration as described above in Section 10.c shall be created for each pervious land use layer.
    b. 2D Model Settings
       i. Grid extent shall cover the entire study area.
       ii. Default area type shall be set to Active Area. There should not be any inactive areas within the model.
       iii. Default land use should be set to one of the pervious layers (suggested to use

layer with largest total area). However, this should not have any impact on the modeling if there is full coverage of land use layers.

iv. Head boundaries shall be set anywhere where surface flow is able to leave the study area.

c. 1D Model Network
    i. The 1D storm sewer network shall be extensive enough to include enough inlets throughout the watershed so that surface water can adequately pass from the 2D surface into the 1D model. Multiple inlets at the same location may be combined to a single node. Inlets either side of the street shall remain separate nodes.
    ii. Each inlet node must have Link Spill Crest to 2D checked. Each culvert inlet/outlet must have Link Invert to 2D checked. If calibration shows not enough flow is entering each inlet node, Spill Crest elevations may be lowered below the 2D cell elevation (0.5 ft is an acceptable initial lowering value)
d. 1D/2D Interface Lines at Intersections
    i. In steeper watersheds, the water on the grid may not enter the pipe due to the limitations of the xp2d grid module. Pipes should be reviewed after a simulation for this occurrence. Where this occurs, add 1D/2D interface lines to connect the flow at appropriate intersections to the 1D node.

16. Suggested Proposed Solutions Organization
    a. The Proposed Solutions simulations should be set up in the following way (unless discussed with City staff first). The purpose is to have a model with just the proposed storm sewer improvements, just the regional improvements, and then both.
        i. Add the proposed storm sewer to the Existing Conditions Model as a Scenario.
        ii. Once complete, save the model file with a new name. Add the regional solutions in the Base Scenario, keeping the proposed storm sewer as a scenario.

17. Non-Modeling Data
    a. When utilizing XP-SWMM, provide attributed describing the source of data in the representative GIS feature classes
    b. When utilizing PC-SWMM, also add attributes to the entities describing their data sources.

18. Solutions
    a. Analysis – what are the underlying causes of flooding in:
        i. Areas reported in the “Flood Download” from City staff
        ii. Other flooded areas in the modeling not identified in the “Flood Download”
            1. If more than 10 total areas, work with City staff to prioritize locations to evaluate
        iii. City to identify suggested solutions and provide to Consultant for consideration
        iv. Consultant to identify solutions independently and take lead on overall solutions for watershed
    b. Prioritize Solutions
        i. Property Damage
        ii. Major arterials where emergency vehicles cannot get through
        iii. More criteria - TBD
    c. Displaying solutions/Order of solutions
        i. Show each solution independently and then combined
        ii. Order
            1. Property/pipe owned by Stormwater Utility
            2. Pipe size needed to solve remainder of issues
            3. Other public properties
                a. Janet will provide areas where there are non-starters in Parks
            4. Private properties
        iii. Show structures removed from the 100-yr event

1. Intersect the flood raster with the building outlines
2. Buffer buildings by 5-feet to account for in accuracies of building footprint layer
3. Any building outline that intersects the buildings is considered "flooded" if depth of intersection is 6 inches or greater.

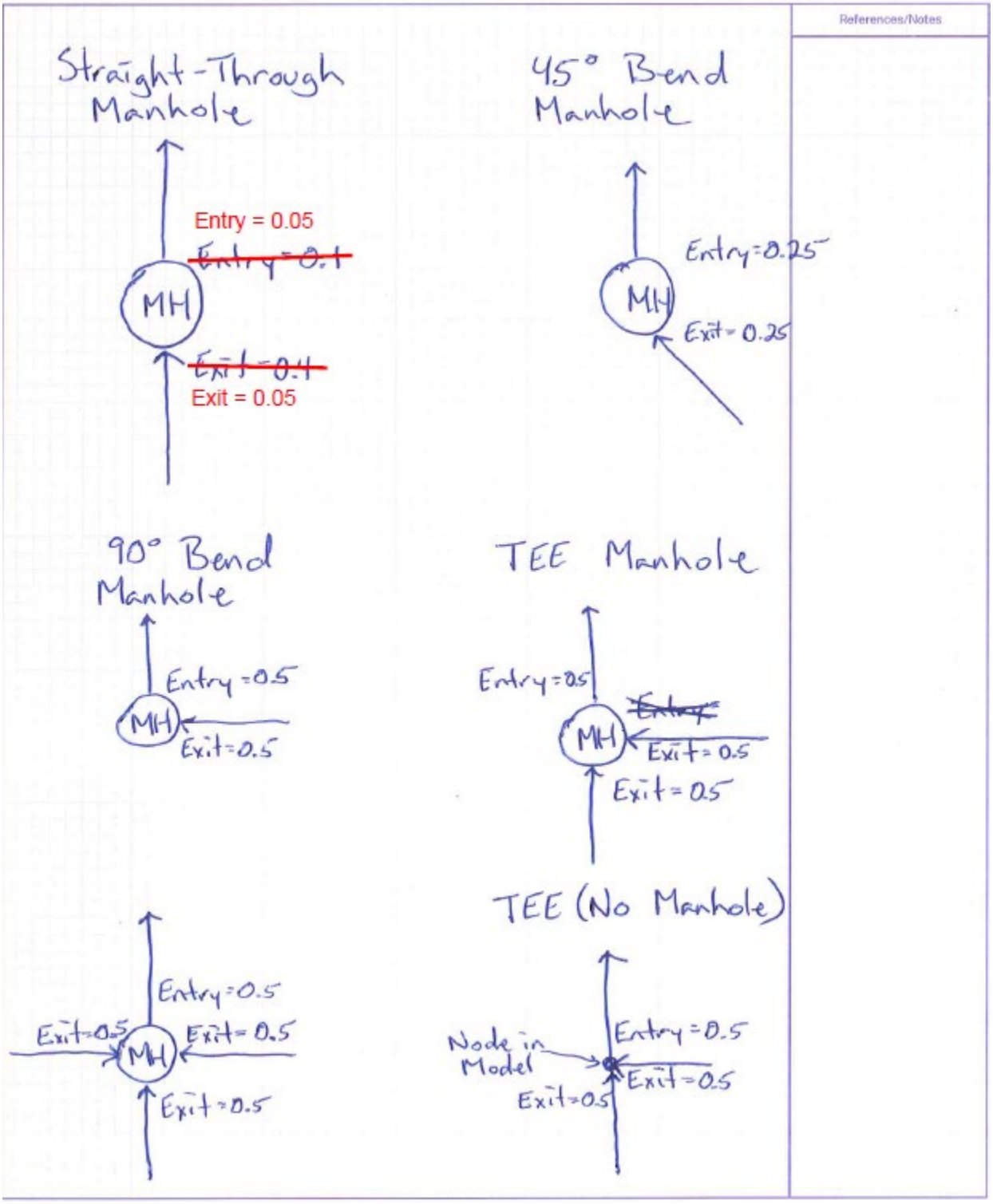
d. In SWU-owned land all proposed grading must have the following conditions for maintenance access:
   i. be offset from the property line on 1 side by 15 feet (parallel to channel flow, from Pond access to pond outlet)
      1. Shall be extended to reach all priority inlets or sanitary access structures within greenway
   ii. All proposed berms must be 10 feet wide @ top of berm
   iii. Slopes no steeper than 4:1
e. Overlay TIP map with inundation mapping to understand where immediate future project opportunities are
f. Freeboard – City does not have a minimum freeboard requirement
g. Properties adjacent to greenway and new greenway crossings – Current ordinance states property low building opening must be 4' above invert of downstream greenway street structure crossing. Therefore, may need to make structures wider, instead of deeper, to not flood upstream properties

19. Water that overflows Watershed Study Boundaries
    a. There may be locations along a watershed study boundary where water overflows that boundary and enters an adjacent watershed. When this occurs
       i. 2D outflow boundaries should be drawn in the locations to allow the water to leave the model as it would normally.
       ii. A 2D flow recording line should be added in this location, just upstream of the 2D outflow boundary.
       iii. The model should be run for all design storm events.
          1. If flow is found to be significant, hydrographs should be exported from the model and provided to the City Project Manager so they can be inserted into the adjacent watershed study model.
          2. If flow is not found to be significant, the flow can be ignored.
       iv. The watershed should report should include a section showing the locations of the overflow. Text and tables in the report should briefly describe the magnitude of the overflow and the duration.

REFERENCES

A. Model Help Files and User Forums
B. Storm Water Management Model version 5.1 User's Manual. (Available at: https://www.epa.gov/water-research/storm-water-management-model-swmm-version-51-users-manual)
C. SWMM reference manual volume I – hydrology (Available at: https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100NYRA.txt)
D. SWMM reference manual volume volume II – hydraulics (Available at: https://nepis.epa.gov/Exe/ZyPDF.cgi/P100S9AS.PDF?Dockey=P100S9AS.PDF)
E. Chow, Open Channel Hydraulics, 1959
F. HEC-RAS Hydraulic Reference Manual. (Available at: https://www.hec.usace.army.mil/software/hec-ras/documentation/HEC-RAS%205.0%20Reference%20Manual.pdf)
G. ASCE Two-Dimensional Modeling Using HEC-RAS, Lecture 8 – Troubleshooting and Reviewing, Page 31; 2017.
H. Australian Rainfall & Runoff Revision Projects, Project 15: Two Dimensional Modeling in Urban and Rural Floodplains, November 2012.
I. FLO-2D Reference Manual, FLO-2D Software, 2012.

J. ASCE Manual of Engineering Practice No 28.
K. SCS Urban Hydrology for Small Watershed, 2nd Ed., (TR-55), June 1986
L. Found during calibration in the Pheasant Branch Watershed. Area underlain with Prairie du Chein geology. Areas with other geology will need to select appropriate multipliers.



Appendix B. Hydrology Input Parameters per Subbasin

Subcatchment	DCIA	UCIA	Pervious	Max Infil. Rate (in/hr)	Min Infil. Rate (in/hr)	Decay Rate (1/s)
AE4170-009	1.961	0.321	148.972	3.56	0.87	0.001
AE4170-023	0.245	0.172	10.369	2.00	0.50	0.001
AE5067-004	1.975	0.03	5.188	1.87	0.46	0.001
AE5169-001	1.529	0.784	9.726	1.93	0.48	0.001
AE5667-014	0.855	0	4.829	2.00	0.50	0.001
AE5767-004	2.717	0.127	22.427	1.42	0.33	0.001
AS4469-001	9.174	1.824	16.813	1.36	0.31	0.001
AS4469-002	9.987	2.48	10.415	1.16	0.25	0.001
AS4667-018	1.655	0	0.837	2.00	0.50	0.001
AS4667-019	2.682	0	0.661	2.00	0.50	0.001
AS4668-004	20.625	0.264	9.399	1.86	0.46	0.001
AS4767-003	6.534	0.279	2.24	2.00	0.50	0.001
AS4767-004	4.973	0.336	0.473	1.72	0.42	0.001
AS4769-012	8.513	0.245	5.911	2.00	0.50	0.001
AS4769-013	10.321	1.435	2.812	2.00	0.50	0.001
AS4769-019	3.533	0.871	2.355	1.64	0.39	0.001
AS4769-021	4.685	0.153	1.877	2.00	0.50	0.001
AS4864-023	3.042	0	1.116	1.73	0.42	0.001
AS4864-038	1.037	0.101	1.652	2.00	0.50	0.001
AS4864-046	2.767	0.035	1.112	2.00	0.50	0.001
AS4865-014	5.242	0.728	6.39	2.00	0.50	0.001
AS4865-039	4.363	0.272	2.217	2.00	0.50	0.001
AS4866-030	0.693	0.007	0.579	2.00	0.50	0.001
AS4867-007	13.856	0.844	3.97	2.00	0.50	0.001
AS4867-009	4.231	0	1.458	2.00	0.50	0.001
AS4868-015	19.209	1.119	3.776	2.00	0.50	0.001
AS4868-016	9.112	1.226	2.757	1.98	0.49	0.001
AS4963-021	4.796	0.341	2.464	2.00	0.50	0.001
AS4964-009	3.217	0.105	1.04	1.71	0.41	0.001
AS5066-009	13.654	1.38	17.598	2.00	0.50	0.001
AS5067-020	13.591	0.935	11.279	1.82	0.45	0.001
AS5067-028	3.46	0.352	4.422	1.84	0.45	0.001
AS5268-003	1.105	0.567	2.838	2.00	0.50	0.001
AS5364-009	2.775	0	3.098	2.00	0.50	0.001
AS5365-011	2.306	1.217	6.684	1.67	0.40	0.001
AS5367-007	2.198	1.394	5.871	1.66	0.40	0.001
AS5367-010	4.177	0.86	7.55	1.17	0.25	0.001
AS5467-009	2.061	0.486	2.04	1.11	0.23	0.001
D_001	0.516	0.06	4.531	2.00	0.50	0.001
D_002	2.052	0.148	4.005	2.00	0.50	0.001
D_003	1.292	0	1.977	2.00	0.50	0.001
D_004	0.501	0	1.462	1.98	0.50	0.001
D_005	4.488	0	3.044	2.00	0.50	0.001
D_006	0.865	0	0.789	2.00	0.50	0.001

Subcatchment	DCIA	UCIA	Pervious	Max Infil. Rate (in/hr)	Min Infil. Rate (in/hr)	Decay Rate (1/s)
D_007	1.092	0.265	2.647	1.65	0.39	0.001
D_008	3.207	0	4.789	1.99	0.50	0.001
D_009	11.506	1.712	9.071	1.88	0.47	0.001
D_010	0.254	0	1.008	2.00	0.50	0.001
D_OUT_001	1.214	0.067	0.177	2.00	0.50	0.001
D_OUT_002_Pond	2.274	0.005	6.464	2.00	0.50	0.001
D_WWTF_001	43.66	2.757	210.778	2.13	0.53	0.001
DT4866-013	0.879	0	0.02	2.00	0.50	0.001
DT4866-014	2.125	0	1.227	2.00	0.50	0.001
DT4966-009	1.932	0.127	1.675	2.00	0.50	0.001
F_2654	0.427	0	0	0.00	0.00	0.001
F_4542	7.671	0.47	10.011	1.94	0.48	0.001
F_5334	1.249	0	0.84	2.00	0.50	0.001
F_5692	1.319	0.093	0.661	2.00	0.50	0.001
F_5698	4.031	0.328	2.01	2.00	0.50	0.001
F_5704	0.894	0.045	0.208	2.00	0.50	0.001
F_5718	0.647	0.04	0.557	2.00	0.50	0.001
F_5723	0.216	0.007	0.111	2.00	0.50	0.001
F_7143	4.415	0.084	1.234	1.88	0.46	0.001
F_Pond_001	17.928	2.343	19.124	2.02	0.51	0.001
F_Pond_002	3.323	0.444	5.643	2.00	0.50	0.001
F_Pond_003	1.202	0	5.601	2.00	0.50	0.001
F_Pond_004	3.048	0.733	5.831	1.71	0.41	0.001
F_Pond_005	3.933	0.601	4.123	2.00	0.50	0.001
F_Pond_006	0.864	0.031	1.484	2.00	0.50	0.001
F_Pond_007	0	0	0.739	2.00	0.50	0.001
IN4169-004	1.812	0.993	6.069	2.01	0.50	0.001
IN4170-022	3.735	2.145	9.578	2.00	0.50	0.001
IN4667-076	5.09	0.092	2.084	2.00	0.50	0.001
IN4766-015	1.043	0.061	0.349	2.00	0.50	0.001
IN4766-026	4.484	0.035	0.95	2.00	0.50	0.001
IN4766-031	4.248	0.466	1.356	2.00	0.50	0.001
IN4767-007	4.932	0.162	1.341	2.00	0.50	0.001
IN4769-035	5.707	0.108	5.297	2.00	0.50	0.001
IN4865-025	1.339	0.021	0.452	2.00	0.50	0.001
IN4866-016	1.996	0.023	0.345	2.00	0.50	0.001
IN4866-040	1.812	0	1.38	2.00	0.50	0.001
IN4867-011	2.341	0	1.056	2.00	0.50	0.001
IN4869-016	8.139	0.369	1.996	1.88	0.47	0.001
IN4964-001	4.165	0.38	2.547	1.05	0.22	0.001
IN4964-004	4.612	0.088	1.946	1.41	0.32	0.001
IN4965-015	3.531	0.24	0.974	1.12	0.24	0.001
IN4967-012	2.667	2.838	6.975	2.00	0.50	0.001
IN4967-019	1.808	0.037	2.72	2.00	0.50	0.001

Subcatchment	DCIA	UCIA	Pervious	Max Infil. Rate (in/hr)	Min Infil. Rate (in/hr)	Decay Rate (1/s)
IN4969-004	7.638	0.112	4.362	2.00	0.50	0.001
IN4969-006	3.739	0.142	2.131	2.00	0.50	0.001
IN5268-006	2.593	1.402	7.177	2.00	0.50	0.001
IN5268-013	2.303	1.178	4.837	1.54	0.36	0.001
IN5268-013a	3.109	1.662	7.075	1.34	0.30	0.001
IN5269-006	2.558	1.1	4.248	1.72	0.41	0.001
IN5364-005	2.021	0.118	2.066	2.00	0.50	0.001
IN5365-003	1.645	0.945	6.497	1.03	0.21	0.001
IN5366-003	0.949	0.266	1.341	1.00	0.20	0.001
IN5366-005	0.293	0.105	0.576	1.08	0.22	0.001
IN5367-001	0.547	0.061	1.264	1.43	0.33	0.001
IN5367-009	0.332	0.188	0.88	1.84	0.45	0.001
IN5367-012	0.558	0.246	1.261	1.82	0.45	0.001
IN5368-007	1.944	0.814	3.027	1.60	0.38	0.001
IN5368-010	1.115	0.439	3.185	1.93	0.48	0.001
IN5368-013	1.042	0.441	2.854	1.14	0.24	0.001
IN5465-003	1.828	0.826	5	1.18	0.25	0.001
IN5467-010	2.129	1.104	4.354	1.52	0.36	0.001
IN5567-010	2.988	0.34	4.706	1.58	0.37	0.001
IN5567-013	0.821	0	0.326	1.96	0.49	0.001
IN5667-018	3.275	0.005	5.473	1.75	0.43	0.001
MSA_6	4.817	0.268	4.149	2.00	0.50	0.001
MSA_P8	4.235	0.758	5.21	2.00	0.50	0.001
ND5468-004	0.019	0.044	0.901	2.00	0.50	0.001
P_16	3.842	0	0.348	1.09	0.23	0.001
P_20	3.758	0.262	2.74	2.00	0.50	0.001
PD5567-017	0	0	0.107	2.00	0.50	0.001
SS5368-021	0.53	0.067	3.664	2.00	0.50	0.001
TO4766-029b	1.817	3.982	0.506	1.47	0.34	0.001
TO4766-030	0.047	0	1.654	2.00	0.50	0.001
TO4766-036	0.884	0	0.026	2.00	0.50	0.001
TO4866-004	1.615	0	0.057	2.00	0.50	0.001
TO4965-010	3.225	0.014	6.481	1.22	0.27	0.001
TO4967-005	11.496	0.368	4.634	2.00	0.50	0.001
TO5065-007	2.994	0	2.923	1.00	0.20	0.001
TO5065-008	1.49	0	0.042	1.00	0.20	0.001
TO5168-012	1.851	0.71	5.764	1.24	0.27	0.001
TO5168-021	3.363	0.426	2.755	1.16	0.25	0.001
TO5169-005	4.896	0.601	5.509	1.31	0.29	0.001

Appendix C. Calibration Memo

TECHNICAL MEMO

To:	Ryan Stenjem, P.E. – City of Madison
From:	Eric Thompson, P.E., Amber Converse, and Makenzie Gingras, P.E.
Subject:	Nine Springs Watershed Study – Existing Conditions Model Calibration
Date:	10/19/2025

Introduction

The memorandum presents the results of MSA's efforts to calibrate the 1D/2D XP-SWMM model for the Nine Springs Watershed Study for the City of Madison (city).

Gages and Calibration Rainfall Events

Model calibration was completed using rainfall gages and water level loggers installed between Spring 2023 and Fall 2024. The location of these can be seen on the attached map.

Rain gages: The city's system of rain gages included three gages within, or close by, Nine Springs Creek watershed.

- The Marlborough Park rain gage, located in the Dunn's Marsh headwaters of Nine Springs Creek malfunctioned frequently during the calibration period and did not provide data of sufficient quality for calibrating the model as data from the gage was not used.
- The Paunack Park rain gage is located outside the watershed boundary; approximately 0.9 miles from the watershed boundary at its closest point. More importantly; however, was that the gage was more than 2 miles from the Englehart Pond level logger and nearly 3.5 miles from the Post Road level logger. While the gage appeared to function properly, it was felt to be too far from the subwatersheds draining to either of the level loggers to allow an accurate representation of hydrologic conditions at the logger sites and so data from the gage was not used.
- The Baxter Park rain gage is within the Nine Springs Watershed boundary and only approximately 500 feet from Englehart Pond. The gage was approximately 1.5 miles from the Post Road Pond, but the pond was still within the Theiseen Polygons associated with the gage. The gage appeared to be functioning property during the calibration period.

Three (3) rainfall events were selected for calibration. **Table 1** summarized precipitation data for each event, as recorded by the Baxter Park rain gage.

Table 1: Calibration Precipitation Events

Event Date	Start Time	Stop Time	Duration (hr)	Total Depth (in)	Peak Intensity (in/hr)	3-Day Antecedent Rainfall (in)	5-Day Antecedent Rainfall (in)
July 12, 2023	11:15	16:50	5.5	1.6	0.72	0.1	0.1
July 2, 2024	4:30	21:25	17	2	1.92	0.1	1.8
October 30-31, 2024	17:15	2:35	9.33	1.8	1.32	0	0

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Level loggers: The City of Madison contracted with the United States Geological Survey who installed two level-loggers within Nine Springs Creek watershed for use in the calibration of the model. One logger was installed within the storm sewer system downstream of the Post Rd Pond in the inlet just upstream of the outfall to Nine Springs Creek (IN4769-024). The other logger was installed within Engelhart Pond, anchored to a stake in the pond bottom, roughly 20-ft away from the pond outlet.



The elevation of the level logger sensors were not surveyed prior to removal. Both loggers were installed below water levels observed by MSA during a site visit on August 8,2024. Modeling efforts completed during the calibration appear to indicate that the Post Road logger is affected by hydraulic conditions downstream from the gage, and outside the limits of watershed model. The inability to correlate logged water depth against the elevations of the pond outlet structure and downstream drainage system added significant uncertainty to the model calibration. the modeling.

Photos of the level-loggers taken during the August 8th site visit are included for reference.



Model Calibration

Calibration process: Early in the calibration process, there was significant difficulty obtaining any level of agreement between base model output and level logger (meter) data. Upon reviewing construction plans for storm sewer systems and pond outlet structures for the portions of the model in the vicinity of the meter locations, it was discovered that several important hydraulic elements were missing from the city's GIS database which was used to construct the model. These elements were manually added to the model and correlation between base model output and meter data improved significantly, most notably regarding the shape of the model output hydrograph (depth vs. time) and the correlation of modeled vs. metered peak depths for all calibration events.

Regardless of the modifications to the model structure, there were still significant observed deviations in the slope of the descending portions of all calibration events for the Englehart Pond. No amount of reasonable adjustment of hydrologic parameters could account for the descending hydrograph and it was concluded that meter data was likely reflective of downstream conditions beyond the limits of the model.

There was also unexplainably high starting water levels at the Post Road meter location. Given that this meter was located in a storm sewer, which should be empty under normal circumstances, this too was assumed to be reflective of downstream conditions beyond the limits of the model.

In the end, ***no changes to base model hydrology were made for this calibration.*** Simulations of the calibration events for the Post Road meter were evaluated assuming a 1-foot tailwater elevation, which was assigned as a constant depth applied for the entire simulation duration.

Calibration Review: The attached graphs present a comparison of meter (level logger depth) vs. model output. Meter and model calibration for the Englehart Pond were made on the basis of depth, with model output expressed as depth above the pond outlet invert (the pond normal water level) and meter depth adjusted to zero which was assumed to equate to the pond outlet invert elevation (also the pond normal water level). Meter and model data for Post Road are presented as obtained direct from the meter data download and the model output (model output adjusted for estimated tailwater conditions as indicated).

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Model calibration was assessed by assessing the bias of model output for simulated rainfall events vs. meter results using Equation 1, below.

Equation 1:

$$PBIAS = \left[\frac{\sum_{i=1}^{n}\left(Y_i^{meter} - Y_i^{model}\right)*100}{\sum_{i=1}^{n}(Y_i^{meter})}\right]$$

Table 2, below, presents summary statistics regarding the bias of model output relative to meter data. Positive PBIAS values indicate model results tend to underestimate meter-observed values while negative PBIAS values indicate overestimation.

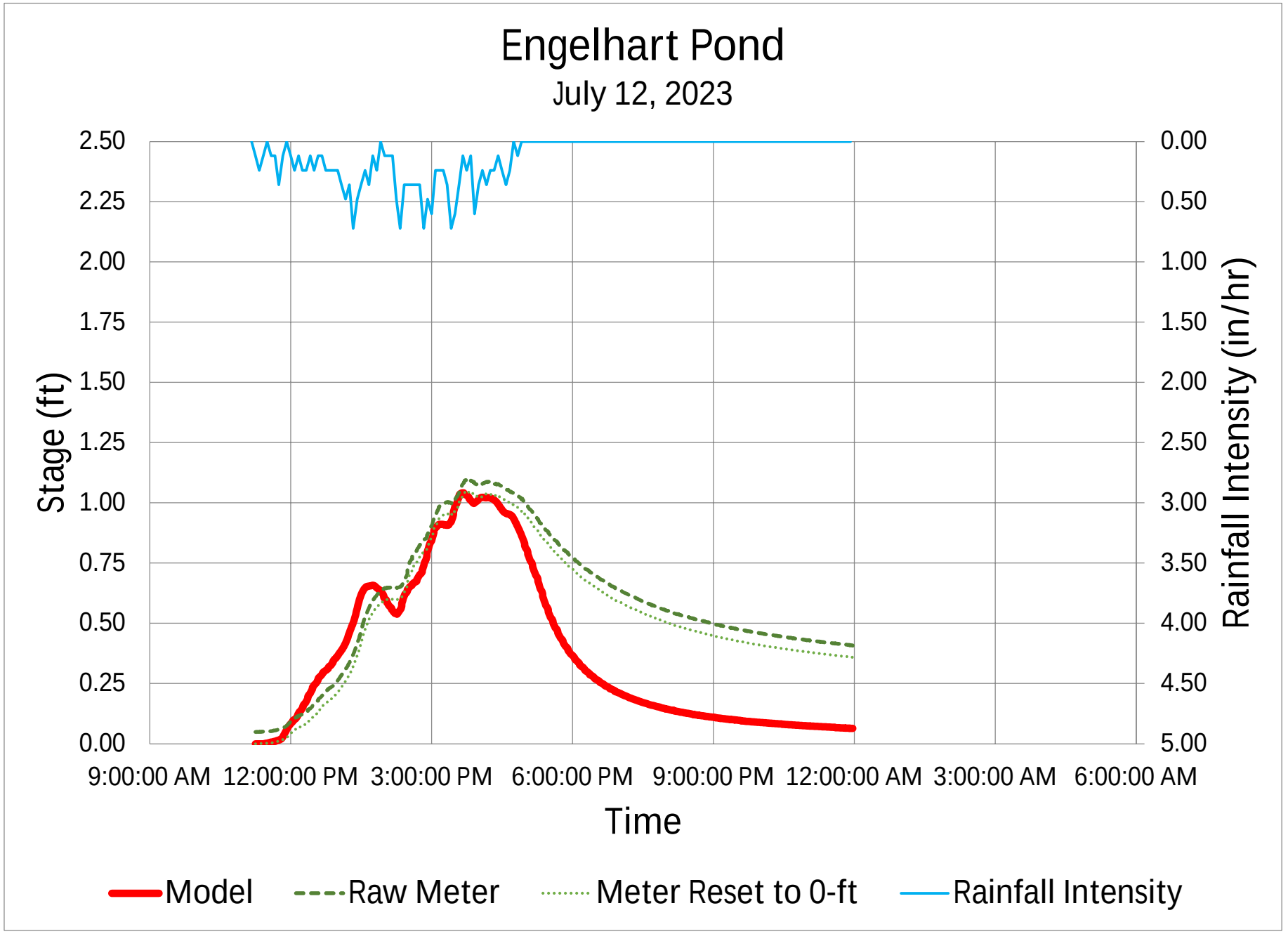
Table 2: Model vs Meter Bias

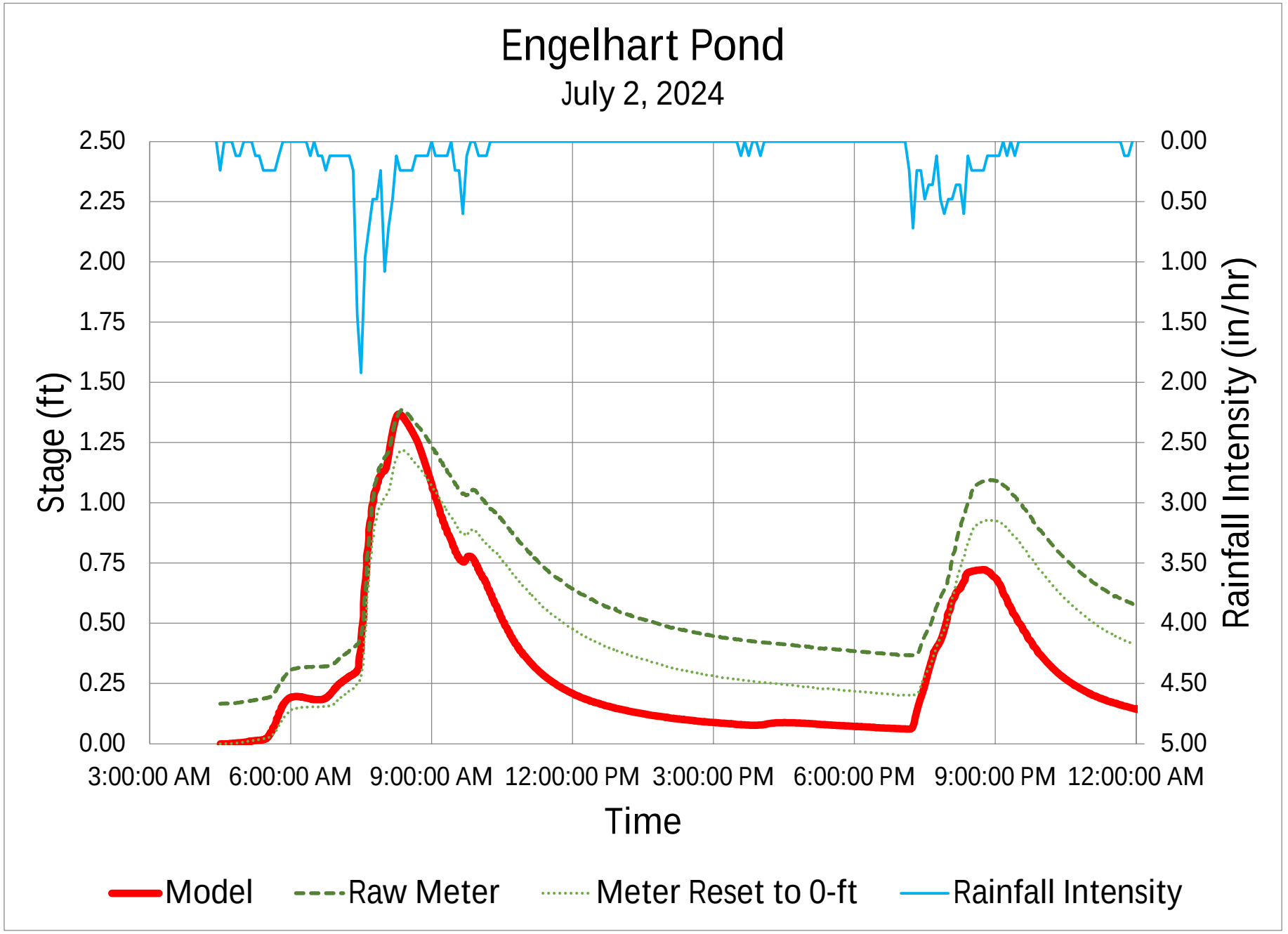
Event Date	Engelhart Pond		Post Road	
	PBIAS TOTAL[1]	PBIAS LIMITED[2]	PBIAS TOTAL[1]	PBIAS LIMITED[3]
July 12, 2023	-45.2%	4.8%	35.6%	-9.8%
July 2, 2024	-43.4%	4.6%	27.3%	0.7%
October 30-31, 2024	-58.2%	-2.8%	31.7%	-3.0%

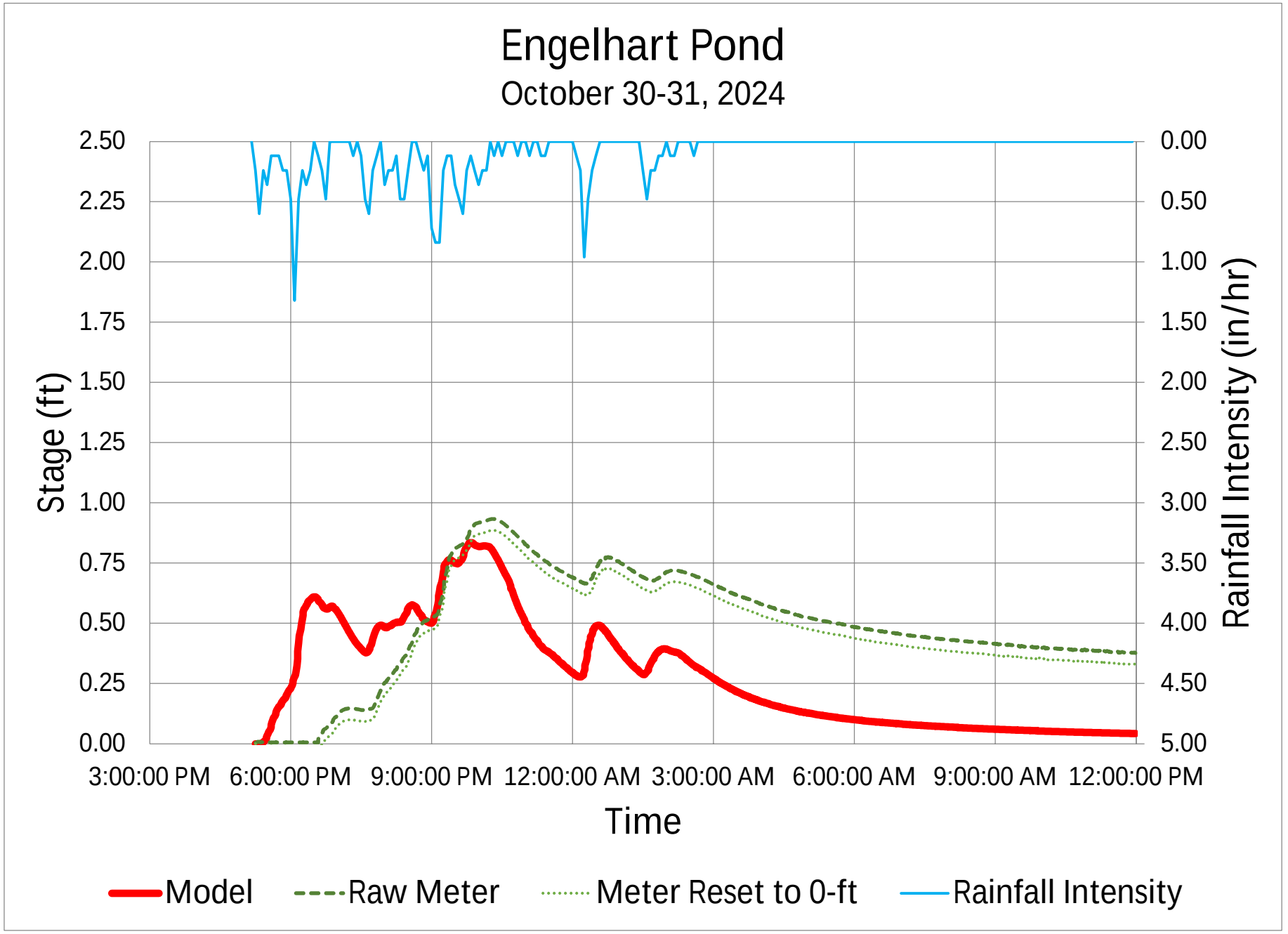
1. *Percent bias over duration of selected calibration event. Refer to duration of meter data on attached graphs*
2. *The limited duration bias assessment for Engehart Pond extends from the beginning of the meter data and ends at the cessation of rainfall (refer to attached graphs). PBIAS data for the July 2, 2024 event is inclusive of only the first hydrograph peak.*
3. *The limited duration bias assessment for Post Road includes only data points where the level logger recorded a depth of 1.0-feet or more, reflective of the duration of the event where tailwater conditions are believed to affect system hydraulics.*

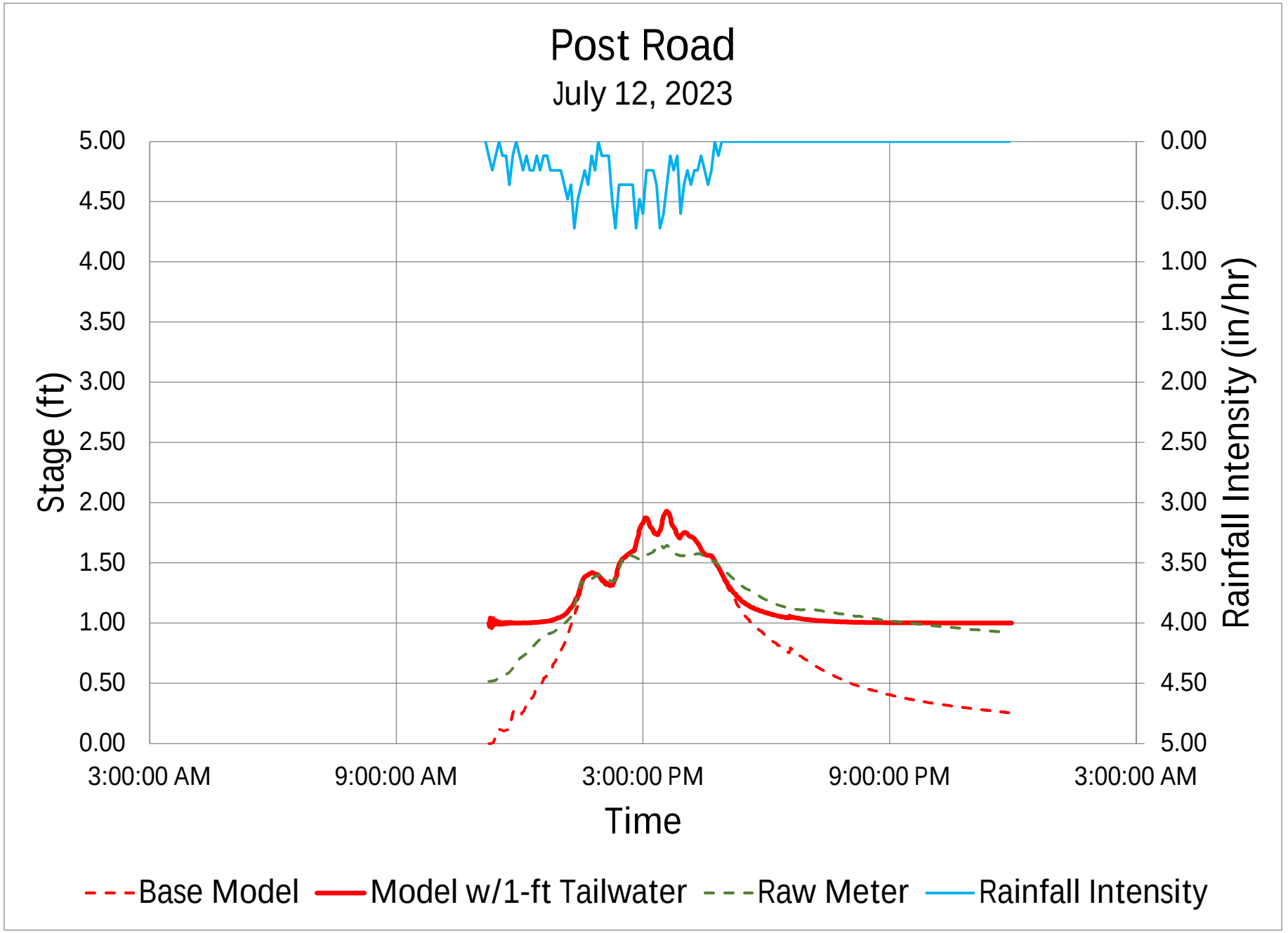
When the total duration of any calibration event is considered as a whole, the net total bias for both locations for all events is poor and doesn't meet city model guidance standards which requires less than +/- 5% bias. However, if the data set is evaluated such that there is a focus only on the portion of each event where tailwater conditions do not appear to affect model function, then model bias is significantly better, with only the July 12, 2023, event at Post Road exceeding the city's +/- 5% maximum.

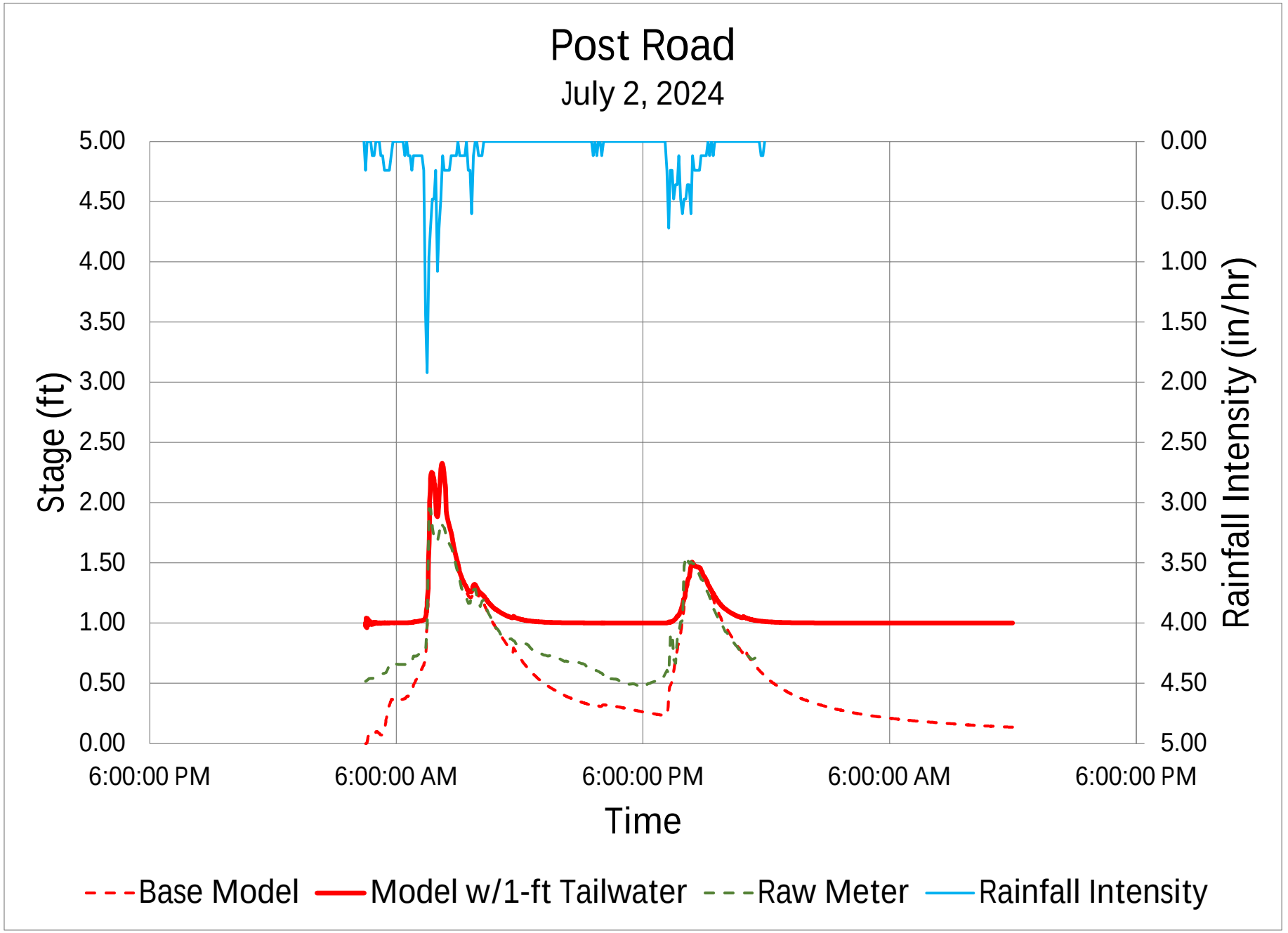
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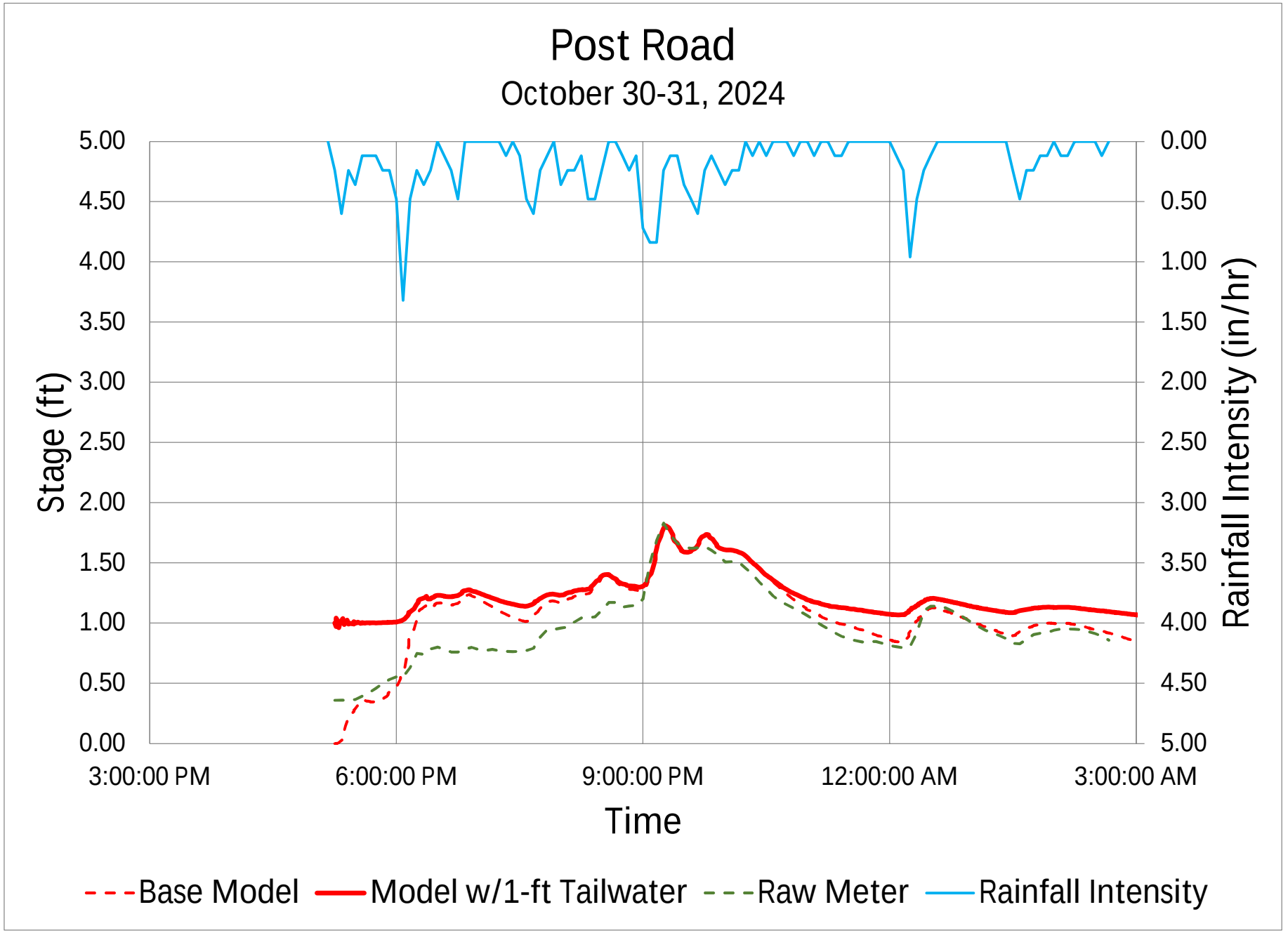

Engelhart Pond
July 12, 2023
Stage (ft)
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Rainfall Intensity (in/hr)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
9:00:00 AM
12:00:00 PM
3:00:00 PM
6:00:00 PM
9:00:00 PM
12:00:00 AM
3:00:00 AM
6:00:00 AM
Time
Model
Raw Meter
Meter Reset to 0-ft
Rainfall Intensity

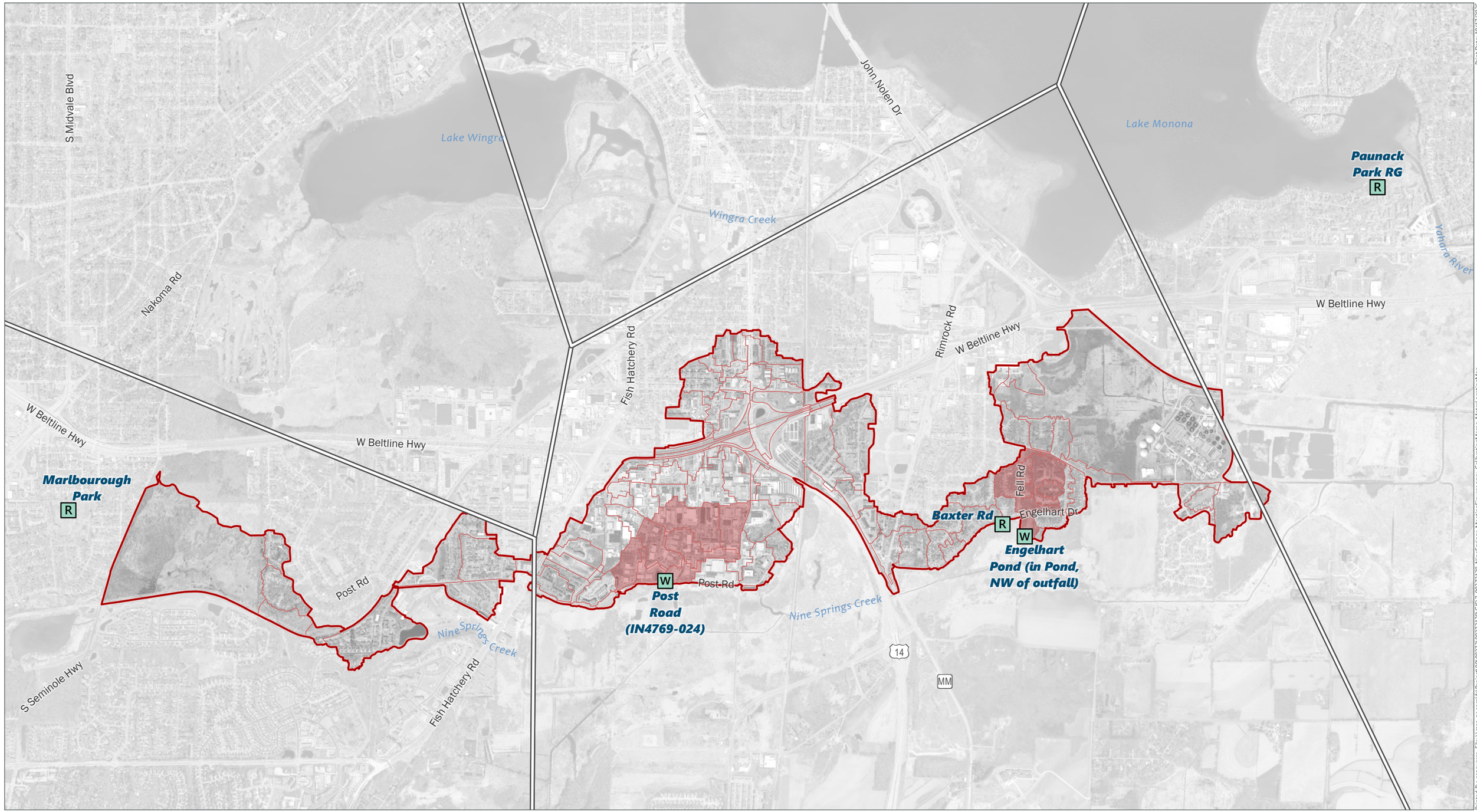

Engelhart Pond
July 2, 2024
Stage (ft)
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Rainfall Intensity (in/hr)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
3:00:00 AM
6:00:00 AM
9:00:00 AM
12:00:00 PM
3:00:00 PM
6:00:00 PM
9:00:00 PM
12:00:00 AM
Time
Model
Raw Meter
Meter Reset to 0-ft
Rainfall Intensity


Engelhart Pond
October 30-31, 2024
Stage (ft)
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Rainfall Intensity (in/hr)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
3:00:00 PM
6:00:00 PM
9:00:00 PM
12:00:00 AM
3:00:00 AM
6:00:00 AM
9:00:00 AM
12:00:00 PM
Time
Model
Raw Meter
Meter Reset to 0-ft
Rainfall Intensity


Post Road
July 12, 2023
Stage (ft)
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Rainfall Intensity (in/hr)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
3:00:00 AM
9:00:00 AM
3:00:00 PM
9:00:00 PM
3:00:00 AM
Time
Base Model
Model w/1-ft Tailwater
Raw Meter
Rainfall Intensity


Post Road
July 2, 2024
Stage (ft)
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Rainfall Intensity (in/hr)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
6:00:00 PM
6:00:00 AM
6:00:00 PM
6:00:00 AM
6:00:00 PM
Time
Base Model
Model w/1-ft Tailwater
Raw Meter
Rainfall Intensity


Post Road
October 30-31, 2024
Stage (ft)
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Rainfall Intensity (in/hr)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
3:00:00 PM
6:00:00 PM
9:00:00 PM
12:00:00 AM
3:00:00 AM
Time
Base Model
Model w/1-ft Tailwater
Raw Meter
Rainfall Intensity



MSA

Data Sources:
Aerial: Dane County (2024)
Storm System and Thiessen Polygons: City of Madison

0 1,000 2,000 Feet

XPSWMM Model Boundary
Subwatersheds
Subwatersheds Upstream of Gage
Rain Gauge Thiessen Polygons
W Water Level Gauge
R Rain Gauge

Rain Gages and Level Loggers

Nine Springs Watershed Study

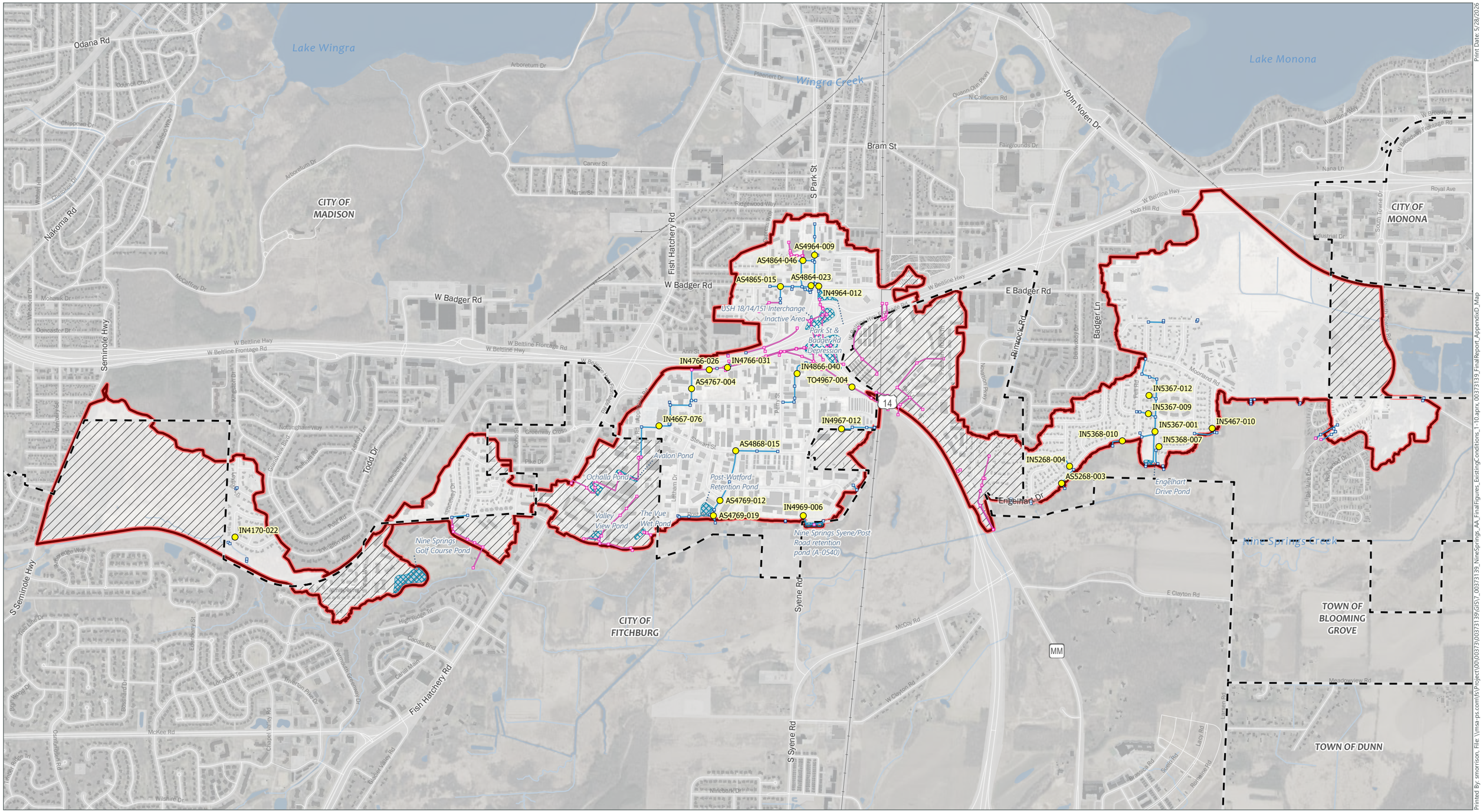
City of Madison, Dane County, WI

Print Date: 10/17/2025

Printed By: aconverse, File: \\msa-ps.com\fs\Project\00\003731\003731391\GIS\7_003731391_NineSprings_MeetingFigures.aprx, CalibrationMemo_MeterLocationMap

Appendix D. Select Locations Flooding Depth & Duration

Node	Location Description	Ground Elevation	50% AEP (2-yr)	20% AEP (5-yr)	10% AEP (10-yr)	4% AEP (25-yr)	1% AEP (100-yr)	0.5% AEP (200-yr)	0.2% AEP (500-yr)
			Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)
AS4767-004	Latham Dr	886.63	-2.62	-1.45	-0.95	0.21	0.74	1.00	1.22
AS4769-012	Watford Way (south of Kingsley Way)	859.26	-2.20	-1.29	-0.18	0.77	1.18	1.24	1.37
AS4769-019	Watford Way (at Post Rd intersection)	857.60	-3.23	-3.04	-2.69	-1.39	0.52	0.93	1.17
AS4864-023	West Badger Road & South Park St Intersection (northwest)	877.69	-1.58	-1.06	0.12	0.86	1.24	1.37	1.61
AS4864-046	Hughes Place	879.40	0.30	0.81	0.98	1.10	1.24	1.32	1.43
AS4865-015	West Badger Road (at Perry St Intersection)	885.19	-5.14	-4.20	-4.00	-3.73	-3.34	-3.25	-2.87
AS4868-015	Stewart St & Watford Way Intersection	872.99	-7.19	-6.75	-5.95	-2.84	0.34	0.58	0.83
AS4964-009	South Park St (north of Hughes Place)	881.30	-1.53	-0.80	-0.49	-0.34	0.06	0.15	0.26
AS5268-003	Engelhart Dr (between Settlement Dr and Artesian Ln)	863.19	-3.54	-3.06	-2.34	-1.27	-0.53	-0.35	1.97
IN4170-022	Westview Ln	933.35	-2.05	-1.56	-0.70	0.35	0.82	1.01	1.21
IN4667-076	Greenway Cross (south of Bergstrom)	891.00	-1.97	0.17	0.57	1.23	1.69	1.87	2.07
IN4766-026	Applegate Rd (west)	885.00	-0.84	0.16	0.41	0.73	1.07	1.25	1.43
IN4766-031	Applegate Rd (east)	884.52	-0.68	0.09	0.23	0.33	0.46	0.78	1.70
IN4866-040	Backyard area pipes (between Perry St and Syene Rd)	870.65	-3.09	-2.29	-1.93	-1.01	1.02	1.57	2.31
IN4964-012	West Badger Road & South Park St Intersection (northeast)	878.25	0.08	0.37	0.52	0.64	0.74	0.83	1.07
IN4967-012	Rolfsmeyer Dr	891.59	0.27	0.34	0.40	0.46	0.57	0.63	0.71
IN4969-006	Syene Rd (near Post Rd intersection)	867.30	-4.20	-0.79	0.11	0.20	0.32	0.37	0.47
IN5268-004	Settlement Dr (near Engelhart Dr intersection)	866.25	-3.66	-3.27	-2.37	0.27	0.57	0.71	0.88
IN5367-001	Engelhart Dr (near Lorena Pkwy intersection)	888.35	-12.12	-11.57	-10.39	-8.37	-2.84	-2.24	-1.61
IN5367-009	Marcus Ct cul-de-sac	897.06	-3.48	-3.37	-3.27	-3.12	-2.81	-2.56	-0.99
IN5367-012	Book Ct cul-de-sac	906.60	-3.26	-3.09	-2.87	-0.84	0.28	0.56	0.89
IN5368-007	Lorena Pkwy	885.20	-3.98	-3.87	-3.74	-3.56	-3.15	0.00	0.47
IN5368-010	Engelhart Dr (at Ward Ct)	871.27	-3.93	-3.73	-3.44	0.00	0.23	0.31	0.39
IN5467-010	Wayland Dr	888.64	-1.80	-0.84	0.00	0.38	0.66	0.75	0.85
TO4967-004	Outlet Pipes adjacent to USH 14	868.22	-6.90	-6.26	-5.73	-5.05	-3.94	-3.59	-3.27



MSA

Data Sources:
Watershed Boundaries: MSA
Stormwater System: City of Madison
Dane County GIS (2025)

N 0 0.25 0.5 Miles

- Model Area
- Municipal Boundary
- Model Area Outside Madison
- Building Footprint
- Rivers and Streams
- Lakes and Ponds
- Select Locations for Flooding Depth and Duration
- City of Madison Structure
- Structure Owned by Other Entity
- Modeled City Owned Pipe
- Modeled Non-City Owned Pipe; Private
- Modeled Pond/Inactive Area

Selection Locations for Flooding Depth & Duration

Appendix D: Nine Springs Watershed Study Report

City of Madison
Dane County, WI

Print Date: 5/28/2026
Printed By: smorrison, File: \\msa-ps.com\fs\Project\00\00373\003731139\GIS\7_003731139_NineSprings_AA_FinalFigures_ExistingConditions_1-10.aprx, 003731139_FinalReport_AppendixD_Map

Appendix E. Summary of Public Comments

PIM	Date	Postcards Sent	Registered	Attendees
1	9/23/2024	3,836	??	17(?)
2	3/31/2026	3,3836	18	12

PIM 1

The Nine Springs Watershed study held the first Public Information Meeting (PIM) on 9/23/2024 online over Zoom to provide an overview on the Nine Springs Watershed Study model and gather feedback from residents.

Immediately after the presentation, attendees could ask questions; however no attendees asked any questions during the virtual public meeting and no follow up questions were received by the City.

PIM 2

The John Nolen study held the second PIM on 3/31/2026 online over Zoom to review the existing conditions modeling and the recommended solutions and gather feedback from residents. This was a combination of previous PIM #2 & PIM #3.

Immediately after the presentation, attendees could ask questions; a summary of this discussion with residents is recorded below. Generally, there was concurrence on areas that flooded, and there was relatively little feedback from residents.

Question #1a: Am I understanding that you are intending to replace the pipe that goes through my backyard and make it bigger? Will these pipes go all the way to Engelhart?

Response: The city doesn't have jurisdiction to probably this work until the neighboring parcel is potentially redeveloped.

Question #1b: I was told it was because this was the town of Madison that work could not be done.

Response: This area has now been annexed into the City, but we still cannot go in and enforce new requirements as the development met the requirements at the time of development. The

property cannot do anything substantial without adding a parallel pipe, but this would have to be prompted by new development.

Question #1c: The apartment complex resurfaced their entire parking lot a few years ago, does this not constitute work that would require a change?

Response: Parking lot resurfacing does not require a city permit due to current city code.

Question #1d: Is the new piping going to go the entire length down to Englehart, or is just my yard that is being addressed at this point?

Response: Proposed solutions may vary, but changes to the existing pipes would likely occur across the entire length of pipe network.

Question #2: I'm interested in seeing the close up flood maps of the Engelhart/Fell areas.

Response: MSA & City Staff shared maps on screen of the 10% and 1% AEP Events.

Appendix F. Internal City Meetings and Discussions

City Agency Correspondance (4/17/26)

City staff opted to send an email to City Agencies to disseminate information about the Nine Springs Watersheds Proposed Solutions. This email contained an overview description of the Watershed Study as well as a presentation detailing each proposed solution. The email was sent to the following:

Christopher Petykowski (City Engineering)
Andrew Zwieg (City Engineering)
James Wolfe (City Engineering)
Lisa Laschinger (Parks Division)
Brian Grady (Planning Department)
Meagan Tuttle (Planning Department)
Eric Knepp (Parks Division)
Charles Romines (Streets Division)
Liz Callin (Transportation)
Christof Spieler (Transportation)
Adam Wiederhoeft (Water)
Krishna Kumar (Water)
Peter Holmgren (Water)

Only one comment was provided back to Engineering:

- Parks asked for clarification on proposed improvements to an existing pipe along Baxter Road and its alignment through an existing managed meadow. Engineering confirmed that the existing alignment would be improved but kept in its current location. Engineering also confirmed it would note that this location is a managed meadow. Parks noted the volunteers at this meadow are very engaged and Engineering should be aware if improvements take place.

Appendix G. Cost Estimates

Westview Lane (Solution A)

Storm System Improvements

Conceptual Cost Estimate

6/1/2026

Standard/Special	Item #	Item	Quantity	Unit	"Average" Unit Cost provided by City	Adjusted Unit Cost (if used)	Total Item Cost
Standard	50419	19 INCH X 30 INCH TYPE I HERCP STORM SEWER PIPE	35	L.F.	$ 125.00	N/A	$ 4,375
Special	NS6	19 INCH X 30 INCH HERCP AE	1	EACH	$ 1,600.00	N/A	$ 1,600
Standard	20314	REMOVE PIPE	35	L.F.	$ 39.40	N/A	$ 1,379
Standard	50741	TYPE "H" INLET	2	EACH	$ 3,600.00	N/A	$ 7,200
Special	NS10	5 INCH CONCRETE SIDEWALK	400	S.F.	$ 8.00	N/A	$ 3,200
Special	NS11	REMOVE CONCRETE SIDEWALK & DRIVE	400	S.F.	$ 4.00	N/A	$ 1,600
Special	NS12	TERRACE SEEDING	185	S.Y.	$ 3.00	N/A	$ 555
					Subtotal		**$ 19,909**
					Contingency	**25%**	**$ 4,977**
					Design	**10%**	**$ 1,991**
					Total		**$ 26,877**
					Land Acquisition	**0**	**$ -**
					Wetland Mitigation	**0.000**	**$ -**
					Total Total		**$ 26,877**

Post Road (Solution B)

Storm System Improvements

Conceptual Cost Estimate

6/1/2026

Standard/Special	Item #	Item	Quantity	Unit	"Average" Unit Cost provided by City	Adjusted Unit Cost (if used)	Total Item Cost
Standard	50409	36 INCH TYPE I RCP STORM SEWER PIPE	784	L.F.	$ 200.00	N/A	$ 156,800
Standard	50425	48 INCH X 76 INCH TYPE I HERCP STORM SEWER PIPE	591	L.F.	$ 440.00	N/A	$ 260,040
Special	NS7	53 INCH X 83 INCH TYPE I HERCP STORM SEWER PIPE	393	L.F.	$ 485.00	N/A	$ 190,605
Special	WW10	5'x8' BOX CULVERT	261	L.F.	$ 1,500.00	N/A	$ 391,500
Special	WW11	5'x10' BOX CULVERT	289	L.F.	$ 1,700.00	N/A	$ 491,300
Standard	20314	REMOVE PIPE	2,318	L.F.	$ 39.40	N/A	$ 91,329
Standard	50741	TYPE "H" INLET	48	EACH	$ 3,600.00	N/A	$ 172,800
Special	NS1	LARGE CAST-IN-PLACE STORM ACCESS STRUCTURES (60" pipes and greater)	6	EACH	$ 25,000.00	N/A	$ 150,000
Standard	50725	5'X5' STORM SAS	2	EACH	$ 8,400.00	N/A	$ 16,800
Special	NS8	5'X8' BOX CULVERT WING WALLS	1	EACH	$ 36,000.00	N/A	$ 36,000
Special	NS9	5'x10' BOX CULVERT WING WALLS	1	EACH	$ 38,000.00	N/A	$ 38,000
Special	NS15	COORDINATION WITH DANE COUNTY	1	EACH	$ 100,000.00	N/A	$ 100,000
					Subtotal		**$ 2,095,174**
					Contingency	**25%**	**$ 523,794**
					Design	**10%**	**$ 209,517**
					Total		**$ 2,828,485**
					Land Acquisition	**0**	**$ -**
					Wetland Mitigation	**0.000**	**$ 10,000**
					Total Total		**$ 2,838,485**

Applegate Bypass (Solution C)

Storm System Improvements

Conceptual Cost Estimate

6/1/2026

Standard/Special	Item #	Item	Quantity	Unit	"Average" Unit Cost provided by City	Adjusted Unit Cost (if used)	Total Item Cost
Special	NS17	54 INCH TYPE I RCP STORM SEWER PIPE	3,130	L.F.	$ 280.00	N/A	$ 876,400
Special	NS18	72 INCH TYPE I RCP STORM SEWER PIPE	1,939	L.F.	$ 375.00	N/A	$ 727,125
Standard	50405	24 INCH TYPE I RCP STORM SEWER PIPE	67	L.F.	$ 130.00	N/A	$ 8,710
Standard	20314	REMOVE PIPE	1,912	L.F.	$ 39.40	N/A	$ 75,333
Standard	50741	TYPE "H" INLET	40	EACH	$ 3,600.00	N/A	$ 144,000
Special	NS1	LARGE CAST-IN-PLACE STORM ACCESS STRUCTURES (60" pipes and greater)	36	EACH	$ 25,000.00	N/A	$ 900,000
Standard	50407	30 INCH TYPE I RCP STORM SEWER PIPE	10	L.F.	$ 150.00	N/A	$ 1,500
Special	NS14	COORDINATION WITH WISDOT	1	EACH	$ 100,000.00	N/A	$ 100,000
					Subtotal		**$ 2,833,068**
					Contingency	**25%**	**$ 708,267**
					Design	**10%**	**$ 283,307**
					Total		**$ 3,824,642**
					Land Acquisition	**0**	**$ 200,000**
					Wetland Mitigation	**0.000**	**$ -**
					Total Total		**$ 4,024,642**

Applegate Outfall & Hwy 14 Cross Pipe (Solution D)

Storm System Improvements

Conceptual Cost Estimate

6/1/2026

Standard/Special	Item #	Item	Quantity	Unit	"Average" Unit Cost provided by City	Adjusted Unit Cost (if used)	Total Item Cost
Special	NS19	78 INCH TYPE I RCP STORM SEWER PIPE	1,052	L.F.	$ 405.00	N/A	$ 426,060
Standard	20314	REMOVE PIPE	1,052	L.F.	$ 39.40	N/A	$ 41,449
Special	NS1	LARGE CAST-IN-PLACE STORM ACCESS STRUCTURES (60" pipes and greater)	4	EACH	$ 25,000.00	N/A	$ 100,000
Special	NS20	78 INCH RCP AE	1	EACH	$ 5,000.00	N/A	$ 5,000
Special	NS2	3'x6' BOX CULVERT	138	L.F.	$ 700.00	N/A	$ 96,600
Special	NS14	COORDINATION WITH WISDOT	1	EACH	$ 100,000.00	N/A	$ 100,000
Special	NS15	COORDINATION WITH DANE COUNTY	1	EACH	$ 100,000.00	N/A	$ 100,000
					Subtotal		**$ 869,109**
					Contingency	**25%**	**$ 217,277**
					Design	**10%**	**$ 86,911**
					Total		**$ 1,173,297**
					Land Acquisition	**0**	**$ -**
					Wetland Mitigation	**0.000**	**$ 10,000**
					Total Total		**$ 1,183,297**

DOT Ponds (Solution E)

Storm System Improvements

Conceptual Cost Estimate

6/1/2026

Standard/Special	Item #	Item	Quantity	Unit	"Average" Unit Cost provided by City	Adjusted Unit Cost (if used)	Total Item Cost
Special	NS3	3'x5' BOX CULVERT	122	L.F.	$ 650.00	N/A	$ 79,300
Special	NS2	3'x6' BOX CULVERT	149	L.F.	$ 700.00	N/A	$ 104,300
Special	WW7	4'x6' BOX CULVERT	391	L.F.	$ 800.00	N/A	$ 312,800
Standard	50425	48 INCH X 76 INCH TYPE I HERCP STORM SEWER PIPE	629	L.F.	$ 440.00	N/A	$ 276,760
Standard	50409	36 INCH TYPE I RCP STORM SEWER PIPE	326	L.F.	$ 200.00	N/A	$ 65,200
Standard	50405	24 INCH TYPE I RCP STORM SEWER PIPE	214	L.F.	$ 130.00	N/A	$ 27,820
Standard	20314	REMOVE PIPE	988	L.F.	$ 39.40	N/A	$ 38,927
Special	NS1	LARGE CAST-IN-PLACE STORM ACCESS STRUCTURES (60" pipes and greater)	4	EACH	$ 25,000.00	N/A	$ 100,000
Standard	50724	4'X4' STORM SAS	1	EACH	$ 6,500.00	N/A	$ 6,500
Standard	50468	36 INCH RCP AE	2	EACH	$ 2,100.00	N/A	$ 4,200
Special	WW15	4'x6' BOX CULVERT WING WALLS	1	EACH	$ 28,000.00	N/A	$ 28,000
Special	NS4	3'x6' BOX CULVERT WING WALLS	1	EACH	$ 24,000.00	N/A	$ 24,000
Special	NS5	3'x5' BOX CULVERT WING WALLS	2	EACH	$ 22,000.00	N/A	$ 44,000
Special	NS12	TERRACE SEEDING	2,100	S.Y.	$ 3.00	N/A	$ 6,300
Special	NS14	COORDINATION WITH WISDOT	1	EACH	$ 100,000.00	N/A	$ 100,000
					Subtotal		**$ 1,218,107**
					Contingency	**25%**	**$ 304,527**
					Design	**10%**	**$ 121,811**
					Total		**$ 1,644,445**
					Land Acquisition	**0**	**$ -**
					Wetland Mitigation	**0.000**	**$ -**
					Total Total		**$ 1,644,445**

Engelhart & Settlement (Solution F)

Storm System Improvements

Conceptual Cost Estimate

6/1/2026

Standard/Special	Item #	Item	Quantity	Unit	"Average" Unit Cost provided by City	Adjusted Unit Cost (if used)	Total Item Cost
Special	NS16	27 INCH TYPE I RCP STORM SEWER PIPE	643	L.F.	$ 140.00	N/A	$ 90,020
Standard	50409	36 INCH TYPE I RCP STORM SEWER PIPE	279	L.F.	$ 200.00	N/A	$ 55,800
Standard	50423	38 INCH X 60 INCH TYPE I HERCP STORM SEWER PIPE	452	L.F.	$ 350.00	N/A	$ 158,200
Standard	20314	REMOVE PIPE	731	L.F.	$ 39.40	N/A	$ 28,801
Standard	50741	TYPE "H" INLET	48	EACH	$ 3,600.00	N/A	$ 172,800
Special	NS13	ADJUST SEWER ACCESS STRUCTURE	4	EACH	$ 750.00	N/A	$ 3,000
Special	NS1	LARGE CAST-IN-PLACE STORM ACCESS STRUCTURES (60" pipes and greater)	2	EACH	$ 25,000.00	N/A	$ 50,000
Standard	50724	4'X4' STORM SAS	6	EACH	$ 6,500.00	N/A	$ 39,000
Standard	50401	12 INCH TYPE I RCP STORM SEWER PIPE	370	L.F.	$ 105.00	N/A	$ 38,850
Standard	50402	15 INCH TYPE I RCP STORM SEWER PIPE	197	L.F.	$ 110.00	N/A	$ 21,670
Standard	50403	18 INCH TYPE I RCP STORM SEWER PIPE	321	L.F.	$ 115.00	N/A	$ 36,915
Standard	50486	38 INCH X 60 INCH HERCP AE	1	EACH	$ 4,100.00	N/A	$ 4,100
					Subtotal		**$ 699,156**
					Contingency	**25%**	**$ 174,789**
					Design	**10%**	**$ 69,916**
					Total		**$ 943,861**
					Land Acquisition	**0**	**$ -**
					Wetland Mitigation	**0.000**	**$ -**
					Total Total		**$ 943,861**

Fell Road (Solution G)

Storm System Improvements

Conceptual Cost Estimate

6/1/2026

Standard/Special	Item #	Item	Quantity	Unit	"Average" Unit Cost provided by City	Adjusted Unit Cost (if used)	Total Item Cost
Standard	50407	30 INCH TYPE I RCP STORM SEWER PIPE	1,177	L.F.	$ 150.00	N/A	$ 176,550
Standard	50409	36 INCH TYPE I RCP STORM SEWER PIPE	55	L.F.	$ 200.00	N/A	$ 11,000
Standard	50410	42 INCH TYPE I RCP STORM SEWER PIPE	498	L.F.	$ 235.00	N/A	$ 117,030
Standard	20314	REMOVE PIPE	945	L.F.	$ 39.40	N/A	$ 37,233
Standard	50741	TYPE "H" INLET	12	EACH	$ 3,600.00	N/A	$ 43,200
Special	NS13	ADJUST SEWER ACCESS STRUCTURE	2	EACH	$ 750.00	N/A	$ 1,500
Standard	50767	TERRACE INLET TYPE 2	2	EACH	$ 8,000.00	N/A	$ 16,000
Standard	50725	5'X5' STORM SAS	3	EACH	$ 8,400.00	N/A	$ 25,200
Standard	50469	42 INCH RCP AE	1	EACH	$ 2,550.00	N/A	$ 2,550
Special	NS10	5 INCH CONCRETE SIDEWALK	1,400	S.F.	$ 8.00	N/A	$ 11,200
Special	NS11	REMOVE CONCRETE SIDEWALK & DRIVE	1,400	S.F.	$ 4.00	N/A	$ 5,600
Special	NS12	TERRACE SEEDING	3,260	S.Y.	$ 3.00	N/A	$ 9,780
					Subtotal		**$ 456,843**
					Contingency	**25%**	**$ 114,211**
					Design	**10%**	**$ 45,684**
					Total		**$ 616,738**
					Land Acquisition	**0**	**$ -**
					Wetland Mitigation	**0.000**	**$ -**
					Total Total		**$ 616,738**