SPRING HARBOR WATERSHED STUDY

AMENDMENT 1
MADISON, WI

02/26/2025

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This amendment functions to update and supplement the Spring Harbor Watershed Study and final report. Recommendations and updated flood maps presented in this report take precedence over those presented in the original report. For the areas that this report does not cover (e.g. model development), it can be assumed that those specific details of the Watershed Study were not changed, except where noted.

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1. Executive Summary

1.1 City's Watershed Study Program

Recognizing an increase in frequency of extreme rain events within the City of Madison, the City of Madison (City) is conducting a multi-faceted approach to address stormwater flooding. As one component of that approach, City Engineering is developing comprehensive stormwater management studies for each watershed within the City. The studies are conducted in two phases.

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 measured runoff events and used to identify the areas of the watershed most likely to flood under various rain conditions.

Phase 2, Proposed Conditions: Using the model developed during Phase 1, evaluate alternative methods and/or infrastructure improvements to eliminate, or reduce flooding impacts from large rain events and develop a second model of the watershed with the full recommend suite of proposed solutions that help the City meet its flood mitigation targets.

1.2 City's Flood Mitigation Targets*

City Engineering developed a set of flood mitigation targets that exceed their current minimum design standards, so as to better understand where targets are being met, where the flooding conditions could be improved, and guide the development of the recommended solutions during Phase 2 of the Watershed Studies. City Engineering 's flood mitigation targets for the Spring Harbor Watershed Study are as follows. Note that these targets may change in the future.

1. No surcharging onto the street for up to the 10-year (10% chance event) design storm
2. Centerline of street to remain passable during 25-year (4% chance event) design storm with no more than 0.2 feet of water at the centerline
3. No home or business will be flooded during the 100-year (1% chance event) design storm.
4. Enclosed depressions to be served to the 100-year (1% chance event) design storm.
5. Greenway crossings at streets to be served to the 100-year (1% chance event) design storm.
6. Safely convey stormwater during the 500-year (0.2% chance event) design storm event.
7. Provide flooding solutions that do not negatively impact downstream properties.

1.3 Original Spring Harbor Watershed Study and Public Feedback

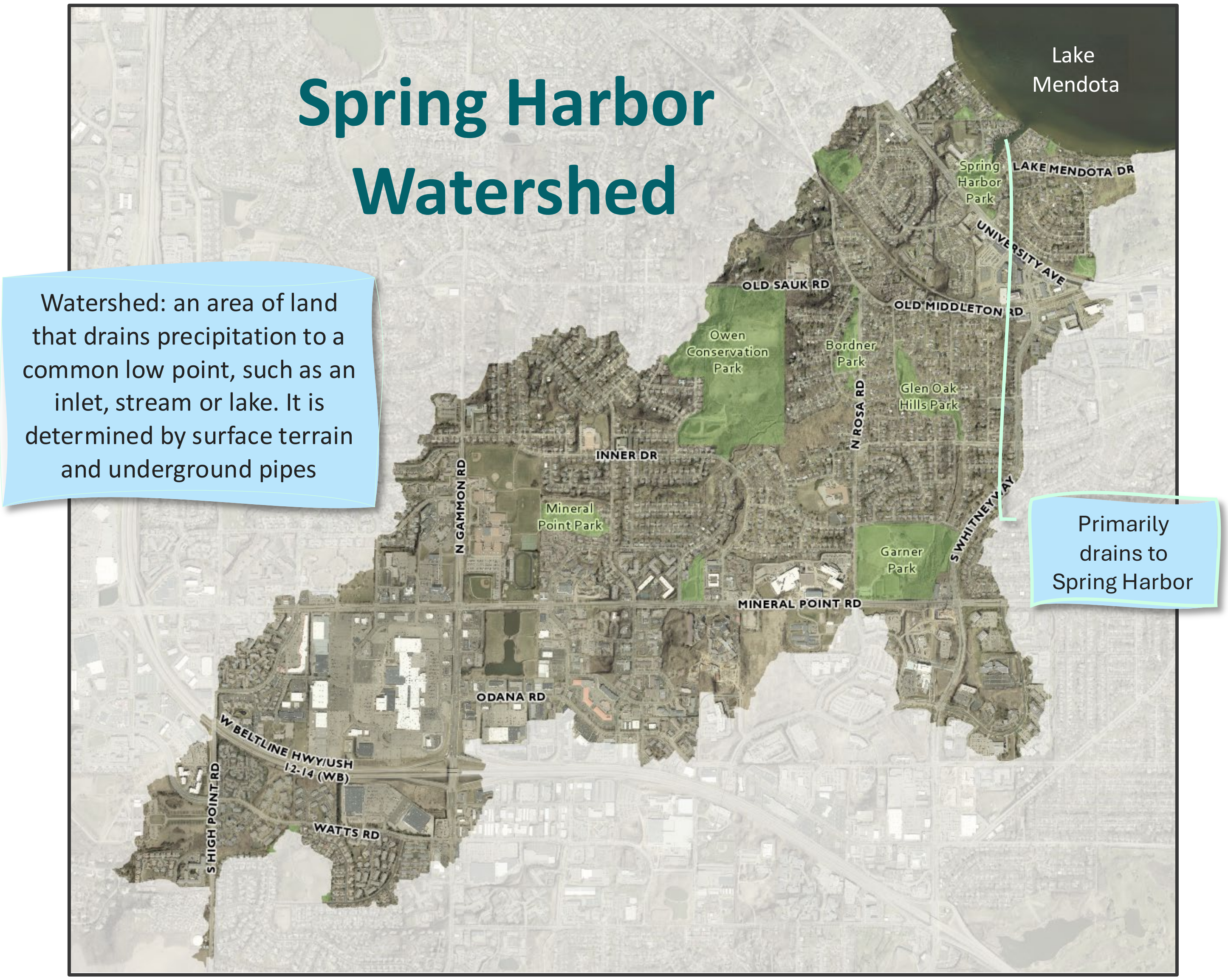
Spring Harbor was one of the first watersheds studied as a part of the City of Madison's Watershed Study Program. The study began in 2019, by AE2S an engineering firm hired by City Engineering to complete the study and was ended in June 2022. At the conclusion of the study AE2S, with the help of City Engineering, developed a recommended suite of solutions for the Spring Habor Watershed that included 3 detention area improvements, 2 channel conveyance improvements, 7 greenway crossing improvements, 1 flood wall (10.5' tall at highest point), upgrades to the Spring Harbor Box and significant upgrades to the local sewer across the watershed. These solutions would help the watershed reach the City's flood mitigation targets.

After posting the final report for public comment, the City received a significant amount of feedback centered around concerns about recommended changes to the Watershed's wooded greenways, including

* In the original Spring Harbor Watershed Study Report, the terminology *Flood Mitigation Goals* was used. This has since been updated to *Flood Mitigation Targets*, which is the terminology that will be used in this report.

the recommended Kenosha Greenway Regrading project and the Forsythia Flood Wall and Owen Park N/S Channel project. This feedback led the City to the decision to conduct additional modeling of the Spring Harbor Watershed and develop an alternate set of recommended improvements.

Figure i : Spring Harbor Watershed Overview Map



1.5 Modeling Update

The supplemental modeling for the Spring Habor Watershed was started by City Engineering in July 2022 and was completed in four major phases.

1.5.1 Living Model Update

City Engineering first started by updating the Existing Conditions and Proposed Conditions models provided by the consultants of the original watershed study. These models were updated with construction projects that had been completed since the time that the original watershed study models were built.

1.5.2 Resident Driven Scenario Modeling

After updating the models, the City began addressing residents' questions about alternative solutions for the watershed. The least favored solutions were those that would provide stormwater storage within the major wooded greenways in the watershed and excluding those solutions from the Proposed Conditions model resulted in increased flood depths downstream. As the City evaluated these modifications to the initial recommended projects, it became clear that a comprehensive reevaluation and redevelopment of the recommended solutions was necessary to balance the City's flood mitigation targets with residents' preferences.

1.5.3 All Solutions Model Development

City Engineering developed a new set of recommendations for the entire watershed, sizing local sewers first and then developing regional solutions, working from upstream to downstream. During this process many new solutions and combinations were tested. In the end a new suite of recommended solutions was developed, but in order to meet the flood mitigation targets, some unpopular storage solutions from the original watershed study still had to be included. Additionally, it was found that the lower portion of the Spring Harbor Box would need to be upsized, a project that will not be desirable for decades given the costs and anticipated remaining lifespan of the box. The City decided that this did not provide a suitable near-term plan, and additional modeling would be needed. However, City Engineering would keep this "All Solutions" suite of solutions to help document what would be needed to meet all the flood mitigation targets in the watershed.

1.5.4 Near-Term (0-25 Years) Solutions Model Development

Using feedback from residents regarding their preferences for prioritizing solutions, City Engineering worked to create a near-term plan for the watershed knowing that not all the flood mitigation targets would be able to be met watershed wide. This near-term plan would likely be implemented over the next 0-25 years and provide flood mitigation benefits to areas in the watershed without relying on or requiring the reconstruction of the Spring Harbor Box right away. Areas served by recommended projects that did not drain to the Spring Habor Box were not re-evaluated since meeting flood mitigation targets in these areas was achievable and had no effect on the rest of the watershed since these are discrete drainage areas. Solutions that provided flood mitigation to arterial roads were prioritized and regional solutions that had less resident concern were utilized in the short-term plan development. Through this process City Engineering developed a suite of recommended solutions that would be more feasible in the near-term and that would address the concerns raised by residents after the original watershed study.

1.6 Proposed Solutions and Costs

At the completion of the additional round of modeling, the City had updated the Spring Harbor Existing Conditions model and developed two new Proposed Conditions models with accompanying suites of solutions: the All Solutions and the Near-Term Solutions.

It should be noted that the flood mitigation solutions documented in this report are not meant to be full design -level efforts; they are conceptual solutions that help City Engineering 's Engineering Division understand the magnitude of solution needed in a given area to meet the established targets. As projects are evaluated further, and if they move to the point they are contemplated for programming, additional project refinement will occur. The detailed design phase collects site specific data needed for design and looks at refining the design as needed to address site constraints, permitting, and environmental issues associated with the particular project.

1.6.1 All Solutions Suite

- Upsize Upper SH (Spring Harbor) & Box Glen Hwy Box Culvert
- West Towne Retention Pond (Currently Programmed in 2025-2026)
- Masthead Greenway Pond
- Forsythia Wall (3.5' shorter at tallest point—7' max) + Owen Park Ditch (half the size of original)
- Glen Oak Hills Berms
- Greenway Crossing Upsizes: Yellowstone, Quarterdeck, Jetty, Masthead, Inner, South Hill, and Regent Box Culverts
- Beltline Off-Ramp Pond
- Garner Park Flood Wall (4' high) + Kenosha Relief Pipe
- Forsythia Cunette Modifications
- Upsized Lower SH (Spring Harbor) Box
- Local Sewer Upsize Pipes watershed-wide

1.6.2 Near-Term Solutions Suite

- Upsize Upper SH (Spring Harbor) & Box Glen Hwy Box Culvert
- West Towne Retention Pond (Currently Programmed in 2025-2026)
- Inner Dr and South Hill Greenway Crossing Upsize
- Beltline Off-Ramp Pond
- Garner Park Flood Wall (4' high) + Kenosha Relief Pipe
- Forsythia Cunette Modifications
- Local Sewer Upsize Pipes on arterials and in the West Towne Pond and Mendota drainage areas

1.6.3 Solutions Costs Summary

Table i: Solutions Cost Summary

Near-Term Solutions (0-25yrs)	All Solutions (0-50 yrs)
• Upsized Upper Spring Harbor Box - $9M • Beltline Off-Ramp Pond - $1.5M • Garner Park Flood Wall & Kenosha Relief Sewer - $2.7 M • West Towne Retention Pond - $4.5M (Currently programmed in 2025-2026) • Forsythia Wall (shorter) + Cunette Modifications - $5 M • Inner Dr and South Hill Culvert - $0.7M • Local Sewer • **Total without local sewer: $23.4M**	• Upsized Upper & Lower Spring Harbor Box - $9M (upper) + $12M (lower) • Beltline Off-Ramp Pond - $1.5M • Garner Park Flood Wall & Kenosha Relief Sewer - $2.7M • West Towne Retention Pond - $4.5M (Currently programmed in 2025-2026) • Masthead Greenway Pond - $2.6M • Forsythia Wall (shorter) + Cunette Modifications - $7.1M • Glen Oak Hills Berms – $1.8M • Greenway Crossings - $4.7M • Local Sewer • **Total without local sewer: $46M**

2. Introduction

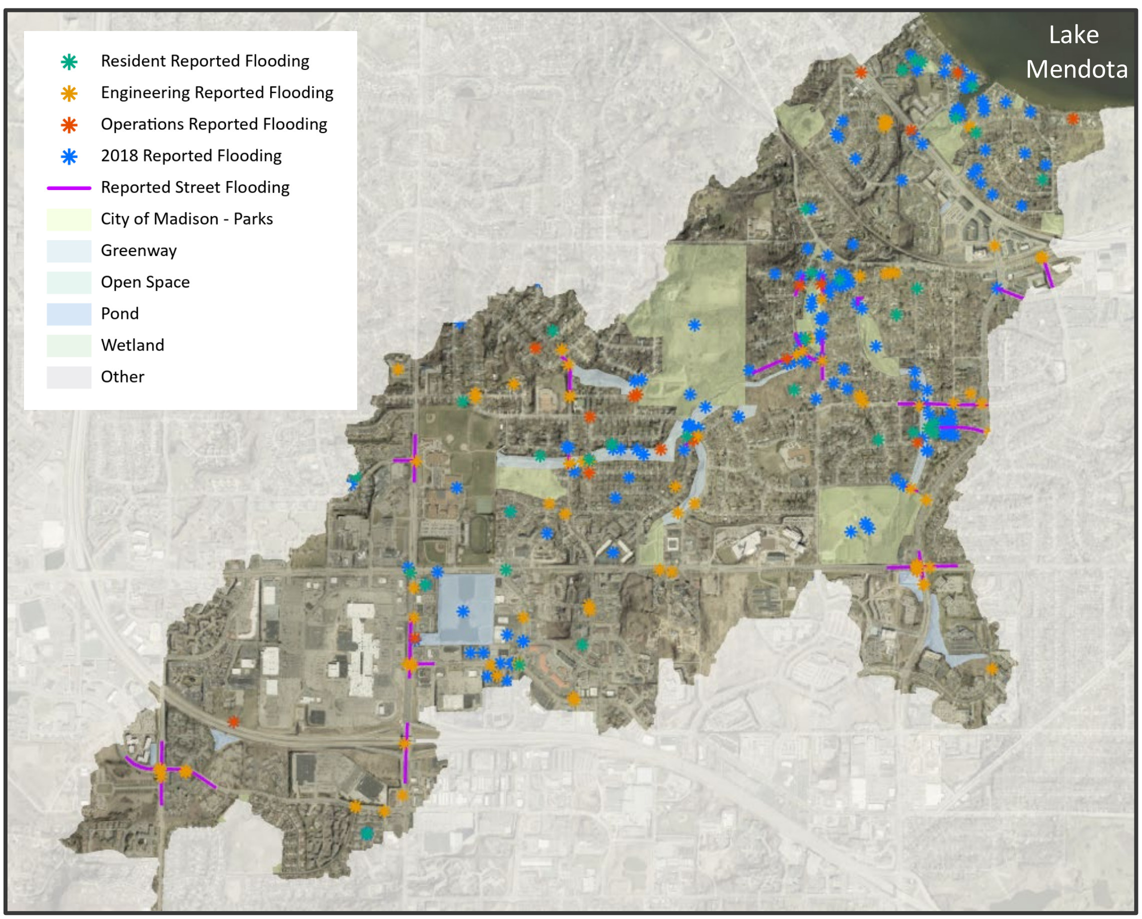
2.1 Spring Harbor Watershed Challenges

The Spring Harbor Watershed has many unique challenges that make managing stormwater and mitigating flooding within the watershed particularly difficult. Outlining these challenges below serves to provide additional background on the decision-making process in developing and recommending the conceptual flood mitigation projects.

2.1.1 The Development of the Spring Harbor Watershed

The Spring Habor Watershed in the City of Madison was developed mostly during the 1950's and 1960's. Stormwater designers, who designed the initial stormwater systems in the watershed during that time, designed to different standards. They did not plan for the larger rain events that we plan for today. Additionally, they did not account for the current trend towards more frequent intense rain events that we are experiencing today and expect to continue to experience into the future. They also did not have the modern tools that we have today that allow us to complete a comprehensive study of the entire watershed. Because of these factors, during the development of the stormwater drainage system and the surrounding areas, it was often the case that an insufficient amount of land was set aside to store or transport stormwater. This has led to frequent flooding of certain areas. Additionally, because most of the watershed is now developed for other uses there is little space available to expand the surface storage and transport of stormwater which has led engineers to rely more heavily on underground infrastructure (larger storm pipes) to mitigate the current flooding challenges.

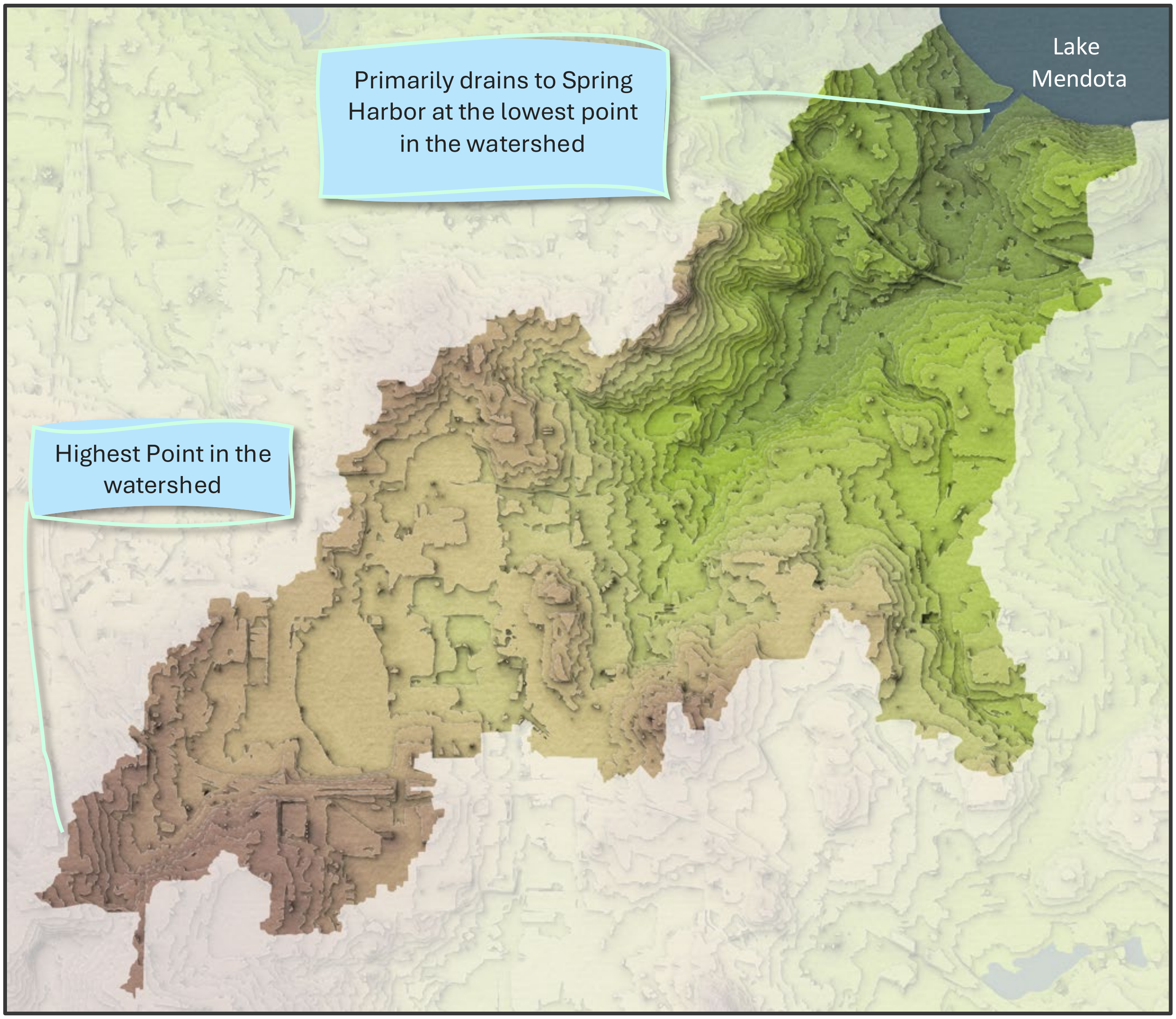
Figure ii: Flooding in the Spring Harbor Watershed Map



2.1.1 The Unique Topography of the Spring Harbor Watershed

The Spring Harbor Watershed, which spans from southwest of the Beltline down to Lake Mendota, covers approximately 2,390 acres. It ranges in elevation from about 1190 ft. at its highest point to about 850 ft. near Lake Mendota at its lowest point. The Spring Harbor Watershed boundary is drawn to encompass all areas that drain to or immediately near Spring Harbor at Lake Mendota.

Figure iii: Spring Harbor 3D Topography Map

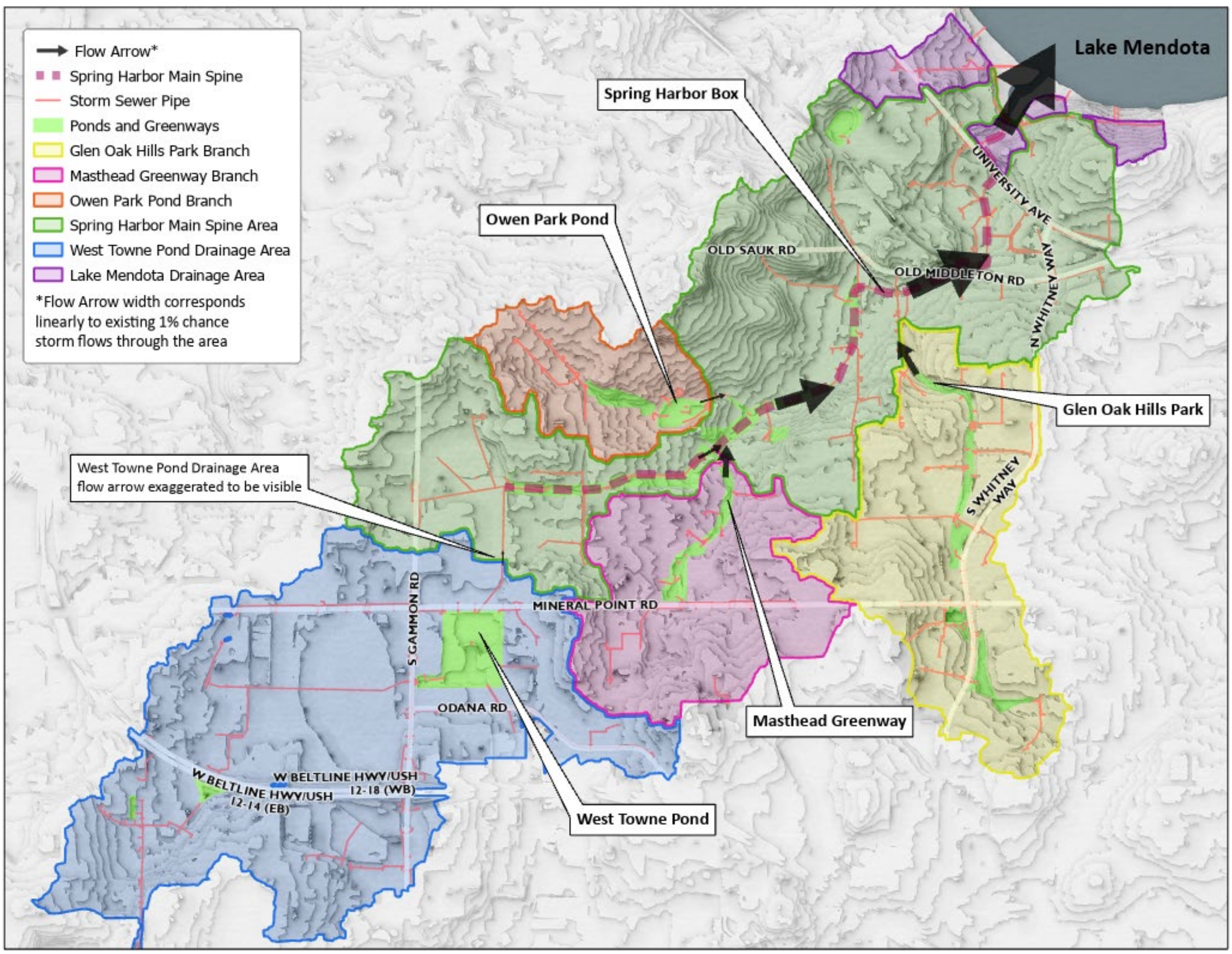


While the Spring Harbor Watershed is one single watershed, it can be subdivided further into a few different discrete drainage areas or sub-watersheds. First are the areas that drain directly to Lake Mendota near Spring Harbor, next are the areas that drain to the Spring Habor Box (a large rectangular-shaped storm pipe that carries more flow than a standard round pipe) before eventually draining to Spring Harbor at Lake Mendota, and last are the areas that drain to West Towne Pond before eventually draining to the Spring Harbor Box and then Spring Harbor at Lake Mendota.

The West Towne Pond drainage area or sub-watershed *(See the blue area in Figure iv below)* functions virtually independently from the rest of the watershed, as there are no major over land routes that stormwater can take to the Spring Harbor Box drainage area of the watershed. This is because the area is "bathtub shaped", lower in the Middle and Higher along the edges. Additionally, the only pipe that connects the West Towne Pond drainage area to the other portions of the watershed is a 36" pipe which doesn't have additional capacity to carry more flow than it does currently. The areas that drain directly to Lake Mendota *(See the purple areas in Figure iv below)* also function virtually independently from the rest of the watershed. Flooding in these areas is dependent on the small sections of the stormwater system, storms sewers in this case, that transport stormwater directly to Lake Mendota near Spring Harbor and that don't connect to other larger portions of the stormwater system.

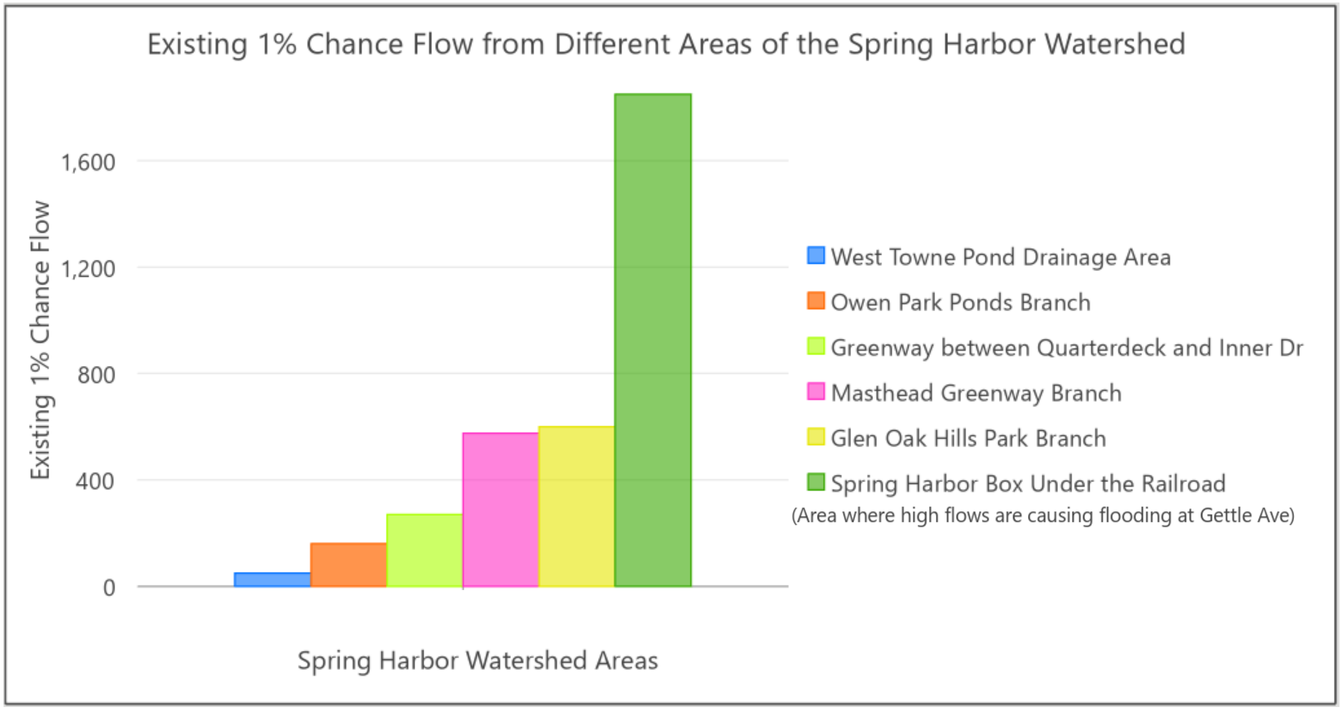
The Spring Harbor Box drainage area is the largest and most complex portion of the Spring Harbor Watershed. It is also the area with some of the biggest challenges. This portion of the watershed is made up of a main "spine" and three smaller branches. The main drainage spine *(See dotted line in Figure iv below)* flows west to east from Mineral Point Park, to Owen Park, to Gettle Ave. and finally to Spring Harbor at Lake Mendota. It also carries the largest portion of stormwater through the watershed. The watershed also has three "branches" one that flows through the Masthead Greenway *(See the pink area in Figure iv below)*, one that flows through the Owen Park Ponds *(See the orange area in Figure iv below)*, and one that flows through the Glen Oak Hills Park/Greenway *(See the yellow area in Figure iv below)*. The flows through these branches are much smaller than through the main spine but contribute to the flows and issues in the main spine.

Figure iv: Spring Harbor Drainage Areas Map



The existing 1% annual chance event flows, or the flows that we would expect during a storm that has a 1% chance of occurring during a given year, for different areas of the Spring Harbor watershed can be seen in more detail in Figure v below.

Figure v: Spring Harbor Existing 1% Chance Flows

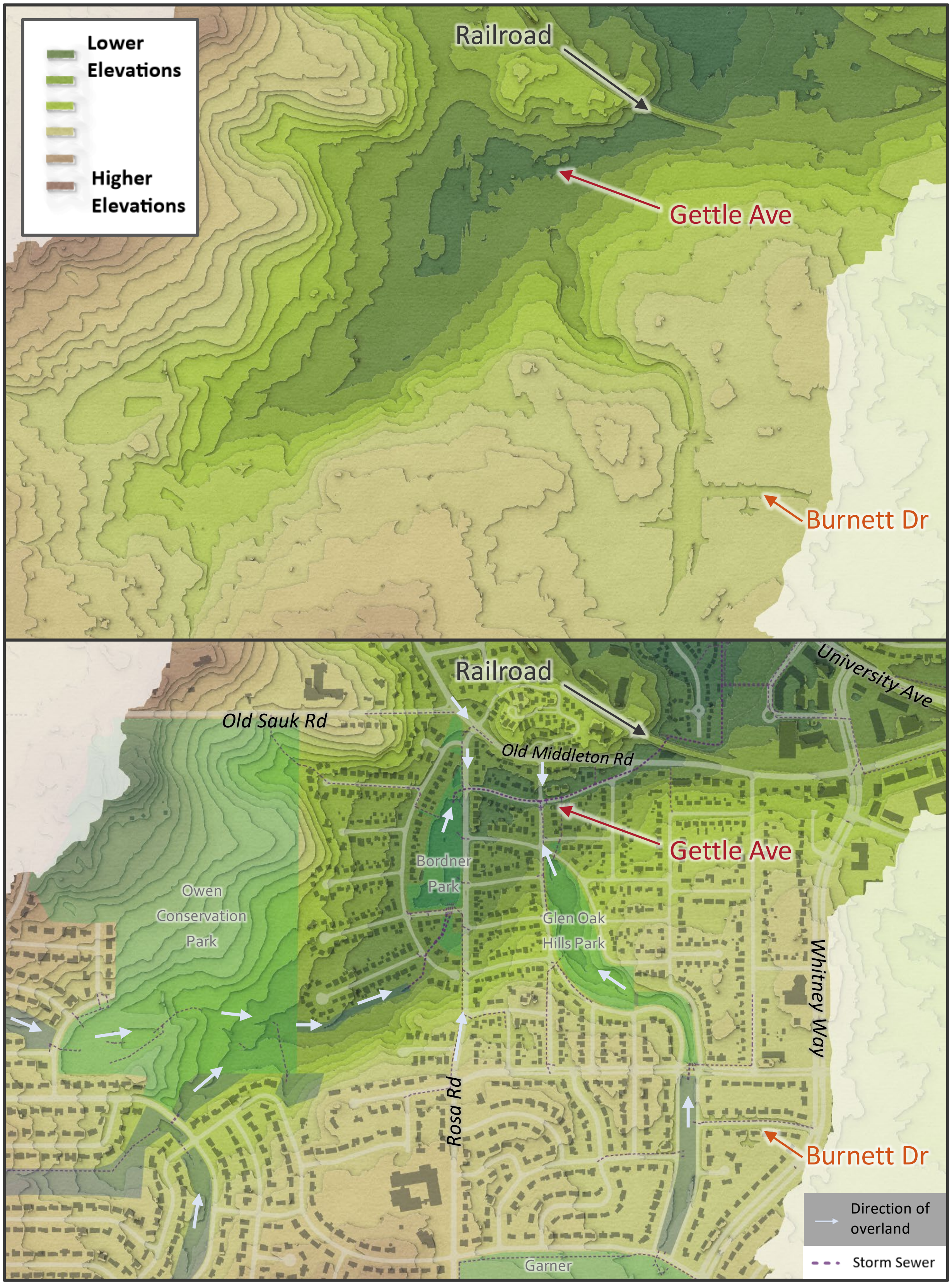


There are two areas to note in the watershed where flood mitigation is particularly difficult due to the topography. Please refer to the Figure vii on the next page to help illustrate the explanation below.

The first area is Gettle Ave., situated between Rosa Rd and Old Middleton Rd. It lies lower than the surrounding areas resulting in stormwater draining to it from many directions. It also lies on top of the first/most upstream segment of the Spring Harbor box. The box essentially functions as the only route for stormwater to leave the area and continue flowing downstream towards Spring Harbor at Lake Mendota. The surrounding higher areas especially near the railroad tracks keep the stormwater from having a secondary route to flow overland when the box becomes overwhelmed. This leads to significant flooding in the area.

The second area is Burnett Ave. located between the Kenosha Greenway and Whitney Way. Some of the homes on this road and in the surrounding areas are situated relatively low compared to the adjacent Kenosha Greenway. When the greenway becomes overwhelmed by flows draining to it the lower homes in the area quickly start to flood. One way to mitigate flooding in this area would be to increase the conveyance at the downstream end of the greenway by increasing the size of the pipe under the road at Regent St. Doing this would help stormwater leave the greenway more quickly and help mitigate some of the home flooding. However, doing this would also increase flows into the Glen Oak Hills Greenway and, as a result, to Gettle Ave. which is just downstream of the Glen Oak Hills Park and already experiences significant flooding. Unfortunately, this means the simplest solution for Burnett Dr is one City Engineering will not pursue as it does not meet the flood migration target that states the City must “provide flooding solutions that do not negatively impact downstream properties”.

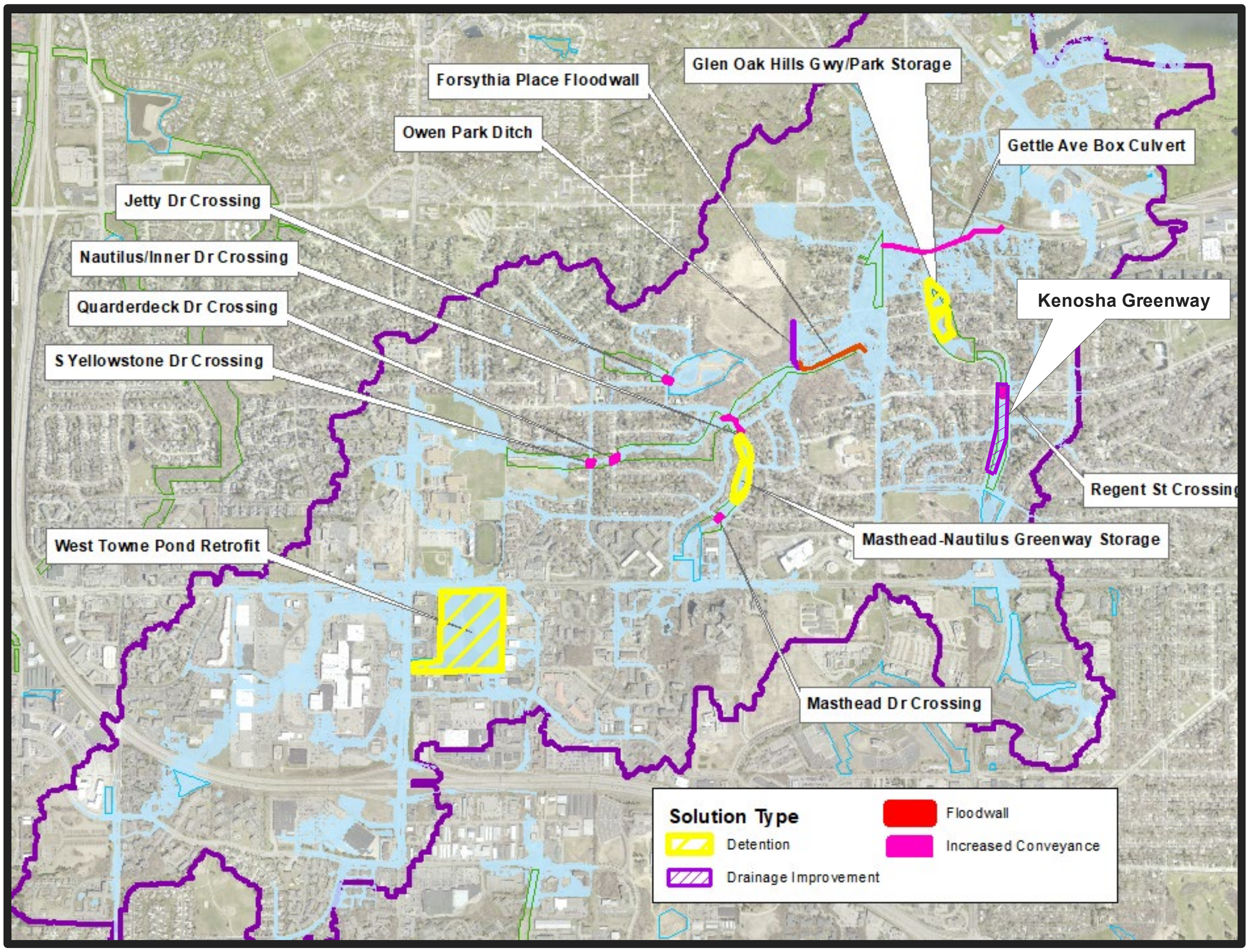
Figure vi: Spring Harbor Challenges – Gettle Ave and Burnett Dr Areas



2.2 Original Watershed Study

Spring Harbor was one of the first watersheds studied as a part of, the then new, City of Madison's Watershed Study Program. The study began in 2019, led by AE2S a consulting firm hired by City Engineering. During the study, the consultant team developed a comprehensive Hydrology and Hydraulics model of the Spring Harbor Watershed and developed a comprehensive set of flood mitigation recommended solutions within the watershed to reach the stated flood mitigation targets. Along with City Engineering, AE2S held three public information meetings (April 25, 2019, February 24, 2020, June 30, 2021) to provide updates on the study and to engage with residents. Several focus groups were also held throughout the watershed with residents to gather more information on the flooding experiences of residents and to answer questions. In the end the project team's recommendations included 3 detention area improvements, 2 channel conveyance improvements, 7 greenway crossing improvements, 1 flood wall (10.5' tall at highest point), upgrades to the Spring Harbor Box and significant upgrades to the local sewers throughout the watershed. The watershed study final report was posted for public comment in October 2021 and the contract with AE2S ended in June 2022.

Figure vii: Spring Habor Original Watershed Study Recommended Solutions



2.3 Public Feedback on Draft Final Report

During the public comment period, following the final report being posted in October 2021, City Engineering received 58 comments and over 100 individual questions. The feedback on the final report centered around concerns about recommended changes to the Watershed's wooded greenways, including the recommended Kenosha Greenway Regrading project and the Forsythia Flood Wall and Owen Park N/S Channel project. Residents were concerned about the significant tree removals required for some of the projects. They were also concerned that the overall natural feel of the area would change. Additionally, residents in the area of the Kenosha Greenway did not want the greenway vegetation and character modified as they had been voluntarily actively managing the greenway by removing invasives since 2020.

Figure viii: Original Study Public Feedback – Concern by Topic

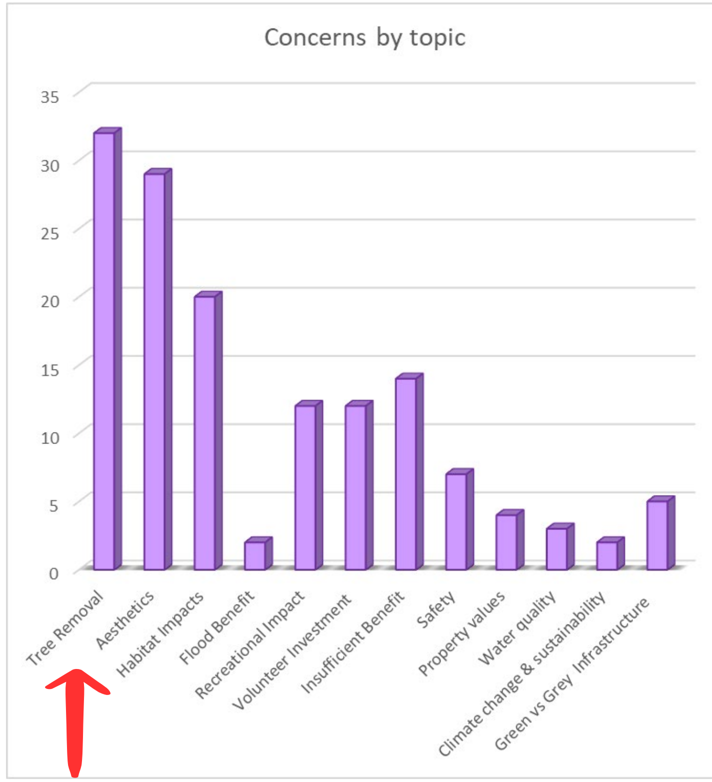
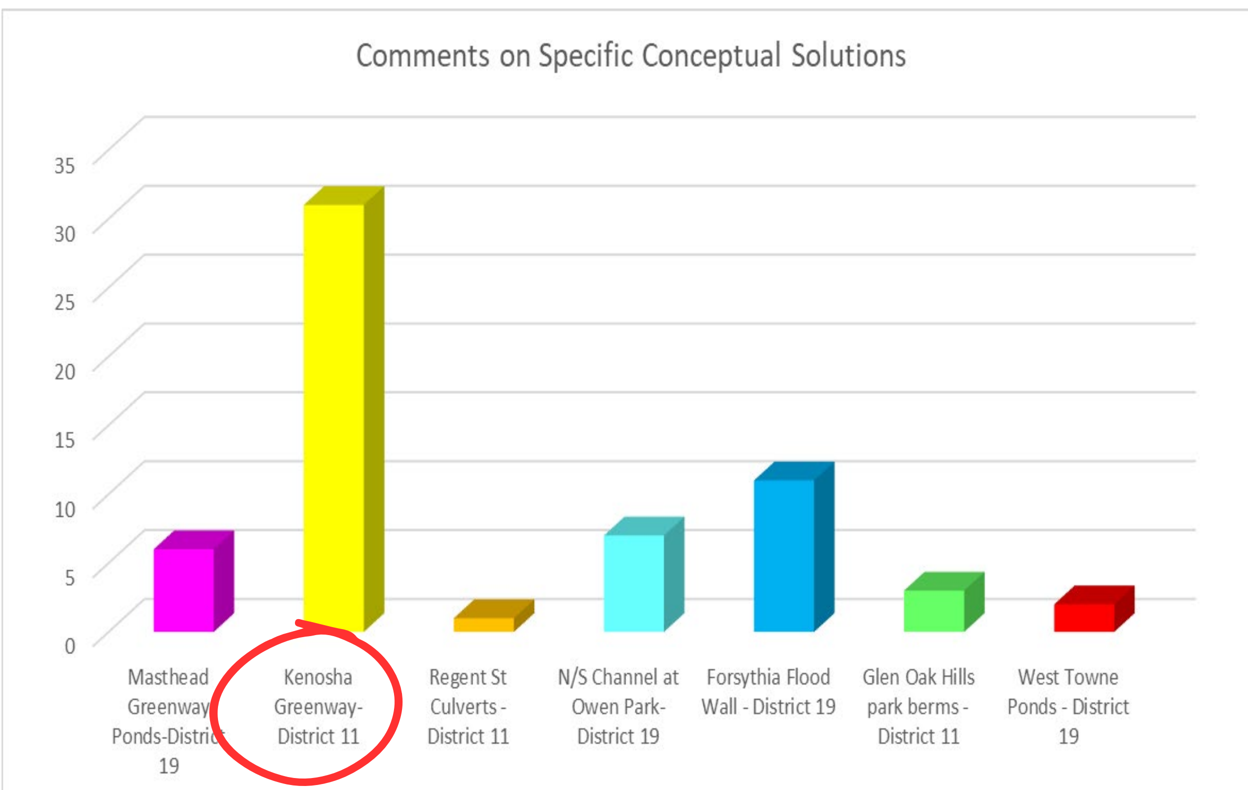


Figure ix: Original Study Public Feedback – Comments by Conceptual Solution



2.4 Need for Additional Watershed Modeling

City Engineering responded to many resident questions that were received during the comment period; however, some questions could not be answered without additional watershed computer modeling. Residents desired to know whether certain projects could be omitted or replaced by other alternatives. Residents provided many alternatives combinations that they hoped could be modeled in addition to the previous work that was done.

This led City Engineering to make the decision to conduct a round of additional watershed modeling in-house starting in July 2022. After reviewing resident feedback and completing an initial round of brainstorming, City Engineering decided it would model over 29 different scenarios and would host a 4th public information meeting to provide a project update and answer the questions that residents had after the initial study.

THE TARGETS OF THE IN-HOUSE MODELING WERE TO:

1. Determine the impact of not implementing solutions with public concerns
2. Determine the viability of alternative solutions that were recommended by the public or brainstormed internally
3. Develop near-term plan for flood mitigation projects, including a plan for the replacement of the Regent St. culvert, which was deteriorated and needed to be replaced.

Additionally, it was decided as part of this effort that City Engineering would update the Existing Conditions and Proposed Conditions models with projects within the watershed that had been completed since the development of the models starting in 2019 or that were nearing completion.

3. Living Model Updates

As part of this modeling effort, City Engineering updated the Existing Conditions and Proposed Conditions models provided by AE2S after their completion of the original watershed study. This was done to get the most accurate estimation of the flooding in the watershed at that current point in time. Several recent street reconstruction projects and private development projects, including the Element Collective project in University Research Park, were included as part of the update. General updates made to the models' datasets were also made, including the update to the most recent ground surface data that was available. Lastly, changes were made to the models' methodological parameters to standardize the model with guidance developed for the later watershed studies.

A summary of the specific updates to the models can be found in the sections below.

3.1 Existing Conditions Model Updates

1. Added Old Middleton Rd. & Craig Ave. Reconstruction Projects with new storm sewers
2. Added Gammon Rd. Reconstruction Project with new storm sewers
3. Added Mendota Dr. Reconstruction Project with new storm sewers
4. Added the designs for the Element Collective Development Project in University Research Park including new stormwater ponds and underground storage
5. Added the designs for the Zor Shrine Development Project including new storm sewer
6. Added the designs for the 5133 University Ave. Redevelopment Project new stormwater ponds
7. Added the designs for the West Place Redevelopment Project new storm sewer and underground storage
8. Added the design for Car Max Redevelopment Project new storm sewer and underground storage
9. Adjusted the manning's n in the Kenosha greenway per the recommendation of residents
10. Increased the Min/Max Infiltration rates for Owen Park subcatchments per the recommendation of residents
11. Updated 1D/2D connections in the model to optimize functionality of stormwater culverts
12. QC'ed pipes throughout the watershed and updated from plans where needed
13. QC'ed stormwater ponds throughout the watershed and added to the 2D portion of the model and updated from plans where needed
14. Split subcatchments where a finer level of detail in the models was needed to answer resident questions
15. Added pipes from older private development projects from plans where a finer level of detail in the models was needed
16. Update the model surface with City Engineering _of_Madison_DEM_2022.tif created from a Lidar flight collected in 2022

3.2 Proposed Solutions Model Updates

1. Added Old Middleton Rd. & Craig Ave. Reconstruction Projects with new storm sewers
2. Added Gammon Rd. Reconstruction Project with new storm sewers
3. Added Mendota Dr. Reconstruction Project with new storm sewers
4. Added the designs for the Element Collective Development Project in University Research Park including new stormwater ponds and underground storage
5. Added the designs for the Zor Shrine Development Project including new storm sewer
6. Added the designs for the 5133 University Ave. Redevelopment Project new stormwater ponds
7. Added the designs for the West Place Redevelopment Project new storm sewer and underground storage
8. Added the design for Car Max Redevelopment Project new storm sewer and underground storage

9. Adjusted the manning's n in the Kenosha greenway per the recommendation of residents
10. Increased the Min/Max Infiltration rates for Owen Park subcatchments per the recommendation of residents
11. Updated 1D/2D connections in the model to optimize functionality of stormwater culverts
12. QC'ed pipes throughout the watershed and updated from plans where needed
13. QC'ed stormwater ponds throughout the watershed and added to the 2D portion of the model and updated from plans where needed
14. Split subcatchments where a finer level of detail in the models was needed to answer resident questions
15. Added pipes from older private development projects from plans where a finer level of detail in the models was needed
16. Update the model surface with City Engineering _of_Madison_DEM_2022.tif created from a Lidar flight collected in 2022
17. Removed long weirs used to route water from the subcatchment runoff nodes into the storm sewers*

*To simulate inlet capacity in the original watershed models, AE2S used flat crested weirs of varying lengths to route subcatchment runoff into the storm sewers. This methodology originally seemed logical, as it was an easy way to switch between simulating areas with a specific amounts of inlet capacity for the Existing Conditions model and areas with assumed unlimited inlet capacity for the Proposed Conditions model. However, it was discovered by City Engineering during the update of the model that the very long weirs, used to simulated unlimited inlet capacity in the Proposed Conditions models, created additional model instability and reduced the amount of peak runoff getting into the storm sewers. The long weirs present in the Proposed Conditions model were removed by City Engineering to stabilize the model and provide more reliable model results. With modeled runoff flows now able to enter the storm sewers more effectively, slight increased flows were seen throughout the watershed including in the main spine of the watershed and in Spring Harbor Box (the major outlet of the watershed from Bordner Park thru the outlet at Spring Harbor). It should be noted that the increased flows from these changes is a more accurate representation of the actual stormwater system performance and by including the changes the most appropriate size for solutions would be able to be determined. The shorter weirs present in the Existing Conditions model were left in the model, as their lengths were more precise, and they were not creating instability issues.

4. Resident Driven Scenario Modeling

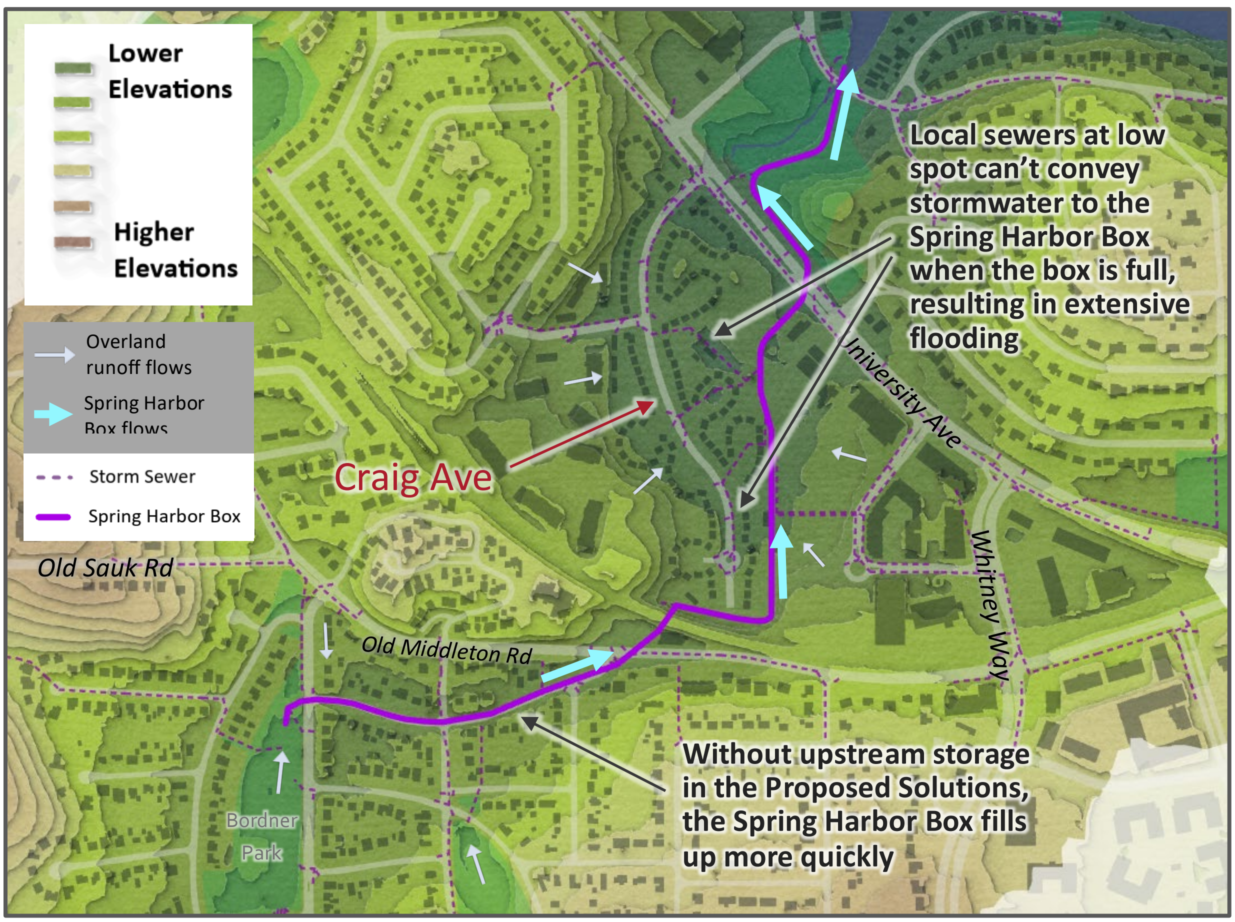
4.1 Resident Concern Driven Scenario Modeling

With the newly updated Existing Conditions and Proposed Conditions models, City Engineering started working to complete the over 29 additional modeling scenarios developed to investigate the questions and concerns raised by residents after the initial watershed study and to examine alternatives to the initial proposed solutions. It was during this time that City Engineering decided that it would be necessary to fully redevelop the suite of recommended solutions laid out during the initial watershed study, and that it would be necessary to do additional modeling to answers questions around the Craig Ave. Reconstruction and Regent St. Culvert Replacement projects that were planned to be/or needed to be constructed soon in the immediate future.

4.2 Craig Ave. Scenarios and the Decision to Redevelop the Proposed Solutions Model

While modeling these additional resident concern driven scenarios, it became clear that removing any of the stormwater storage solutions, in the upstream portion of Spring Harbor Box drainage area, resulted in negative impacts at Craig Ave. When these projects (Glen Oak Hills Berms, the Masthead Greenway Ponds, the Forsythia Flood Wall, and the Regrading of the Kenosha Greenway) were removed in the model, flows to the Spring Harbor Box increased past what had been proposed with the original recommended suite of solutions. With these increases in flows, runoff flowing overland from the surrounding neighborhood to the

Figure x: Craig Ave. Area Challenging Drainage



low spot at Craig Ave. was no longer able to enter the local storm sewer and the Spring Harbor Box, resulting in significant flooding in this area. Additional flows to the Spring Harbor Box also resulted from the improved modeling of the inlets to the system in the proposed conditions model, further exacerbated the issue. Flooding in this area was not predicted in the Existing Conditions model but was specifically predicted in the Proposed model because of the increased flows upstream.

In 2022, with the Craig Ave. reconstruction project scheduled to begin soon, City Engineering decided to run several scenarios to determine if any feasible solutions in the Craig Ave. area could be developed to mitigate the negative impacts seen in the modeling when increasing flows to the Spring Harbor Box upstream of Craig Ave. Different configurations of relief pipes from Craig Ave. to Lake Mendota were modeled. While the modeling showed that a large relief pipe could mitigate flooding at Craig Ave., the scope of the project made it similarly as infeasible as replacing the lower portion of the Spring Harbor Box that the relief pipe was meant to provide additional capacity to.

Ultimately, after discovering the many challenges created by modest alterations to the original recommended suite of solutions, City Engineering decided that it made more sense to fully redevelop the Proposed Conditions model and the recommended suite of solutions. This new Proposed Conditions model and the recommended suite of solutions would incorporate the feedback from residents and the increased flows into the local sewer from the removal of the inlet weirs. The Craig Ave. reconstruction project would move forward as designed.

4.3 Regent Street Scenario Development

After it was decided that City Engineering would redevelop the recommended suite of solutions for the Spring Habor watershed, the attention of the modeling efforts turned to the culvert under Regent St. at Kenosha Dr. which was failing and in need of replacement very soon. The redevelopment of the recommended suite of solutions would take a significant amount of time and effort, and a plan for the replacement of the Regent St. culvert needed to be developed so the culvert could be replaced during the summer of 2023.

4.3.1 Near-Term Regent Street Solutions Modeling

While the main goal at this time was to decide what size pipe would be needed to replace the current failing pipe under Regent St., it was also a goal to develop a set of recommended solutions for the Kenosha/Glen Oak Hills branch of the watershed that could function in concert with the new pipe at Regent St. During the process to develop a suite of solutions for the branch, City Engineering developed and ran a total of 40 scenarios with additional sub-scenarios. These scenarios included different combinations of upsized or additional storms sewers in the larger area, and walls/berms in Glen Oaks Hills Park/Greenway, Garner Park, and the Kenosha Greenway. The various walls and berms analyzed were included as solutions that could increase storage without the need to regrade these areas, thus minimizing impacts to trees.

4.3.2 Near-term Regent Street Recommended Solution

Through this modeling process, City Engineering was able to come to a set of conclusions. However, there were no near-term feasible solutions that had large flood improvements at Burnett without shifting flooding to Gettle Ave. Additionally, larger, possibly unpopular solutions, would be needed to prevent shifting flooding to Gettle Ave. It was decided that it would be inappropriate to recommend any of the larger projects without fully understanding the implications that they could for other parts of the larger watershed. Until the time that a full recommended suite of solutions could be developed for the watershed, City Engineering would replace the current culvert under Regent St. with slightly larger culvert pipes and build a set of terrace inlets to capture the slightly increased flows immediately downstream of Glen Oak Hills Park. This effort was shared with the public on June 28th, 2023, and constructed in late summer of 2023.

5. All Proposed Solutions Model Development

With the urgent questions addressed, City Engineering started the process of redeveloping a new suite of recommended solutions and a new Proposed Solutions Model for the Spring Harbor watershed. The goal would be to meet all City Engineering 's flood mitigation targets while minimizing projects that raised the most concerns for residents, while also ensuring the new project recommendations handled the increased flows that resulted from the removal of the inlet weirs. The development of the model and solutions would proceed starting first with the development of local sewer upgrades followed by the development of regional solution, the same process that was used to develop the original model and suite of solutions.

5.1 Local Sewers Modeling

The first stage of building the Proposed Solutions model was to upsize local storm sewers to meet the 10 and 25-year targets. This step was completed first, so increased flows from the local storm sewers would be accounted for when sizing regional solutions such as greenway crossings. First, local storm sewers were sized appropriately so runoff would not leave the storm sewers and inundate the local roads in the 10-year event. Local storm sewers were then additionally upsized so no roads would be inundated at a depth greater than .5 ft at the road centerline in the 25-year event.

5.2 Regional Solutions Scenarios Modeling

During the next stage of building the Proposed Conditions model, regional solutions were added to the model starting in the upstream sections of the watershed moving downstream. Solutions developed during the initial watershed study, that did not receive significant feedback were added into the Proposed Conditions model first. For areas where the original watershed study had recommended solutions that ended up being unpopular, City Engineering brainstormed and tested alternative conveyance and storage solutions. Initially, different combinations of solutions were tried with the desire that the timing of the peak flows leaving the branches of watershed could be shifted enough as to no longer "stack" and create excess flooding when reaching the main branch of the watershed. Ultimately the solutions that succeeded in doing this most effectively were storage solutions that slowed the stormwater reaching the main spine of the watershed. City Engineering proceeded by brainstorming and testing new alternative storage solutions not tested in the original watershed study. Some solutions were less feasible but still tested to be thorough.

In the branch of the watershed with Kenosha Greenway and Glen Oak Hills Greenway, City Engineering examined the use of flood walls at Kenosha Greenway and at the northeast corner of Garner Park as alternatives to the regrading of the Kenosha greenway and the Glen Oak Hill Berms recommended in the original watershed study. Flood walls were used in the modeling as they provide additional storage capacity to greenspaces without the need to regrade and remove a large amount of trees/vegetation and they help mitigate flooding of nearby homes. Through many iterations it was determined that a short flood wall around Garner Pond at the northeast corner of the Garner Park appeared to provide the most benefit for a relatively modest project within this area. It would help mitigate flooding downstream at Burnett Dr and would cause the least impacts to greenspace access and viewing. It would not however, create the same flood mitigation benefits as both the regrading of the Kenosha Greenway and the Glen Oak Hills Greenway.

In the branch of the watershed with the Masthead Greenway and Nautilus Pond, City Engineering brainstormed alternative storage options to the Masthead Greenway Ponds, recommended in the original watershed study, but ultimately felt that the alternatives were limited. The Nautilus Pond area had already recently been reconstructed and designed to provide significant flood mitigation benefits to the area. The remaining City owned land in this branch of the watershed was limited to what was in the Masthead greenway. The Masthead greenway had been studying during the original watershed study, and alternative storage solutions for the greenway would not be significantly different from the original recommended solution. Because the solutions developed during the watershed studies are only meant to be conceptual solutions that help City Engineering understand the magnitude of solution needed in each area and are not meant to be full design -level efforts, evaluating alternative storage solutions in the Masthead Greenway would be most valuable when the project is budgeted and in the design phase. However, it is known that the storage is needed within this particular branch, not downstream within the main spine.

Lastly, City Engineering looked at alternative storage solutions in the main branch of the watershed. Because the highest flows through the watershed happen in this main branch of the watershed, alternative storage solutions in the area would need to be different than those in other areas. Because so much of the watershed drains to the main spine, including from the side branches, even when the rainfall intensities are low the flows through the main spine are significant. Additionally, because the most intense rainfalls are often preceded by light rainfall, solutions in the main spine needed to both allow through the significant flows often seen during the earlier parts of a storm and have stormwater storage available for only the most intense parts of a storm. One example of this would be a main channel with adjacent dry basins that only start to fill up when the main channel fills and overflows. If only a standard pond was built, rather than a pond and channel, the pond would end up filling during the earlier parts of a storm with no storage capacity remaining for the most intense parts of a storm that cause the worst flooding. The biggest drawback of these types of solutions is that they often have larger footprints and require significant disruptions to the surrounding landscape.

For the main spine, City Engineering considered 3 locations for these alternative storage solutions: the Mendota-Spring Harbor Greenway between Quarterdeck Dr and Inner Dr, the Owen Conservation Park Area, and the Bordner Park Area. The Mendota-Spring Harbor Greenway between Quarterdeck Dr and Inner Dr was too narrow for the type of storage solution needed (described above). Additionally, some homes surrounding the current greenway are situated low relative to the greenway and could be at greater flooding risk if additional stormwater was stored in this area. The Bordner Park area was also considered for alternative solutions, but City Engineering felt that storage options in the park were thoroughly evaluated during the original watershed study. Lastly, alternative storage solutions in the area of the Owen Conservation Park were considered as alternatives to the Forsythia wall recommended in the original study. Generally, these solutions were less desirable, as they would have impacts to the Owen Conservation Park area but, to be thorough, were evaluated as potential projects. The solutions examined included a large flood berm with a large box culvert immediately upstream of a modified version of the Forsythia Cunette (Figure 1X), and a series of dry ponds running adjacent to a modified version of the Forsythia Cunette (Figure 1X). While these solutions did mitigate flooding enough to meet the City's flood mitigation targets in the area, with other watershed storage solutions, the footprints of the projects and the resulting disruptions to the surrounding natural areas were not preferable to the disruptions from a Forsythia Cunette Wall. These two solutions are not recommended but the details of the solutions have been included in this report.

5.4 Final All Proposed Solutions Suite, the Drawbacks, and Need for Additional Near-Term Proposed Solutions

Through this process of testing alternative solutions, City Engineering concluded that, to meet the flood mitigation targets watershed-wide, many of the solutions that were unpopular in the original watershed suite of solutions would still be needed. Additionally, even with all these solutions in place, the replacement of the Lower portion of the Spring Habor Box would still be needed to mitigate negative impacts to Craig Ave. from increasing flows to the box upstream. The lower Spring Harbor Box is currently in good condition and will not need to be replaced for several decades, and construction was estimated to cost $12 million (2024 dollars). Unfortunately, this set of solutions did not address the concerns of residents and would not be constructable for several decades. Because of this City Engineering decided to keep the All Solutions model and suite of solutions as future hypothetical recommendations to be documented in the updated study and potentially more closely evaluated after the near-term solutions are implemented. These solutions would show the level of projects that would be needed to reach all the City's flood mitigation targets and would function as possible options for when the time came that the Lower Spring Harbor Box could be reconstructed, decades in the future. Also, as conditions change in the watershed or opportunities presented themselves for larger projects City Engineering would understand the potential benefits of such projects without needing additional study. From this decision, City Engineering also decided to make a second near-term solutions model and suite of solutions that would not include the Lower SH Box upsize or any regional solutions that City Engineering felt would not be feasible or popular in the near term.

5.3 All Solutions Recommended Solutions Suite

Solutions included in the All Solutions model and suite of solutions from the original watershed study:

- Upsize Upper SH (Spring Harbor) & Box Glen Hwy Box Culvert
- West Towne Retention Pond (Currently Programmed in 2025-2026)
- Masthead Greenway Pond
- Forsythia Wall (3.5' shorter at tallest point—7' max) + Owen Park Ditch (half the size of original)
- Glen Oak Hills Berms
- Greenway Crossing Upsizes: Yellowstone, Quarterdeck, Jetty, Masthead, Inner, South Hill, and Regent Box Culverts
- Local Sewer Upsize Pipes watershed-wide

New regional solutions included in the All Solutions model and suite of solutions:

- Beltline Off-Ramp Pond
- Garner Park Flood Wall (4' high) + Kenosha Relief Pipe
- Forsythia Cunette Modifications
- Upsized Lower SH (Spring Harbor) Box

Original Watershed Study solutions that are Excluded from the All Solutions model and suite of solutions:

- Kenosha Greenway

All Solutions Suite map can be found on Figure xxi: All Solutions - Recommended Solutions (0-50 yrs)

6. Near-Term (0-25 Years) Proposed Solutions Model Development

With the All Solutions model and suite of solutions complete, City Engineering started the process of developing a modified set of solutions for the near-term. The goals of this new model and suite of solutions, were to meet as many of the City's flood mitigation targets as possible while not including the Lower SH Box upsize or any regional solutions that City Engineering felt would not be feasible or supported by residents in the near term.

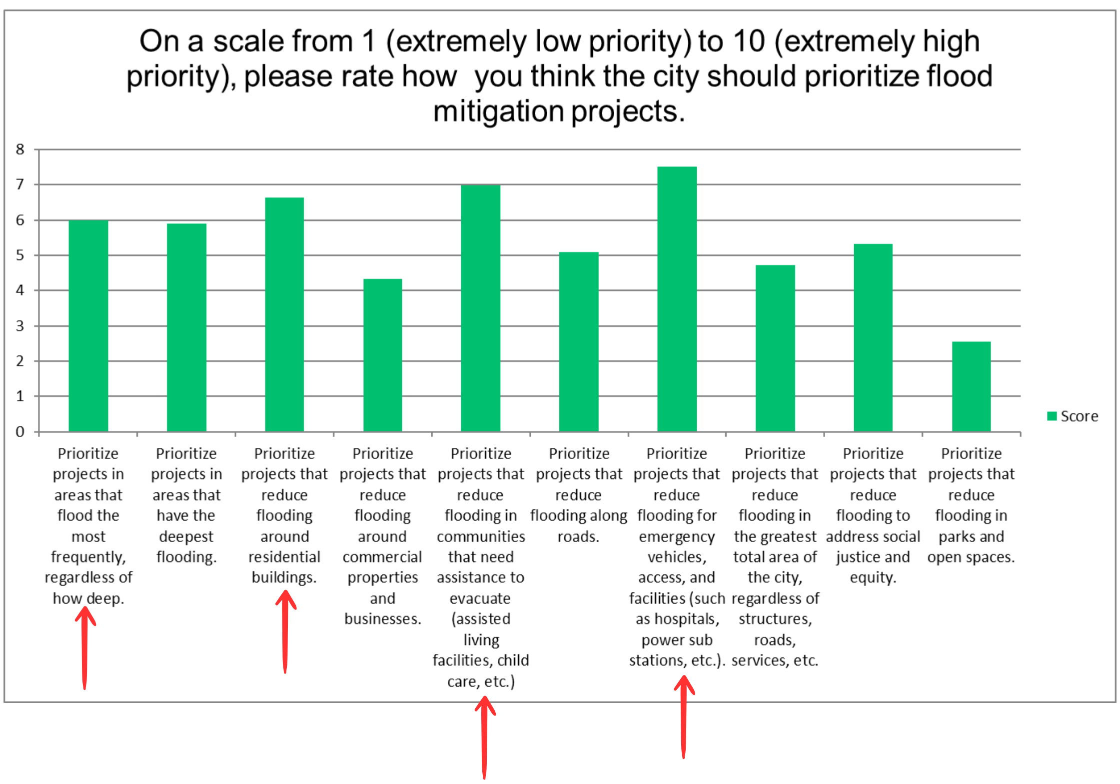
Knowing that the watershed study flood mitigation targets would not be met watershed-wide, City Engineering used resident feedback (from a citywide resident survey conducted starting in May 2021- https://www.cityofmadison.com/news/2021-05-11/survey-open-city-engineering-works-to-prioritize-flood-projects) as a guide for what areas would be prioritized in the Near-Term Solutions. These priorities included:

- Providing access for **Emergency Vehicles**
- Reducing risk of flooding for **residential homes**
- Reducing risk of flooding for residential homes that **flood most frequently or deepest**
- Reducing risk of flooding for **communities that need evacuation assistance**

The process developed to prioritize these needs is detailed in the following sections.

Figure xi: Feedback from Resident Survey

https://www.cityofmadison.com/news/2021-05-11/survey-open-city-engineering-works-to-prioritize-flood-projects



6.1 Splitting up the Watershed

To start the process of creating a near-term model and suite of solutions, City Engineering first started by reevaluating the challenges of developing the All Solutions model and suite of solutions. During this part of the modeling process, the Spring Habor Box was found to be the main limitation. When the Spring Harbor Box is replaced, there is a limit of how large it can reasonably be built while still fitting underneath the road. This means there is additionally a limit to how much stormwater can be sent to the box, within a certain period, before it becomes overwhelmed, and flooding occurs. Areas that drained to the Spring Harbor Box would need to be limited by the capacity of the Spring Harbor Box. Additionally, areas of the watershed that did not drain to the Spring Habor Box, the Mendota Drainage Area, or that did not have a meaningful impact on it, the West Towne Pond Drainage Area, (see Figure iv for reference) didn't have to be subject to the same restrictions. These two areas could keep the solutions that were recommended in the All Solutions suite of solutions. The areas draining to the Spring Harbor Box would need to continue to be evaluated.

6.2 Downsizing Flood Mitigation Targets Analysis

Next in the process of developing solutions for the portion of the watershed draining to the Spring Harbor Box, City Engineering wanted to evaluate if it would be possible to lower the City's flood mitigation targets evenly across the area. This would be a simple way to limit the flows reaching the Spring Harbor Box. Multiple scenarios were run adjusting the local storm sewers and regional solutions to meet the City's flood mitigation targets instead for smaller storms, e.g. meeting the "no surcharging onto the street" target for the 5-year storm instead of for the 10-year storm. However, the resulting flows to the Spring Habor Box were still too large and causing flooding, so reducing the City's flood mitigation targets for this portion of the watershed was not a viable solution.

6.3 10-Year and 25-Year Targets for Arterial Roads

After determining it was not feasible for City Engineering to reduce flood mitigation targets evenly across the Spring Habor box drainage area, City Engineering brainstormed other possible ways to adjust the targets. Due to the importance of the watershed's arterial roads, for transporting emergency vehicles during large storm events and for the BRT routes, these roads were prioritized first. This also aligned with what residents felt was most important to prioritize based on the feedback from the resident survey noted previously on Figure xi: Feedback from Resident Survey. The arterial roads prioritized included Whitney Way, University Ave., Mineral Point, and Gammon Rd and the local sewers would be upsized so that the 10-Year and 25-Year flood mitigations targets were met for those roads. It should be noted that for University Ave., the 10-Year goal could not be fully met due to overland flows from the Indian Hill Neighborhood. However, this goal could be met for University Ave. with the inclusion of improved roads with curb and gutter for the unimproved portions of this neighborhood Indian Hill Neighborhood.

6.4 Feasible Regional Solutions

Compared to upsizing the local sewers watershed-wide, by upsizing the local sewers only on arterial road to meet the 10-Year and 25-Year targets, there were limited increases in flow to the main spine of the Spring Harbor box drainage area. However, because the main spine of the Spring Harbor box already had limited capacity with the existing flows, it did cause additional flooding in the Gettle Ave. area. To mitigate these impacts, City Engineering added in the regional solutions from the All Solutions model that were expected to cause the least amount of concern to residents while providing flood mitigation benefits to the most flood prone areas, including Gettle Ave. These solutions included:

- Forsythia Cunette Deepened & Lowered
- Garner Park Flood Wall & Kenosha Storm Sewer Upsize

- Glen Hwy Box Culvert
- Upper Spring Harbor Box Upsize

6.5 Solutions to Mitigate Negative Impacts

After adding the region solutions, City Engineering felt that the suite of solutions developed adequately provided access to arterial roads and provided flood mitigation benefits to some of the highest flood risk areas while seeming feasible in the near-term. City Engineering did a final analysis to determine if there were any areas of the Spring Harbor drainage areas that were being impacted negatively by one of the other solutions that had been incorporated at that point. City Engineering determined that two areas in the watershed (a small area on Craig Ave. and a small area near the intersection of South Hill Dr and Inner Dr) had a slight increase in flood depth in the 1% chance event. City Engineering determined that to mitigate these negative impacts two solutions could be added that would ensure the near-term solutions weren't moving the flooding to other places within the watershed. To mitigate flooding in these two areas the following solutions were included:

- Inner Dr and South Hill Greenway Crossing Upsize
- Craig Ave. Sewer Upsize

Note: City Engineering also investigated upsizing the Quarterdeck greenway crossing which floods frequently and is predicted to overtop in the 2-year storm in the Existing Conditions model. However, it was found that when adding this solution into the near-term model resulted in negative impacts downstream that we were not able to mitigate without additional large regional solutions.

6.6 Near-Term Recommended Solutions Suite

Solutions included in the Near-Term Solutions model and suite of solutions from the original watershed study:

- Upsize Upper SH (Spring Harbor) & Box Glen Hwy Box Culvert
- West Towne Retention Pond (Currently Programmed in 2025-2026)
- Inner Dr and Sout Hill Greenway Crossing Upsize
- Local Sewer Upsize Pipes on arterials

New regional solutions included in the Near-Term Solutions model and suite of solutions:

- Beltline Off-Ramp Pond
- Garner Park Flood Wall (4' high) + Kenosha Relief Pipe
- Forsythia Cunette Modifications

Original Watershed Study solutions that are Excluded from the Near-Term Solutions model and suite of solutions:

- Kenosha Greenway
- Masthead Greenway Pond
- Forsythia Wall
- Glen Oak Hills Berms
- Owen Park Ditch
- Upsize Lower Spring Harbor Box

Near-Term Solutions Suite map can be found on Figure xxii: Near-Term Recommend Solutions (0-25 yrs)

7. Flood Mitigation Solutions Frequently asked Resident Questions

Why can't we more effectively utilize the greenspaces in the upstream areas of the watershed to infiltrate water and prevent flooding downstream?

The Spring Harbor Watershed is approximately 2,390 acres. 120 acres of those are managed by the Stormwater Utility, with 58 acres specifically being owned by the Stormwater Utility. During a 24-hr 1% annual chance storm (6.6 inches of rain in 24 hours) the Spring Harbor Watershed will receive 1,314 ac-ft* of rainfall (which is equivalent to the volume held by 647 Olympic swimming pools), 847 ac-ft of which our modeling shows will become runoff (which is equivalent to the volume 417 Olympic swimming pools). This 847 ac-ft of stormwater is what is then left for the Stormwater Utility to manage or what will otherwise flow unmanaged overland to areas that are lower in elevation. Based on our modeling, the watershed is already infiltrating 35% of the runoff during a 1% annual chance storm, in order for the Stormwater Utility-owned land to infiltrate the remaining runoff it would need to infiltrate an additional 14.6 ft (847 acres-ft ÷ 58 acres) of stormwater over the entire 58 acres of Stormwater Utility-owned land. This is an unattainable goal.

Why can't re-development near West Towne Pond fix downstream flooding?

The water coming from West Towne Mall all ends up in the West Towne ponds. There is significant flooding around West Towne Mall, which impacts businesses as well as arterial roads that serve as emergency service routes. The watershed study proposes a conceptual solution at West Towne Ponds that mitigates flooding around the ponds and does not increase flooding downstream. The proposed solution maximizes all available space, so there is not additional room to try to decrease the flows leaving this area. Also, to note, there is only a 36" pipe leaving the pond, which can convey 40 cubic feet per second, and by the time the stormwater is moving past Crestwood, the additional watershed area that contributes to the flow results in 1200 cubic feet per second flowing over the Forsythia channel (30 times as much flow). In other words, West Towne and everything upstream is only contributing to 3% of the flows by the time you reach Crestwood and the downstream areas near Gettle that flood. However, as areas around West Towne Mall redevelop, they will be required to meet more stringent stormwater utility rules, and this may help slightly decrease flooding throughout the watershed. Due to the unknown timeframe for redevelopment, and the fact that the City is not in control of when private land would be redeveloped, this was not included in the model. To learn more about the City's redevelopment standards see:

https://www.cityofmadison.com/development-services-center/land-development/private-property/stormwater-management

What other alternatives, such as flood mitigation on individual structures, or elevating the structures, considered? If so, why were they rejected?

Individuals are free to take flood protections on their property as they see fit, including raising structures. The City does not have a grant program and is not able to provide this type of assistance because, to utilize public funds on private property, the SWU needs to justify that the use of those funds benefits the public in general not just the property where they are being spent. If residents who are most at risk are willing to sell their homes to the Stormwater Utility, or flood-proof their homes, then solutions could be re-assessed based on the structures at risk of flooding at that time.

* An ac-ft or acre-foot is a unit of volume equivalent to the amount of water needed to cover an acre of land to a depth of 1 foot.

Could area upstream of Forsythia be used for flood storage to decrease conveyance of water in the cunette?

The Masthead Greenway Ponds is a recommended solutions that would increase storage and decrease flows to Forsythia. The Yellowstone and Quarterdeck Drive Greenways were evaluated but unfortunately the greenways are too narrow, and there are very low-laying houses alongside the greenway, so there is not a lot of available storage space to make a difference in peak flows. Additionally, these greenways compose the major spine of the stormwater conveyance system, therefore there is more water moving through these greenways, and it is harder to make a notable impact in the peak flows (which are what lead to flooding). In both the Masthead and Kenosha Greenways, there is less water moving through the system, and therefore utilizing the existing space in those greenway systems to store water delays the peak flows moving through them. This allows the peak flow to move through the major backbone of the system, before the other peak flows join it, which is what causes the worst flooding at Gettle Ave.

Could we use a pond where the Forsythia Cunette is and prevent the need of a flood wall?

As part of this recent modeling, the City did evaluate the creation of a pond and other storage solutions at this location. To achieve the same level of flood mitigation, a pond along this area would need to be very big. Due to the topography of the area, options for storage are very limited.

The flood wall allows the stormwater to get deeper before it goes into the box culvert under Bordner Drive, which pressurizes the pipe and allows more water to enter—it's essentially pushed into the pipe by the stacked water above it. A pond(s), in contrast, would need to hold enough water to reduce the peak stormwater flows to the rate that can enter the existing box. In order to do that in the main drainage spine, there would need to be significant tree removals south of the existing cunette and due to the steep topography, there would need to be a large retaining wall built on the southern side of the pond(s). For details, see Figure xxxv: Not Recommended Solutions - Forsythia Pond.

Will there be more sediment at the harbor?

There are many varying factors that determine the amount of sediment that deposits at the outfall of Spring Harbor.

Small storm events – most of the sediment and sand that accumulates on roadways and parking lots is transported to local water bodies in small and frequent storm events. The proposed flood solution projects would not materially affect how storms of this size (generally 100% chance storm event and smaller) flow through our system. Therefore, the City would expect no significant change in either the amount of sediment transported or rate at which it is transported.

Large storm events – large storm events can dislodge sediment that makes up the banks or has accumulated in the greenways (stormwater channels) themselves, especially in heavily wooded greenways. This is a result of erosive forces generated during very high rates of flow. These can be large washouts (Pheasant Branch Creek in 2018), or smaller more isolated washouts (10 cubic yards/one dump truck load) experienced in isolated places along the greenway. In an urban area, the washouts of greenways are due to the greenway experiencing flows/velocities/shear stresses that the greenway was not designed to accommodate. In the case of the greenways feeding Spring Harbor the proposed flood solutions take this into consideration and provide design solutions to improve existing greenways and ensure that they are designed to accommodate these larger storm events.

Safety of flood wall—how is it designed to not fail due to water pressure?

Flood walls are designed by structural engineers to withstand the forces of the anticipated water depths, including a factor of safety. This level of engineering design is completed when the project is budgeted and in the design phase.

How fixed is the recommended timeline? Could any projects be pushed back further or moved up?

Projects that increase the amount of stormwater storage, such as the Masthead/Glen Oak Hills greenway projects, could possibly be moved up in the implementation order if there is an opportunity to do the work and the public support is there.

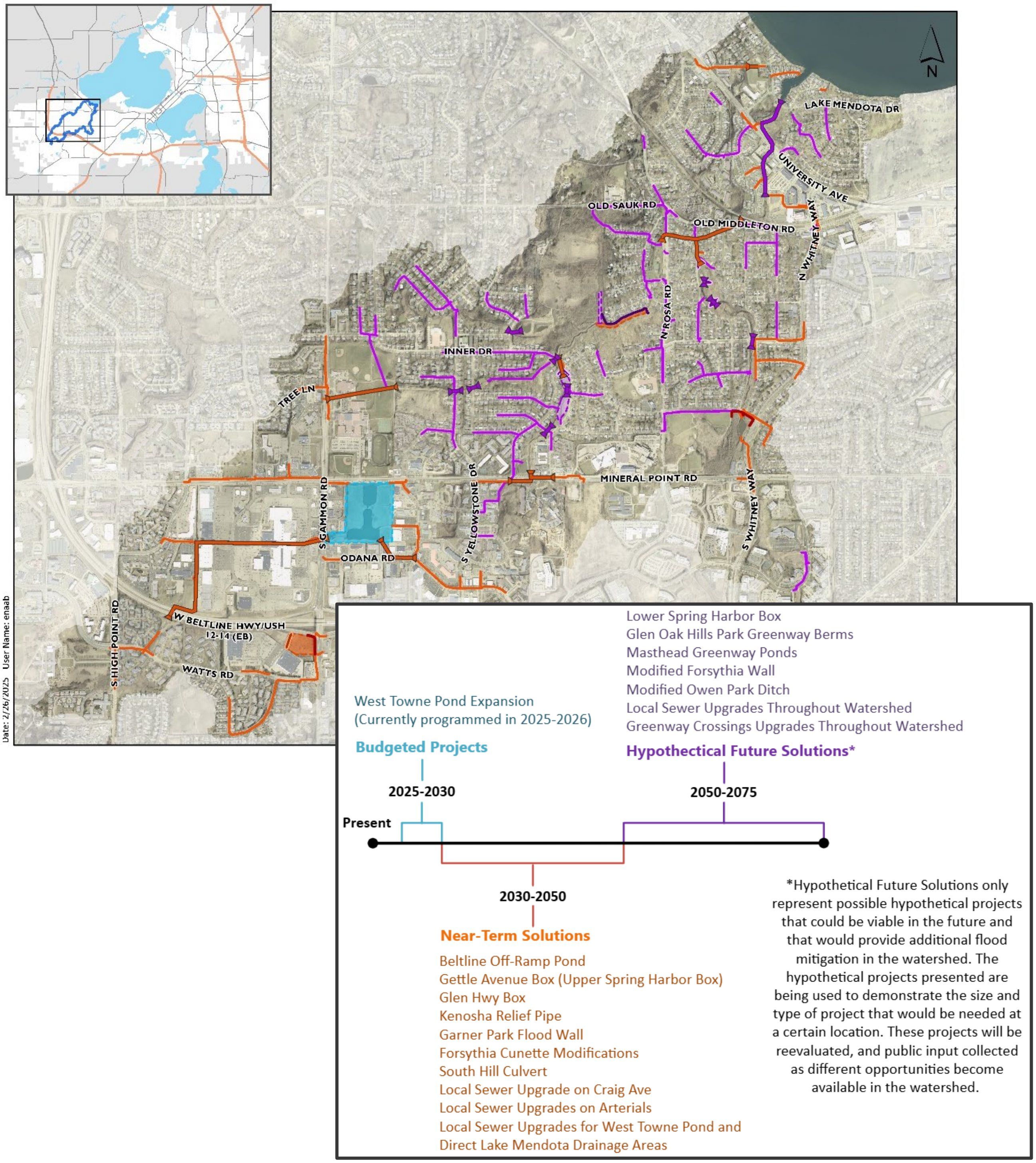
Projects that increase storm conveyance, such as larger pipe and culverts, can only be completed when the necessary storage or increased conveyance is completed downstream. The City will not mitigate flooding at one location if it makes flooding worse at a different location.

8. Solutions Timeline and Implementation Order

8.1 Recommended Solutions Timeline

The below graphic and timeline are an estimation of when projects within the watershed will be constructed based on the recommendations in this report.

Figure xii: Recommended Solutions Timeline Map and Timeline



8.2 Solutions Implementation Order

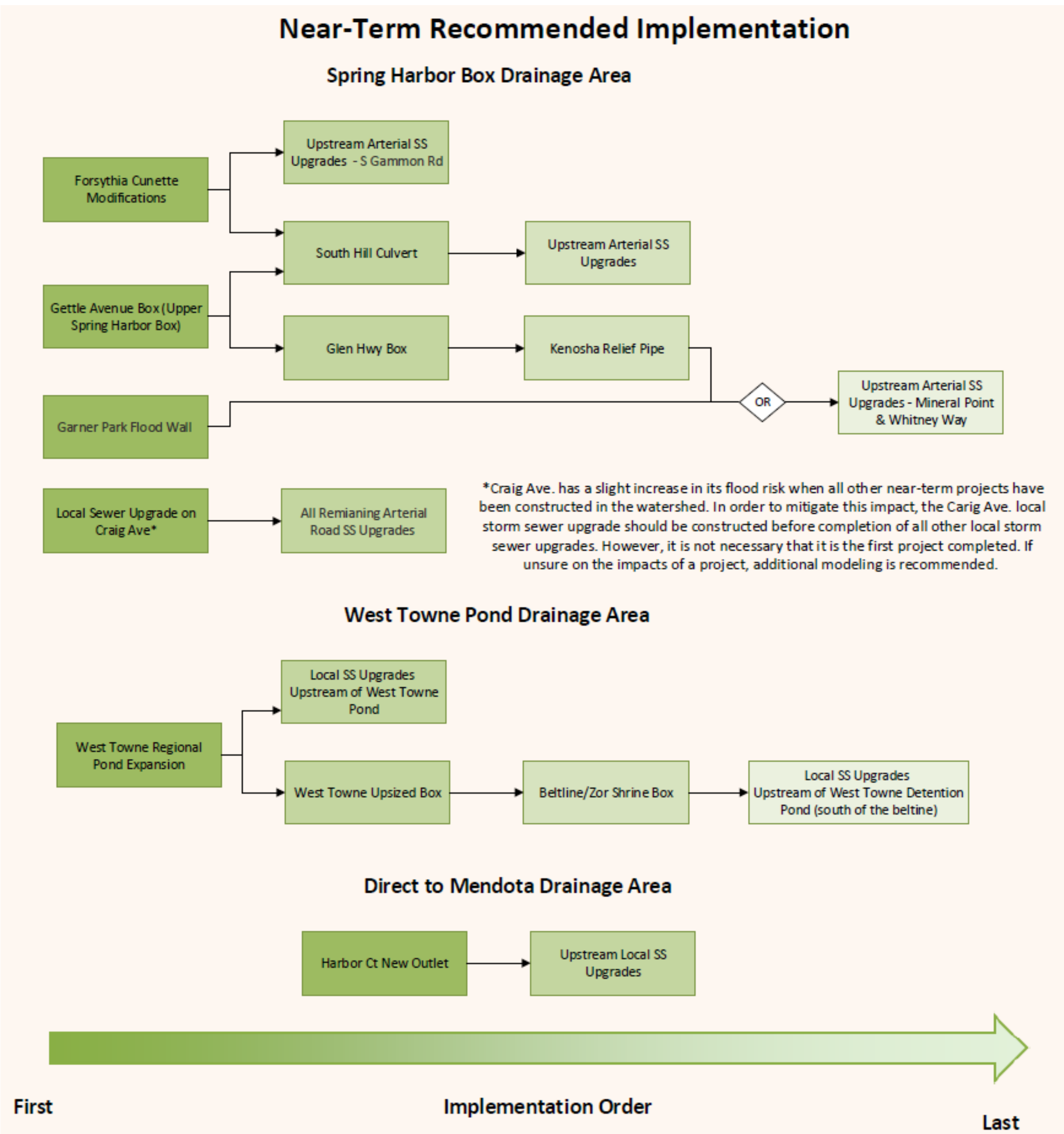
The below sections display the recommended implantation orders of projects that were considered during this portion of the watershed study.

NOTES ON THE IMPLEMENTATION ORDER:

1. City Engineering will not implement a flood mitigation project if it results in an increase in flooding downstream or in a different area of the watershed. Implementation sequences were developed to follow this policy.
2. As new opportunities become available to implement solutions in the watershed, additional modeling will be done to explore options that were not foreseen at the time of this modeling.

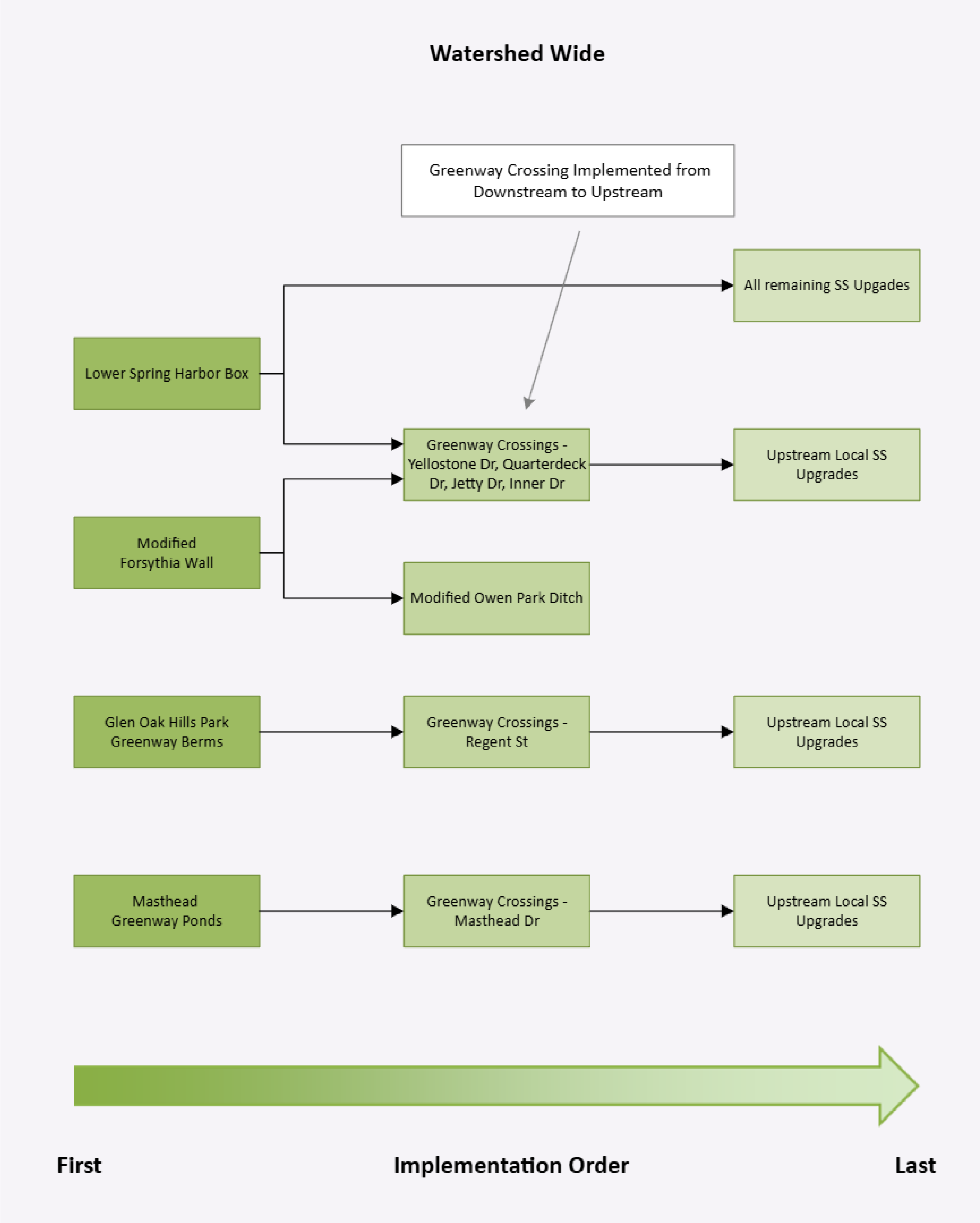
8.2.1 Near-Term Solutions Implementation Order

Figure xiii: Near-Term Recommended Solutions Implementation Order Flowchart



8.2.2 Future Hypothetical solutions Implementation Order

Figure xiv: Future Hypothetical Recommended Solutions Implementation Order Flowchart



9. Recommended Project Permits

Below is a table of the permits that we anticipate will be required to construct the solutions presented in this report.

Table ii: Recommended Project Permits

Project	Anticipated Permits Needed
West Towne Retention Pond (Currently Programmed in 2025-2026)	• City of Madison Erosion Control • Wisconsin DNR Construction Site Disturbance (WRAPP) • Wisconsin DNR/USACE Permit for Wetland Disturbance • Artificial Wetland Permit
Glen Oak Hills Berms	• City of Madison Erosion Control • Wisconsin DNR Construction Site Disturbance (WRAPP) • If the drainage is considered navigable by the WDNR, a Wisconsin DNR Chapter 30 permit would be needed for a culvert along with water quality certification from the USACE (Section 401/404). • If the WDNR takes jurisdiction over the embankment as a small dam, a dam construction permit through NR 333 would be needed.
Forsythia Wall	• City of Madison Erosion Control • Wisconsin DNR/USACE Permit for Wetland Disturbance • Wisconsin DNR/ USACE Permit for Streambank Stabilization
Forsythia Cunette	• City of Madison Erosion Control • Wisconsin DNR Construction Site Disturbance (WRAPP) – May depend on if a • Wisconsin DNR/USACE Permit for Wetland Disturbance • Wisconsin DNR/ USACE Permit for Streambank Stabilization • Level of permitting effort dependent on potential WDNR navigability determination
Masthead Greenway Pond	• City of Madison Erosion Control • Wisconsin DNR Construction Site Disturbance (WRAPP) • If the drainage is considered navigable by the WDNR, a Wisconsin DNR Chapter 30 permit would be needed for a culvert along with water

	quality certification from the USACE (Section 401/404). • If the WDNR takes jurisdiction over the embankment as a small dam, a dam construction permit through NR 333 would be needed.
Upsize Upper Spring Harbor & Box Glen Hwy Box Culvert	• Wisconsin DNR Permit for Culvert • City of Madison Erosion Control • Determination by WDOT on Bridge or Culvert Identification/Number
Beltline Off-Ramp pond	• City of Madison Erosion Control • Wisconsin DNR Construction Site Disturbance (WRAPP) • DOT ROW Permit – (will depend on final design and coordination in land acquisition)
Garner Park flood wall (4' high)	• City of Madison Erosion Control • If the WDNR takes jurisdiction over the wall as a small dam, a dam construction permit through NR 333 would be needed.
Upsized Lower SH (Spring Harbor) Box	• City of Madison Erosion Control • Wisconsin DNR Construction Site Disturbance (WRAPP)
Greenway Crossings	• City of Madison Erosion Control • Wisconsin DNR Construction Site Disturbance (WRAPP) • If the drainage is considered navigable by the WDNR, a Wisconsin DNR Chapter 30 permit would be needed for a culvert along with water quality certification from the USACE (Section 401/404Water Quality Information)

10. Recommended Project Cost Estimates

City staff provided unit costs based on 2024 dollars, which were adjusted based on project specifics and input from City Engineering. Cost estimates should be considered a Class 4 estimate based on guidance from the Association for the Advancement of Cost Engineering (AACE International), which corresponds to a feasibility study level of design (1% to 15%). A Class 4 estimate is generally considered to have an accuracy range of –15% to -30% (i.e., overestimate the true cost estimate) an +20% to +50% (i.e., underestimate the true cost estimate). A contingency of +25% was assigned to all opinions of probable costs to reflect the feasibility level of design.

Table iii: Recommended Project Cost Estimates

Near-Term Solutions (0-25yrs)	All Solutions (0-50 yrs)

• Upsized Upper Spring Harbor Box - $9M
• New regional solutions
    • Beltline Off-Ramp Pond - $1.5M
    • Garner Park Flood Wall & Kenosha Relief Sewer - $2.7 M
• Regional solutions
    • West Towne Retention Pond - $4.5M (Currently programmed in 2025-2026)
    • Forsythia Wall (shorter) + Cunette Modifications - $5 M
• South Hill Culvert - $0.7M
• Local Sewer
• **Total without local sewer: $23.4M**
	• Upsized Upper & Lower Spring Harbor Box - $9M (upper) + $12M (lower)
	• New regional solutions
	    • Beltline Off-Ramp Pond - $1.5M
	    • Garner Park Flood Wall & Kenosha Relief Sewer - $2.7M
	• Regional solutions
	    • West Towne Retention Pond - $4.5M (Currently programmed in 2025-2026)
	    • Masthead Greenway Pond - $2.6M
	    • Forsythia Wall (shorter) + Cunette Modifications - $7.1M
	    • Glen Oak Hills Berms – $1.8M
	• Greenway Crossings - $4.7M
	• Local Sewer
	• **Total without local sewer: $46M**

11. Additional Modeling Engagement

As part of this round of modeling, just like with the original round of modeling, it was City Engineering's goal to provide engagement opportunities for other City of Madison departments, the Spring Harbor Watershed alders, and residents.

The following list includes some of the meetings that were held to provide these engagement opportunities:

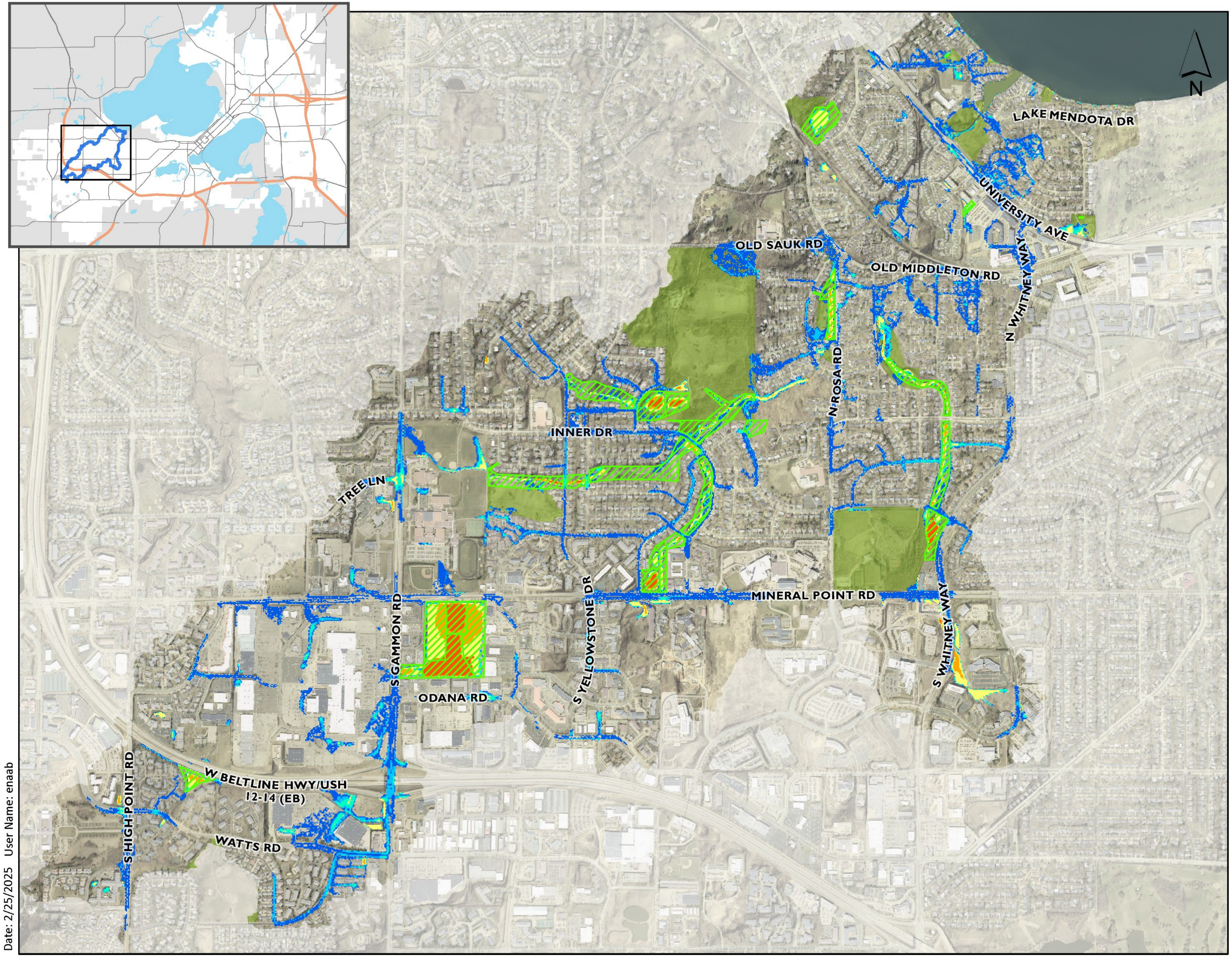
- PWI* – April 30th, 2024 **PWI is the City Internal Public Works Improvement Team Meeting, a group comprised of department heads and mayor's staff.*
- Meeting with Parks staff
- Meeting with Water Utility staff
- Meeting with Alders of impacted districts – June 6th, 2024
- Public Information Meeting #4 – August 28th, 2024

12. Next Steps

It is the recommendation of City Engineering that the Near-Term suite of solutions is accepted as the new official suite of solutions for the Spring Harbor Watershed and that they are incorporated into City Engineering 's construction prioritization matrix with the solutions from the other City of Madison Watershed Studies.

Additionally, it is recommended that City keep a record of the All Solutions suite of solutions to be considered in the future as additional options become available in the watershed or as resident opinions shift, and to help future engineers understand the types and sizes of solutions needed to meet the flood mitigation targets in the watershed.

13. Figures



Updated Existing Conditions - 50% Annual Chance Storm Flooding

Amendment: 1
Figure: xv

Spring Harbor Watershed Study
City of Madison

Ponds and Greenways

Parks

50% Annual Chance Inundation

Maximum Water Depth (Feet)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 3
- 3 - 6
- 6 - 20

0 275550 1,100 Feet

CITY OF MADISON ENGINEERING

Date: 2/25/2025 User Name: enaab

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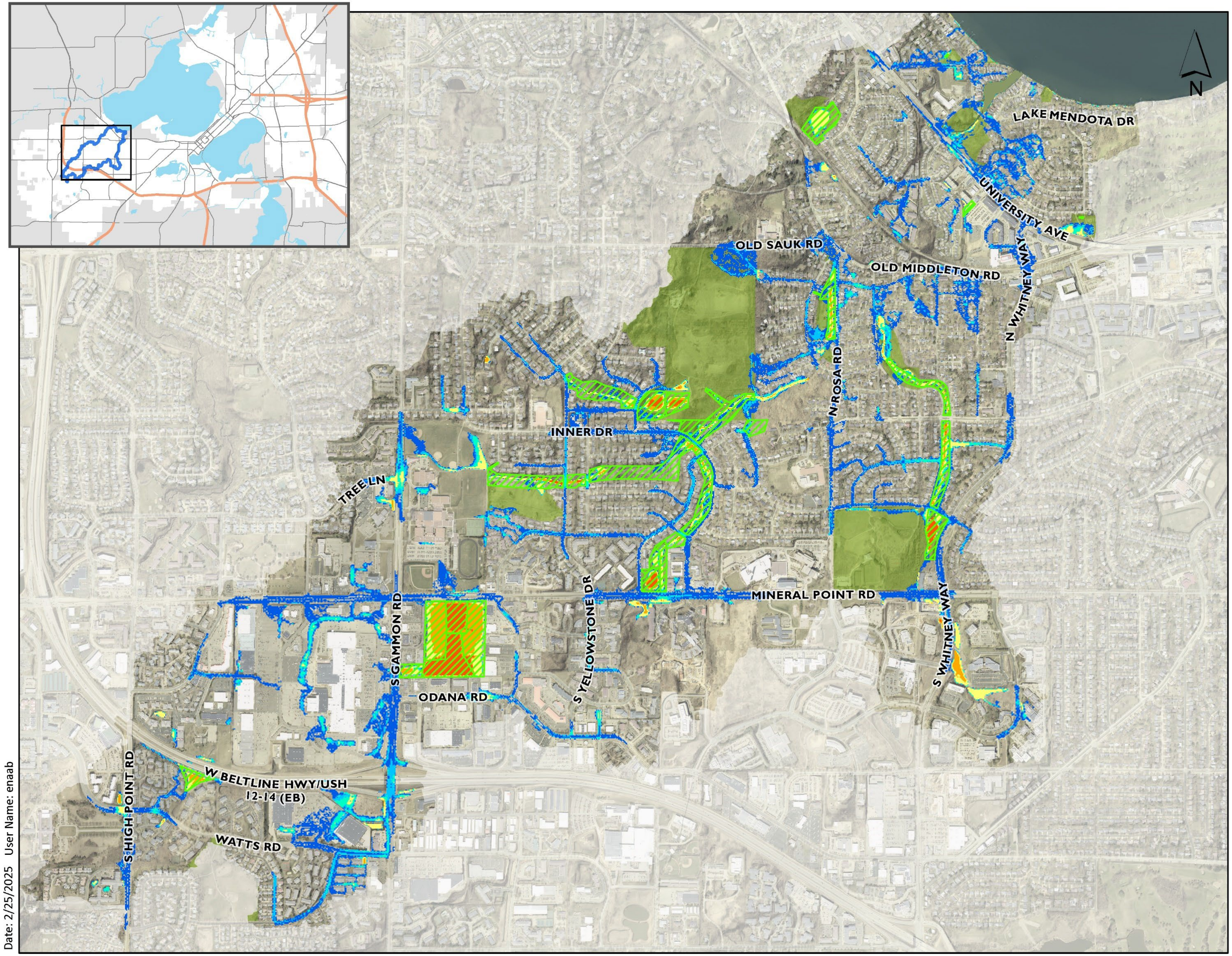

Updated Existing Conditions - 10% Annual Chance Storm Flooding

Amendment: 1

Figure: xvi

Spring Harbor Watershed Study
City of Madison

Ponds and Greenways

Parks

10% Annual Chance Inundation

Maximum Water Depth (Feet)

0 - 0.25

0.25 - 0.5

0.5 - 1

1 - 3

3 - 6

6 - 20

0 275 550 1,100 Feet

CITY OF MADISON ENGINEERING

Date: 2/25/2025 User Name: enaab

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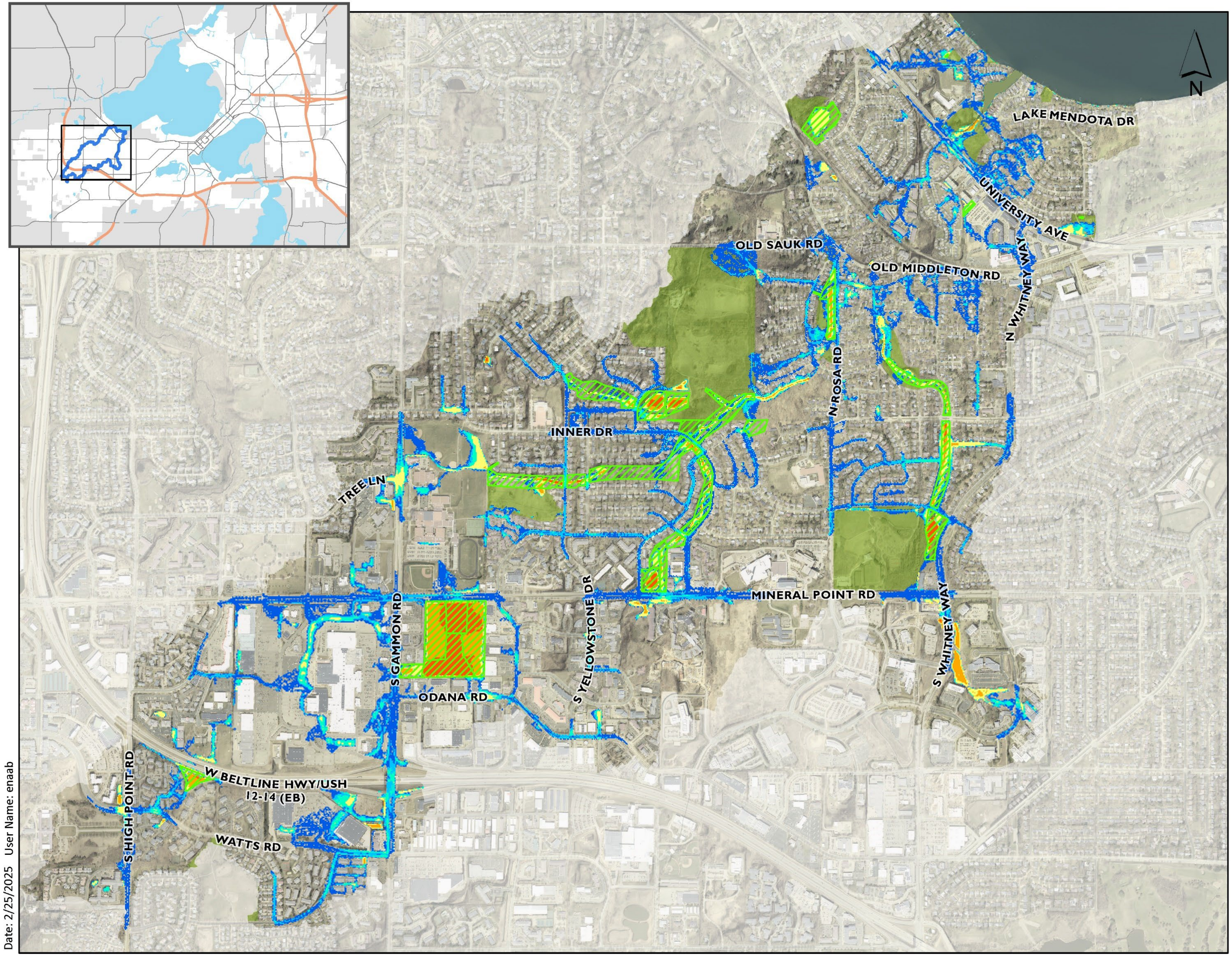

Updated Existing Conditions - 4% Annual Chance Storm Flooding

Amendment: 1
Figure: xvii

Spring Harbor Watershed Study
City of Madison

Ponds and Greenways

Parks

4% Annual Chance Inundation

Maximum Water Depth (Feet)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 3
- 3 - 6
- 6 - 20

0 275 550 1,100 Feet

CITY OF MADISON ENGINEERING

Date: 2/25/2025 User Name: enaab

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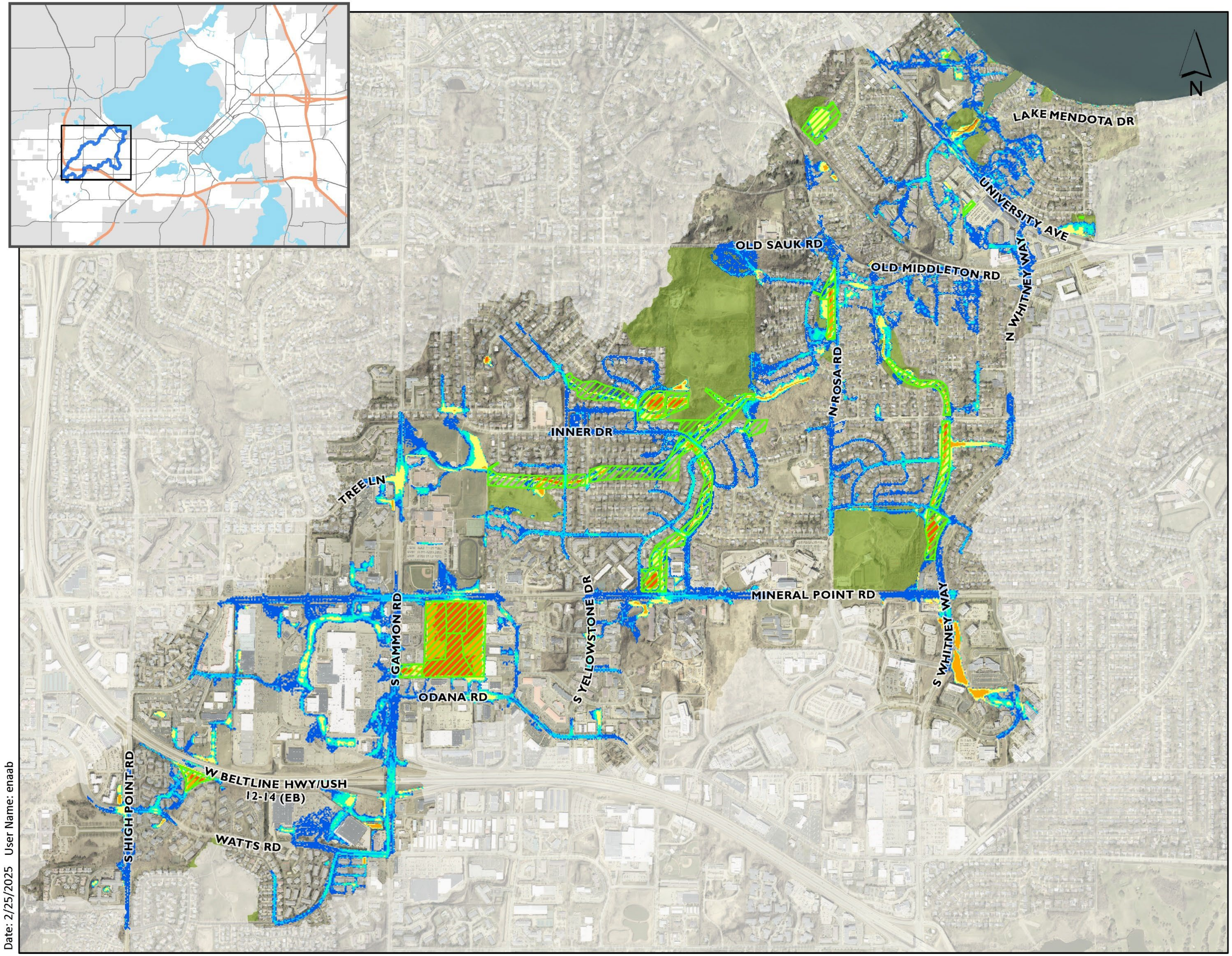

Updated Existing Conditions - 2% Annual Chance Storm Flooding

Amendment: 1
Figure: xviii

Spring Harbor Watershed Study
City of Madison

Ponds and Greenways

Parks

2% Annual Chance Inundation

Maximum Water Depth (Feet)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 3
- 3 - 6
- 6 - 20

0 275550 1,100 Feet

CITY OF MADISON ENGINEERING

Date: 2/25/2025 User Name: enaab

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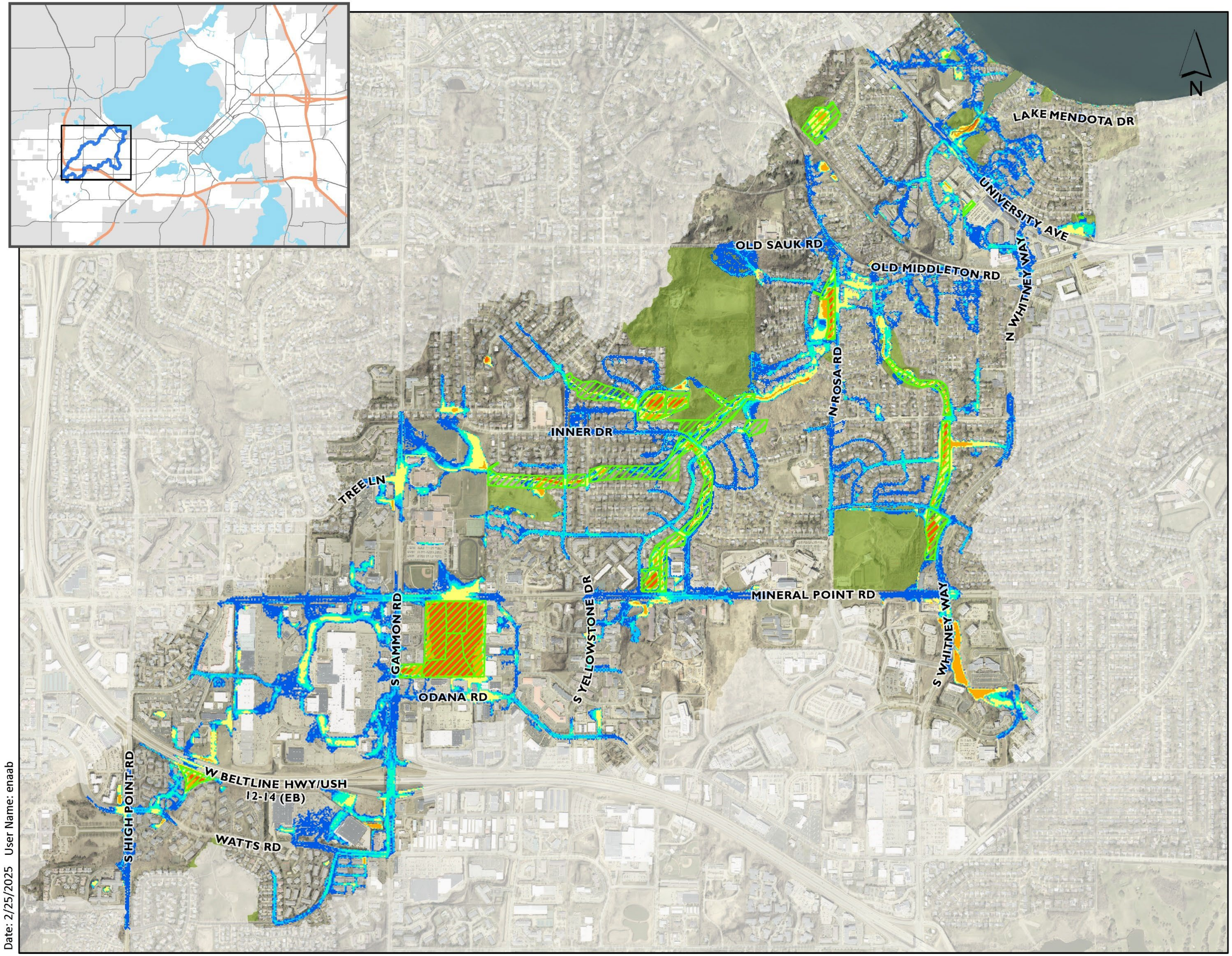
Updated Existing Conditions - 1% Annual Chance Storm Flooding

Amendment: 1
Figure: xix

Spring Harbor Watershed Study
City of Madison



Ponds and Greenways

Parks

%1 Annual Chance Inundation

Maximum Water Depth (Feet)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 3
- 3 - 6
- 6 - 20

0 275550 1,100 Feet

CITY OF MADISON ENGINEERING

Date: 2/25/2025 User Name: enaab

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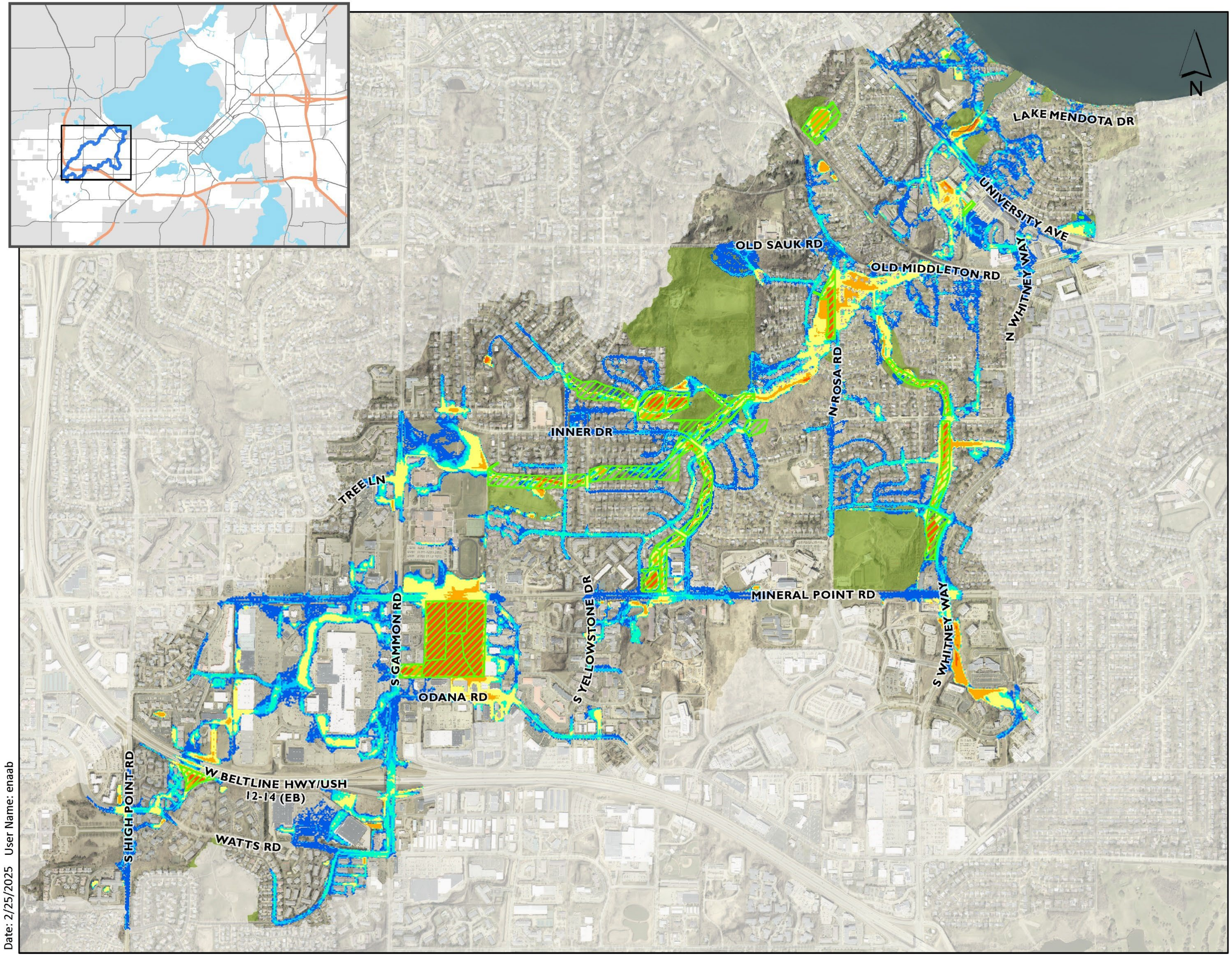

Updated Existing Conditions - 0.2% Annual Chance Storm Flooding

Amendment: 1
Figure: xx

Spring Harbor Watershed Study
City of Madison

Ponds and Greenways

Parks

0.2% Annual Chance Inundation

Maximum Water Depth (Feet)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1
- 1 - 3
- 3 - 6
- 6 - 20

0 275 550 1,100 Feet

CITY OF MADISON ENGINEERING

User Name: enaab

Date: 2/25/2025

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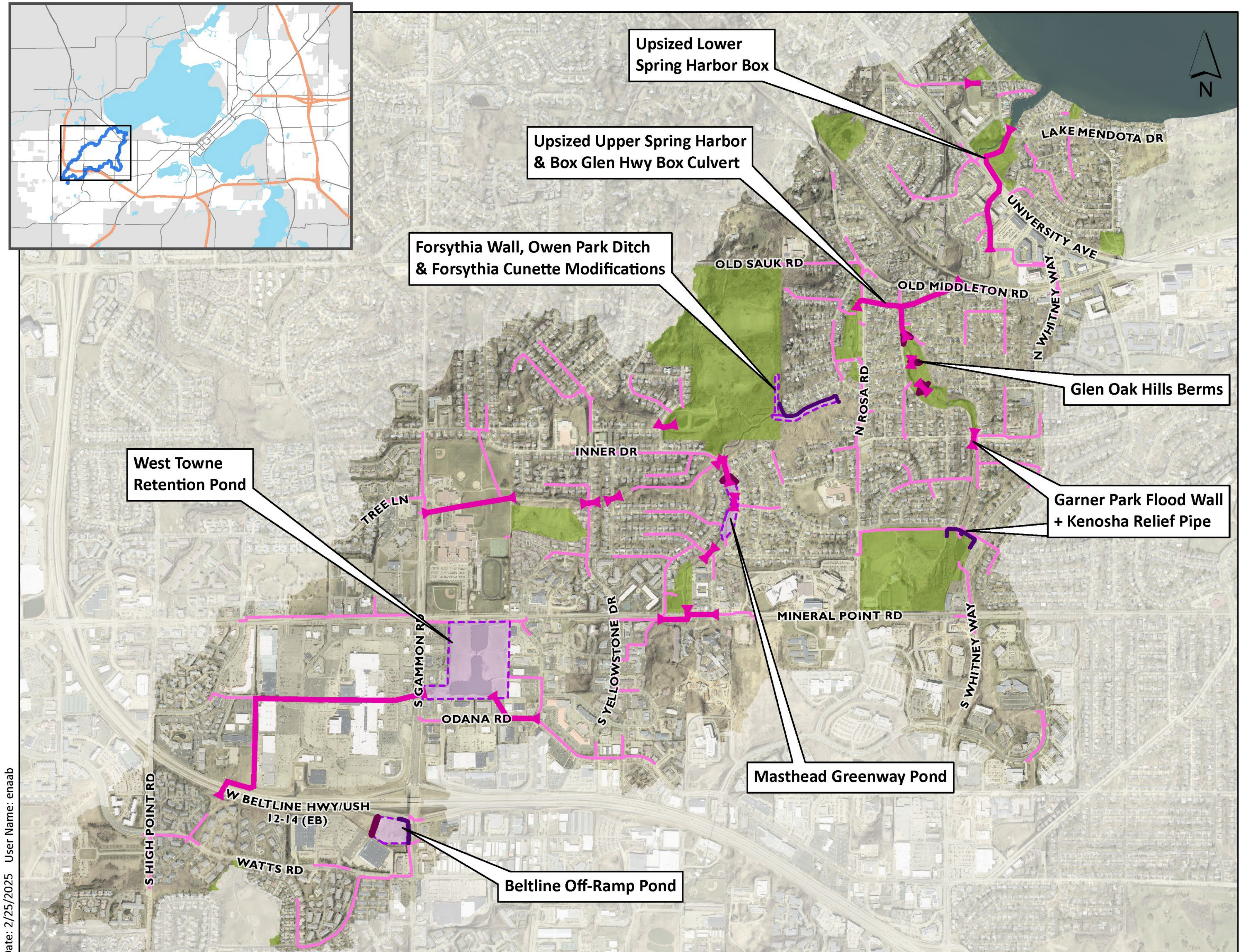
All Recommended Solutions (0-50 yrs)

Amendment: 1
Figure: xxi

Spring Harbor Watershed Study
City of Madison



Proposed Solutions

- Proposed Box
- Proposed Pipes
- Berm
- Floodwall
- Channel; Pond; Other

Other Data

- Parks

0 275550 1,100 Feet

CITY OF MADISON ENGINEERING

Date: 2/25/2025 User Name: enaab

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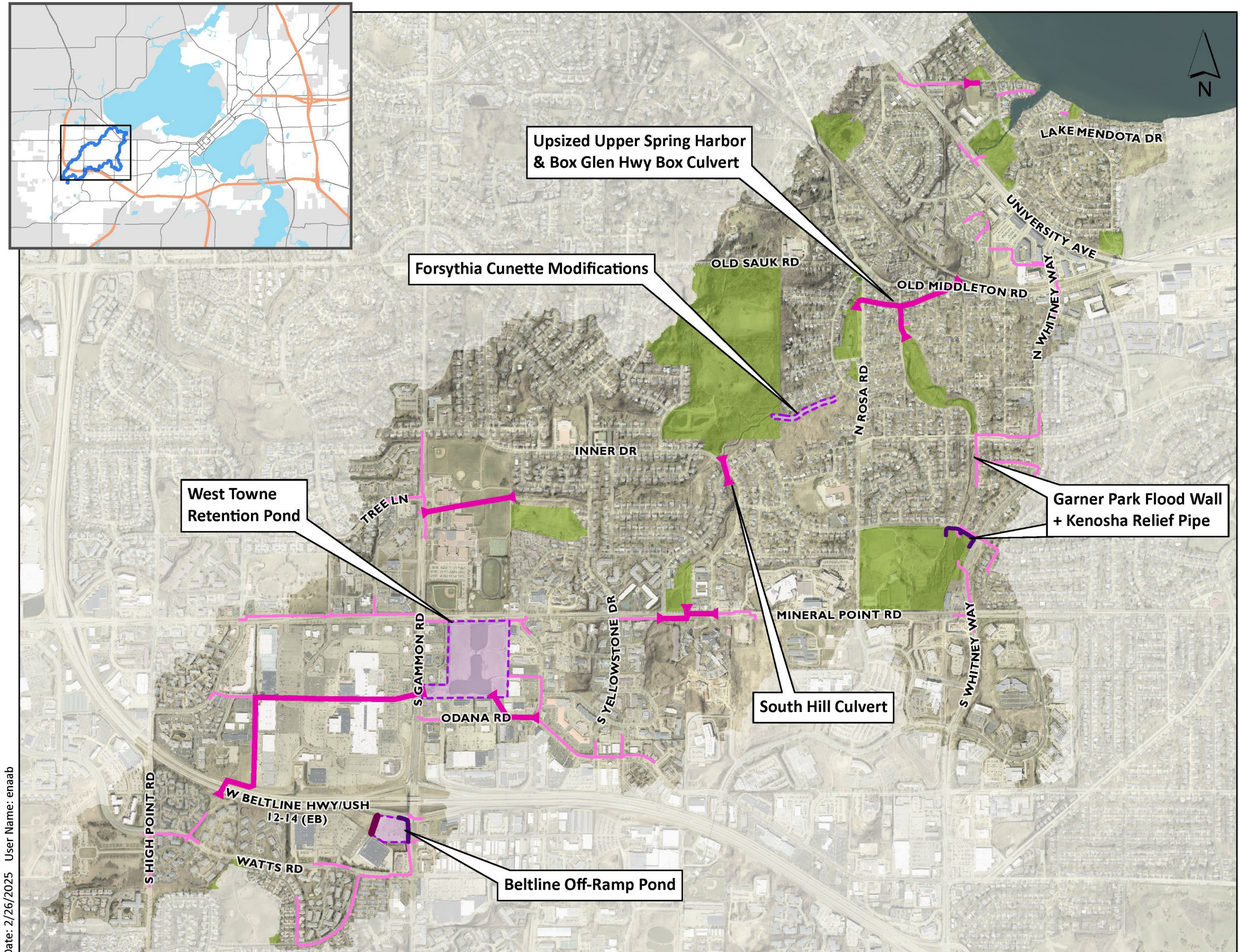

Near-Term Recommended Solutions (0-25 yrs)

Amendment: 1
Figure: xxii

Spring Harbor Watershed Study
City of Madison

Proposed Solutions

- Proposed Box
- Proposed Pipes
- Berm
- Floodwall
- Channel; Pond; Other

Other Data

- Parks

0 275550 1,100 Feet

CITY OF MADISON ENGINEERING

User Name: enaab
Date: 2/26/2025

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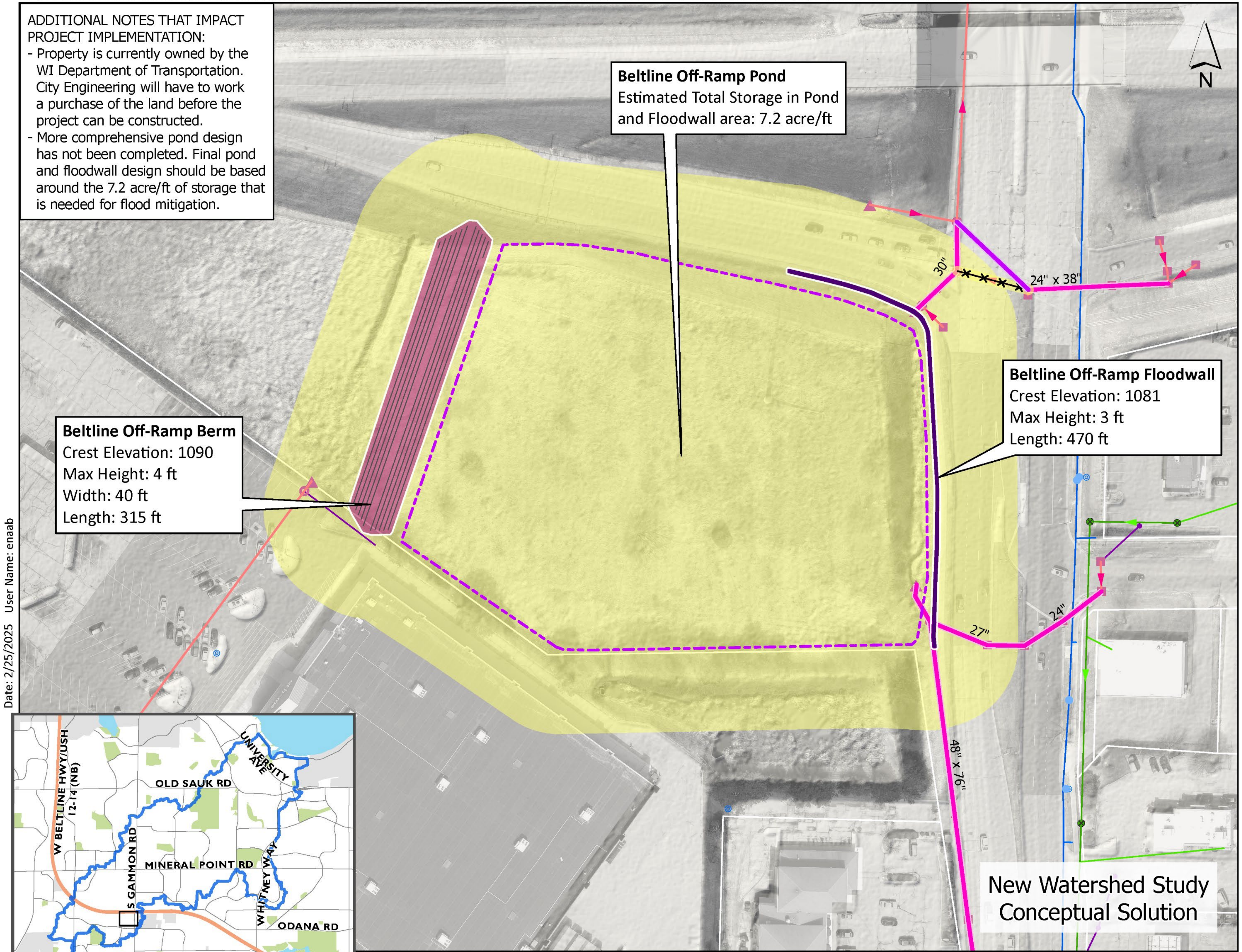
Near-Term Solution- Beltline Off-Ramp Pond & Berm

Amendment: 1
Figure: xxiii

Spring Harbor Watershed Study
City of Madison



Date: 2/25/2025 User Name: enaab

Recommended Solutions
- New Box
- Parallel Box
- Removal Box
- Special Box
- Upsize Box
- New Pipe
- Parallel Pipe
- Removal Pipe
- Special Pipe
- Upsize Pipe
- Channel
- Pond
- Berm
- Floodwall
- Other
- 1' Project Contour
- Project Area of Interest

Other Data
- Ponds and Greenways
- Parks
- Railroads
- Park Paths

Storm Sewer
- Storm Pipe
- Inlet
- Headwall
- Other
- Apron End
- Access Structures
- Storm_Lift_Stations
- PVT Storm Structure -Approx.
- PVT Storm Pipe -Approx.

Other Utilities
- Water Value
- Water Main
- Water Service
- Water Hydrant
- SAS
- Sanitary Main
- Sanitary Lateral
- MMSD SAS
- MMSD Main

0 15 30 60 Feet

CITY OF MADISON ENGINEERING

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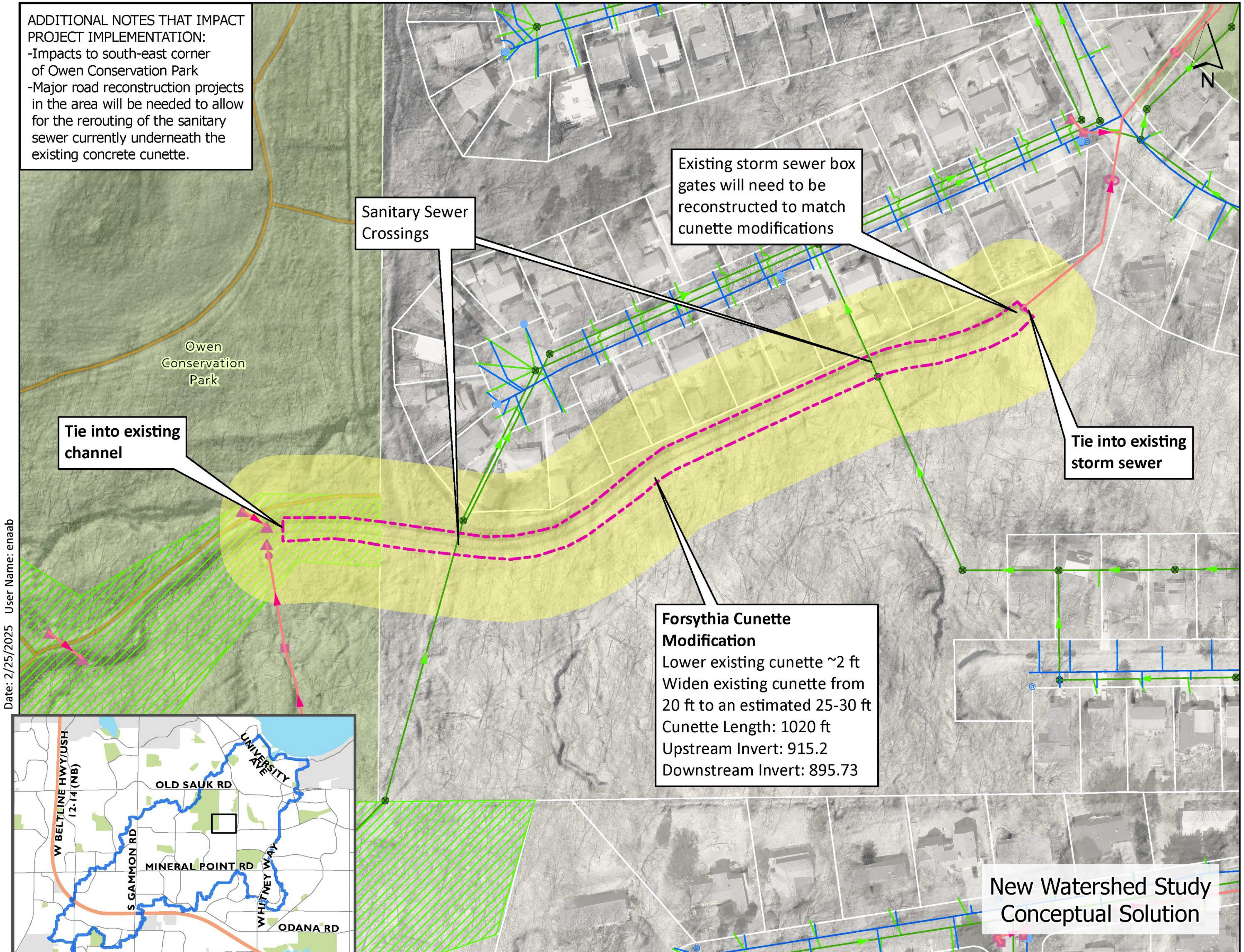
Date: 2/25/2025 User Name: enaab



Near-Term Solution - Forsythia Cunette Modifications

Amendment: 1
Figure: xxiv

Spring Harbor Watershed Study
City of Madison

Recommended Solutions
- New Box
- Parallel Box
- Removal Box
- Special Box
- Upsize Box
- New Pipe
- Parallel Pipe
- Removal Pipe
- Special Pipe
- Upsize Pipe
- Channel
- Pond
- Berm
- Floodwall
- Other
- 1' Project Contour
- Project Area of Interest

Other Data
- Ponds and Greenways
- Parks
- Railroads
- Park Paths

Storm Sewer
- Storm Pipe
- Inlet
- Headwall
- Other
- Apron End
- Access Structures
- Storm_Lift_Stations
- PVT Storm Structure -Approx.
- PVT Storm Pipe -Approx.

Other Utilities
- Water Value
- Water Main
- Water Service
- Water Hydrant
- SAS
- Sanitary Main
- Sanitary Lateral
- MMSD SAS
- MMSD Main

0 25 50 100 Feet

CITY OF MADISON ENGINEERING

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Near-Term Solution - Garner Park Flood Wall & Kenosha Relief Pipe

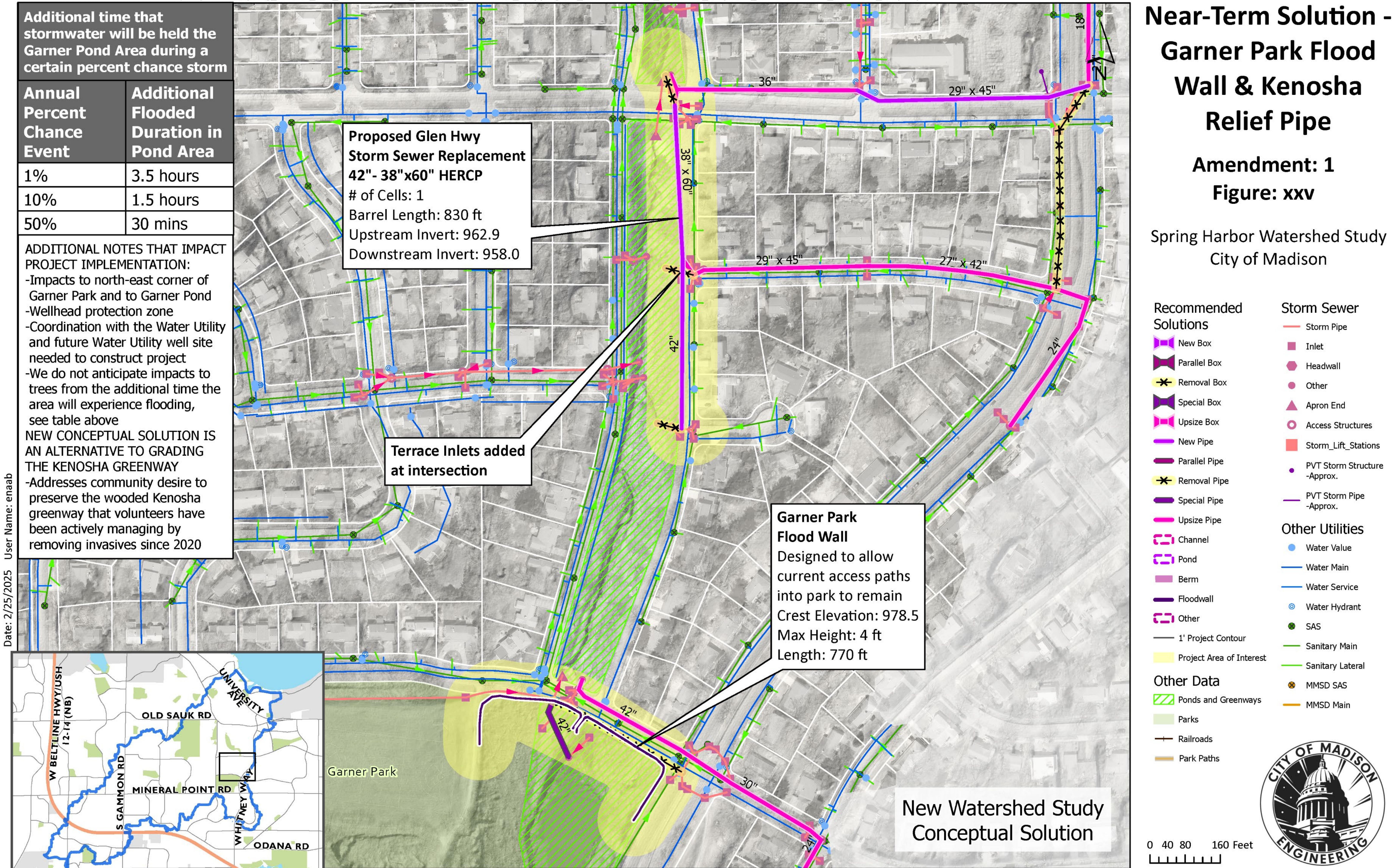
Amendment: 1
Figure: xxv

Spring Harbor Watershed Study
City of Madison

Additional time that stormwater will be held the Garner Pond Area during a certain percent chance storm	
Annual Percent Chance Event	Additional Flooded Duration in Pond Area
1%	3.5 hours
10%	1.5 hours
50%	30 mins

ADDITIONAL NOTES THAT IMPACT PROJECT IMPLEMENTATION:
- Impacts to north-east corner of Garner Park and to Garner Pond
- Wellhead protection zone
- Coordination with the Water Utility and future Water Utility well site needed to construct project
- We do not anticipate impacts to trees from the additional time the area will experience flooding, see table above

NEW CONCEPTUAL SOLUTION IS AN ALTERNATIVE TO GRADING THE KENOSHA GREENWAY
- Addresses community desire to preserve the wooded Kenosha greenway that volunteers have been actively managing by removing invasives since 2020



User Name: enaab
Date: 2/25/2025

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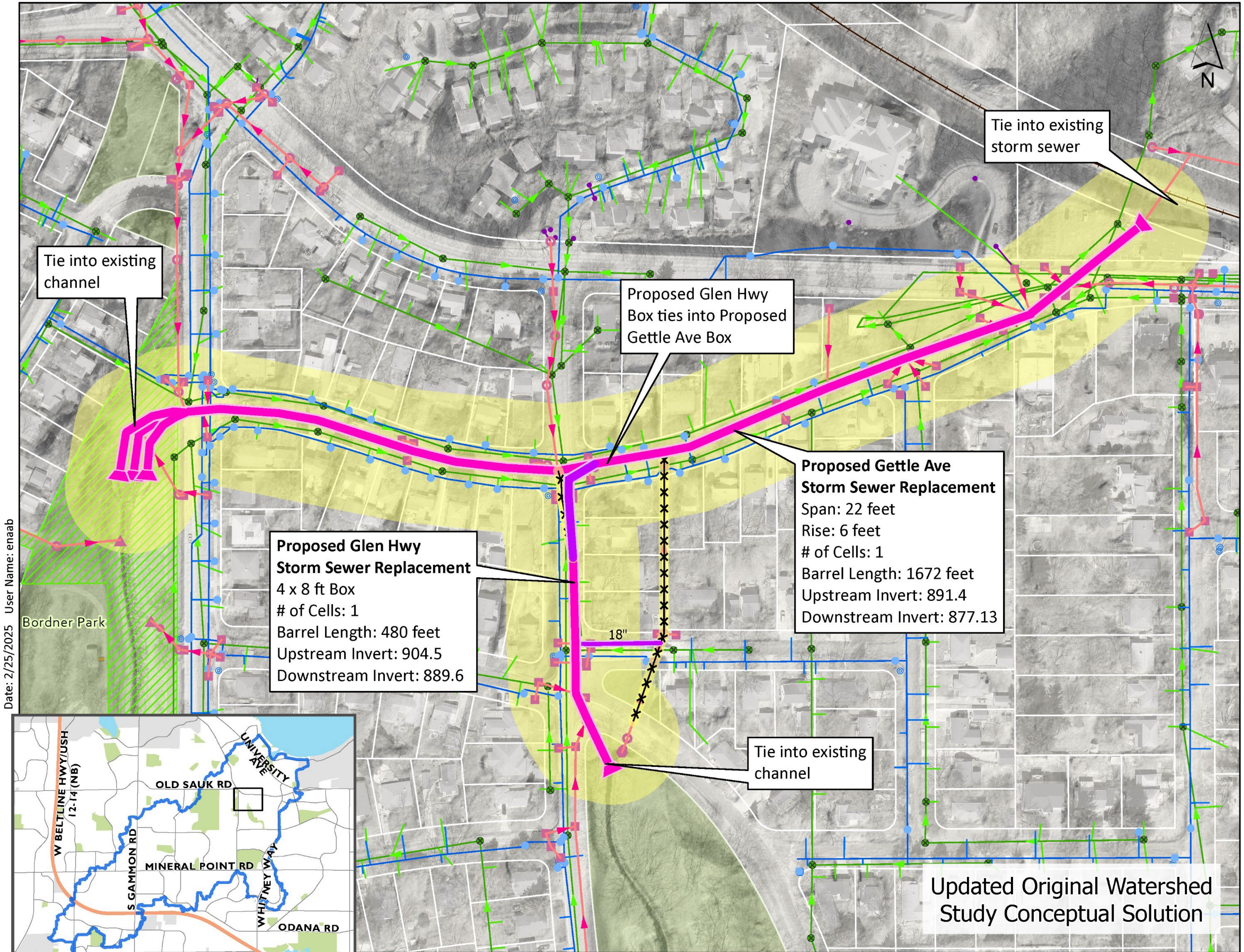
Near-Term Solution - Upsized Upper Spring Harbor Box & Glen Hwy Box

Amendment: 1
Figure: xxvi

Spring Harbor Watershed Study
City of Madison



Recommended Solutions
- New Box
- Parallel Box
- Removal Box
- Special Box
- Upsize Box
- New Pipe
- Parallel Pipe
- Removal Pipe
- Special Pipe
- Upsize Pipe
- Channel
- Pond
- Berm
- Floodwall
- Other
- 1' Project Contour
- Project Area of Interest

Other Data
- Ponds and Greenways
- Parks
- Railroads

Storm Sewer
- Storm Pipe
- Inlet
- Headwall
- Other
- Apron End
- Access Structures
- Storm_Lift_Stations
- PVT Storm Structure -Approx.
- PVT Storm Pipe -Approx.

Other Utilities
- Water Value
- Water Main
- Water Service
- Water Hydrant
- SAS
- Sanitary Main
- Sanitary Lateral
- MMSD SAS
- MMSD Main

0 25 50 100 Feet

CITY OF MADISON ENGINEERING

Date: 2/25/2025 User Name: enaab

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Near-Term Solution - West Towne Retention Pond

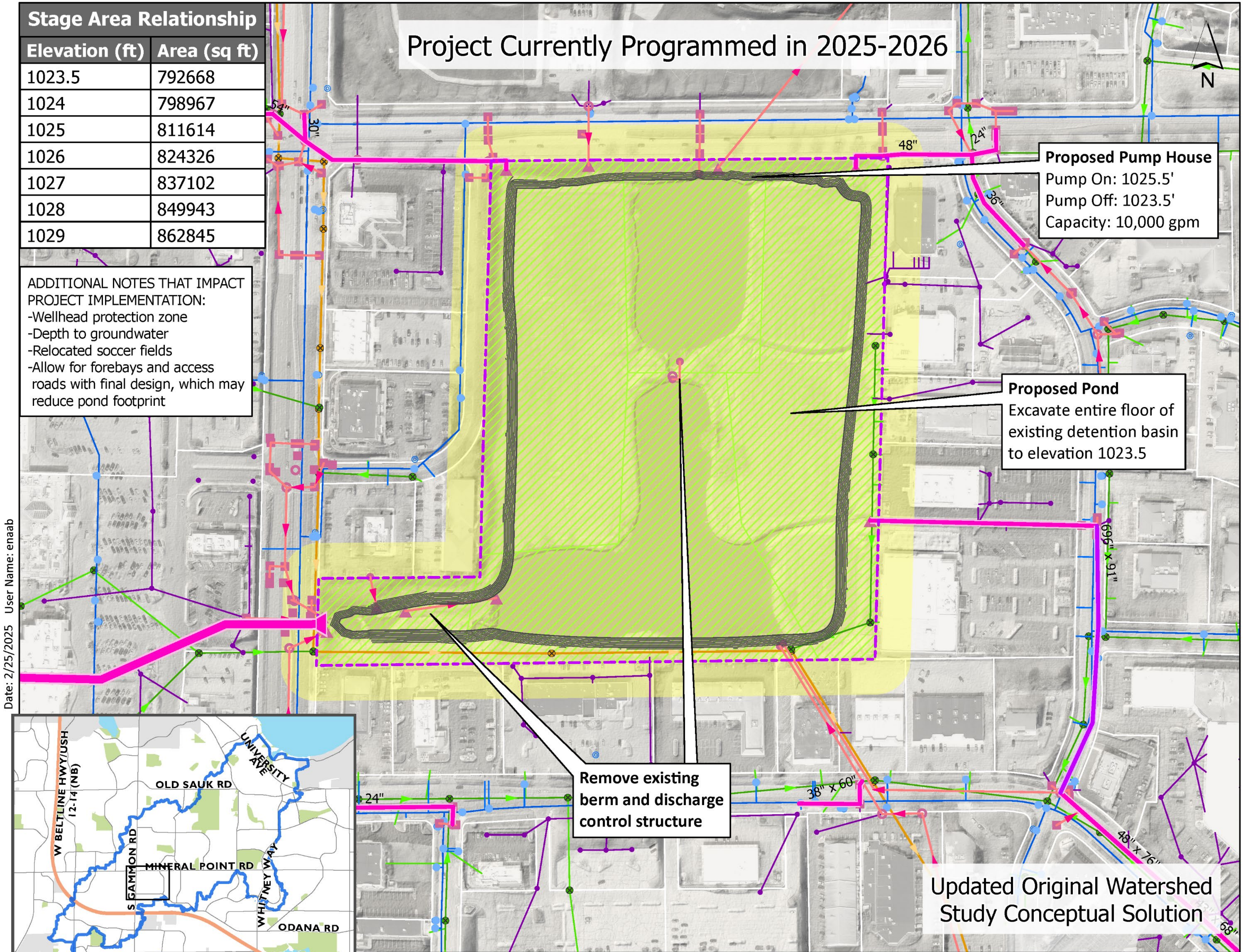
Amendment: 1

Figure: xxvii

Spring Harbor Watershed Study
City of Madison

Stage Area Relationship	
Elevation (ft)	**Area (sq ft)**
1023.5	792668
1024	798967
1025	811614
1026	824326
1027	837102
1028	849943
1029	862845

ADDITIONAL NOTES THAT IMPACT PROJECT IMPLEMENTATION:
-Wellhead protection zone
-Depth to groundwater
-Relocated soccer fields
-Allow for forebays and access roads with final design, which may reduce pond footprint



Recommended Solutions
- New Box
- Parallel Box
- Removal Box
- Special Box
- Upsize Box
- New Pipe
- Parallel Pipe
- Removal Pipe
- Special Pipe
- Upsize Pipe
- Channel
- Pond
- Berm
- Floodwall
- Other
- 1' Project Contour
- Project Area of Interest

Other Data
- Ponds and Greenways
- Parks
- Railroads

Storm Sewer
- Storm Pipe
- Inlet
- Headwall
- Other
- Apron End
- Access Structures
- Storm_Lift_Stations
- PVT Storm Structure -Approx.
- PVT Storm Pipe -Approx.

Other Utilities
- Water Value
- Water Main
- Water Service
- Water Hydrant
- SAS
- Sanitary Main
- Sanitary Lateral
- MMSD SAS
- MMSD Main

0 40 80 160 Feet

CITY OF MADISON ENGINEERING

Date: 2/25/2025 User Name: enaab

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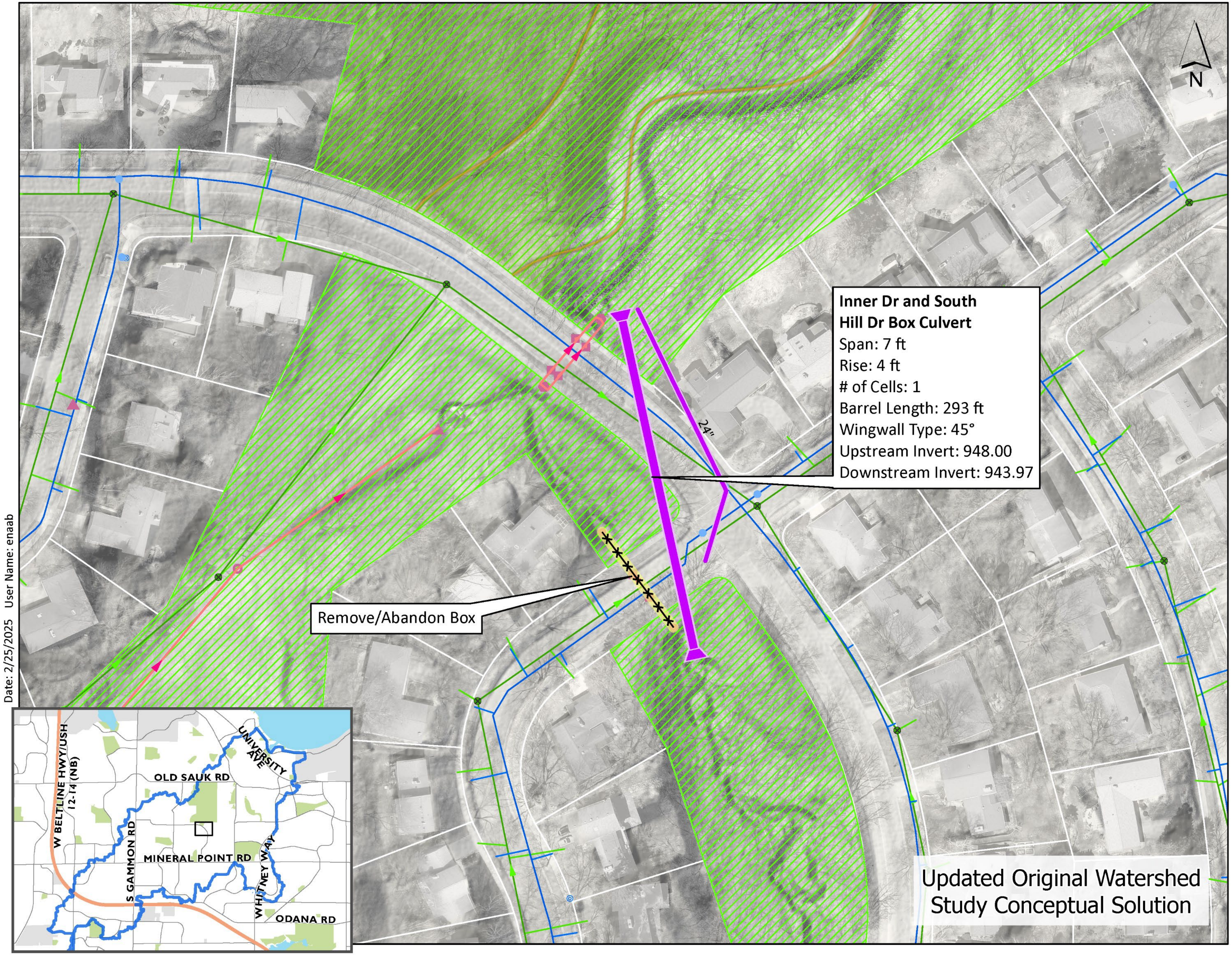
Near-Term Solution- Inner Dr and South Hill Dr Box Culvert

Amendment: 1
Figure: xxviii

Spring Harbor Watershed Study
City of Madison



User Name: enaab
Date: 2/25/2025

Recommended Solutions
- New Box
- Parallel Box
- Removal Box
- Special Box
- Upsize Box
- New Pipe
- Parallel Pipe
- Removal Pipe
- Special Pipe
- Upsize Pipe
- Channel
- Pond
- Berm
- Floodwall
- Other
- 1' Project Contour
- Project Area of Interest

Other Data
- Ponds and Greenways
- Parks
- Railroads
- Park Paths

Storm Sewer
- Storm Pipe
- Inlet
- Headwall
- Other
- Apron End
- Access Structures
- Storm_Lift_Stations
- PVT Storm Structure -Approx.
- PVT Storm Pipe -Approx.

Other Utilities
- Water Value
- Water Main
- Water Service
- Water Hydrant
- SAS
- Sanitary Main
- Sanitary Lateral
- MMSD SAS
- MMSD Main

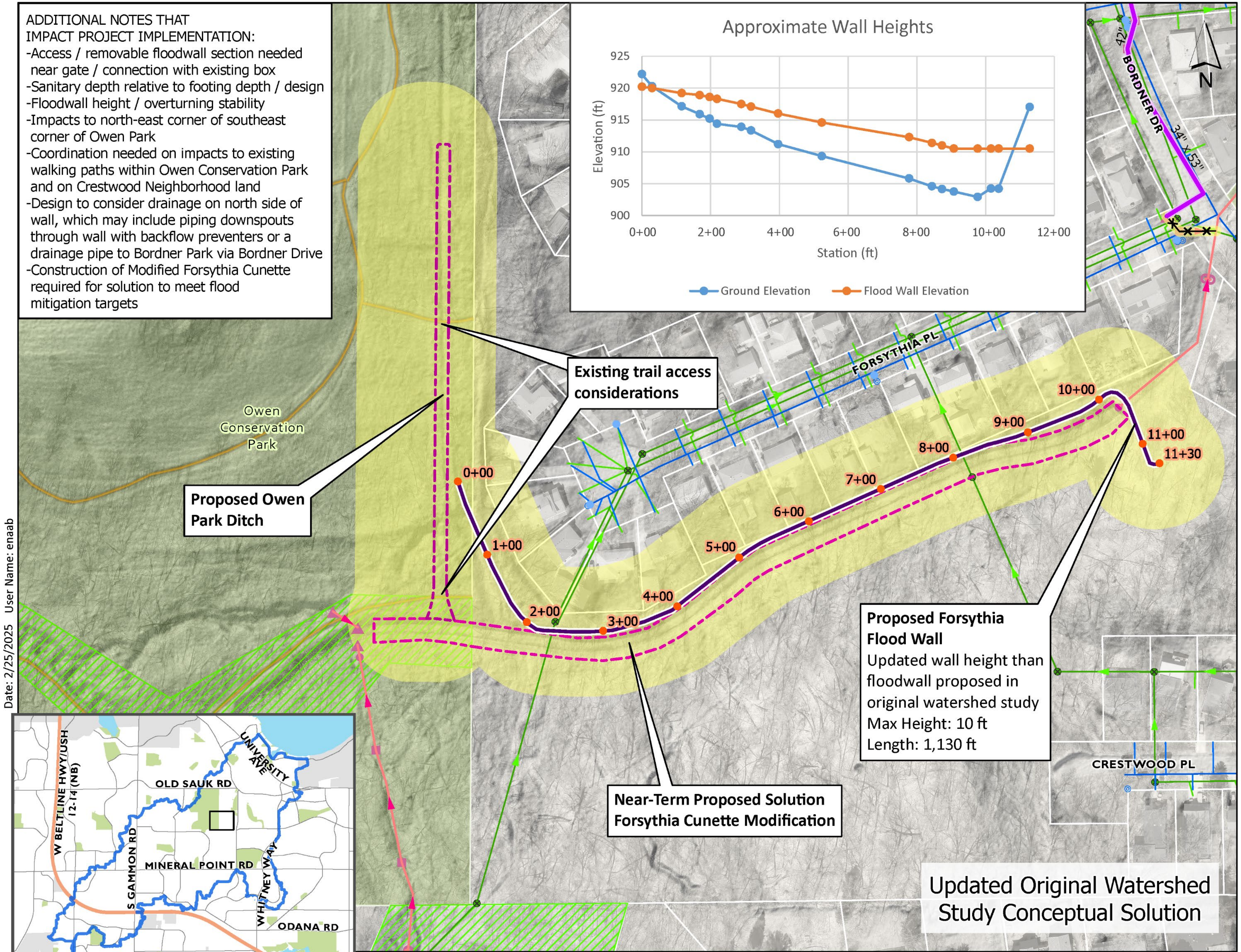
0 15 30 60 Feet

CITY OF MADISON ENGINEERING

Future Hypothetical Solution - Forsythia Wall & Owen Park Ditch

Amendment: 1
Figure: xxix

Spring Harbor Watershed Study
City of Madison



Recommended Solutions
- New Box
- Parallel Box
- Removal Box
- Special Box
- Upsize Box
- New Pipe
- Parallel Pipe
- Removal Pipe
- Special Pipe
- Upsize Pipe
- Channel
- Pond
- Berm
- Floodwall
- Other
- 1' Project Contour
- Project Area of Interest

Other Data
- Ponds and Greenways
- Parks
- Railroads
- Park Paths

Storm Sewer
- Storm Pipe
- Inlet
- Headwall
- Other
- Apron End
- Access Structures
- Storm_Lift_Stations
- PVT Storm Structure -Approx.
- PVT Storm Pipe -Approx.

Other Utilities
- Water Value
- Water Main
- Water Service
- Water Hydrant
- SAS
- Sanitary Main
- Sanitary Lateral
- MMSD SAS
- MMSD Main

0 20 40 80 Feet

CITY OF MADISON ENGINEERING

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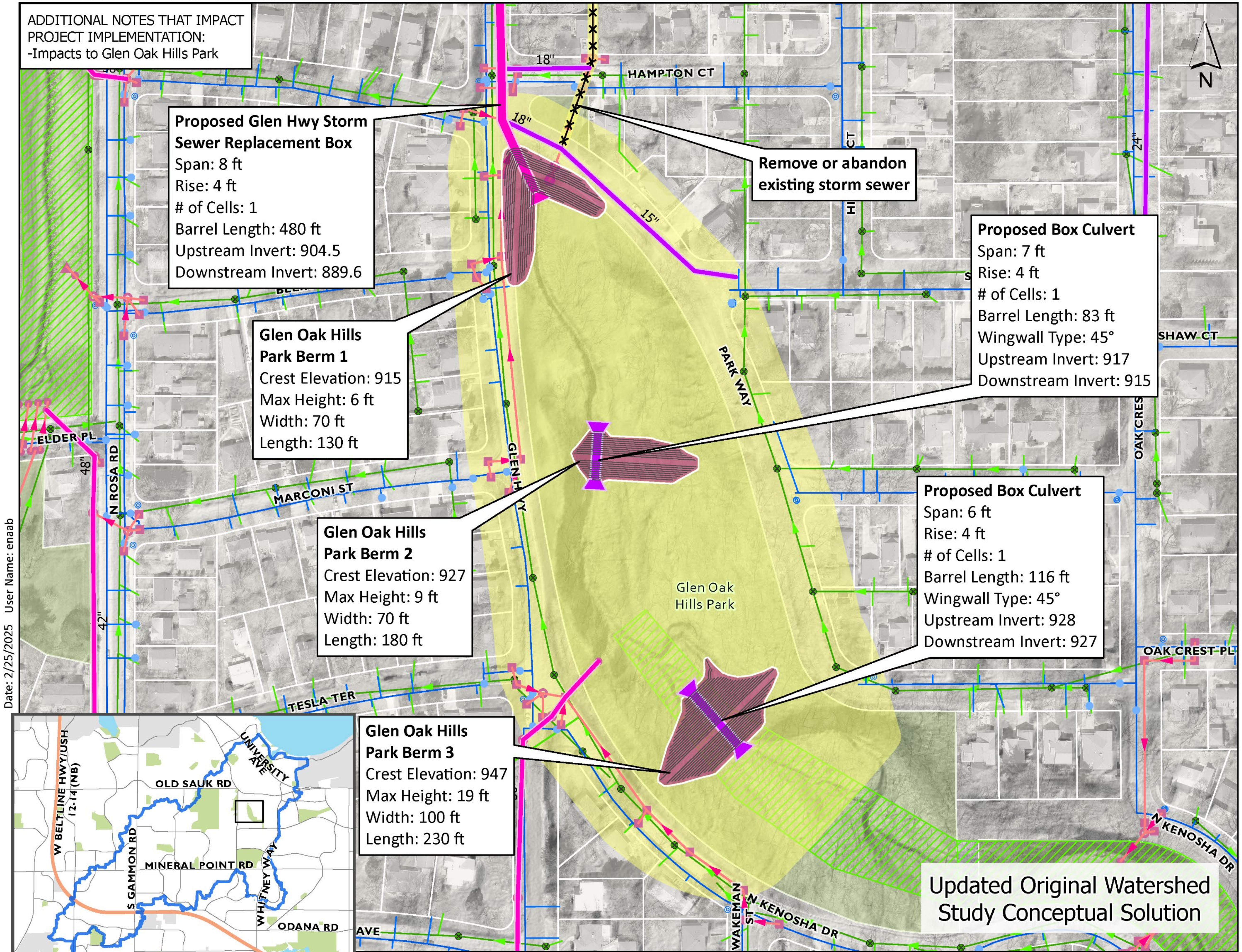

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Future Hypothetical Solution - Glen Oak Hills Berms

Amendment: 1
Figure: xxx

Spring Harbor Watershed Study
City of Madison

Recommended Solutions
- New Box
- Parallel Box
- Removal Box
- Special Box
- Upsize Box
- New Pipe
- Parallel Pipe
- Removal Pipe
- Special Pipe
- Upsize Pipe
- Channel
- Pond
- Berm
- Floodwall
- Other
- 1' Project Contour
- Project Area of Interest

Other Data
- Ponds and Greenways
- Parks
- Railroads
- Park Paths

Storm Sewer
- Storm Pipe
- Inlet
- Headwall
- Other
- Apron End
- Access Structures
- Storm_Lift_Stations
- PVT Storm Structure -Approx.
- PVT Storm Pipe -Approx.

Other Utilities
- Water Value
- Water Main
- Water Service
- Water Hydrant
- SAS
- Sanitary Main
- Sanitary Lateral
- MMSD SAS
- MMSD Main

0 25 50 100 Feet

CITY OF MADISON ENGINEERING

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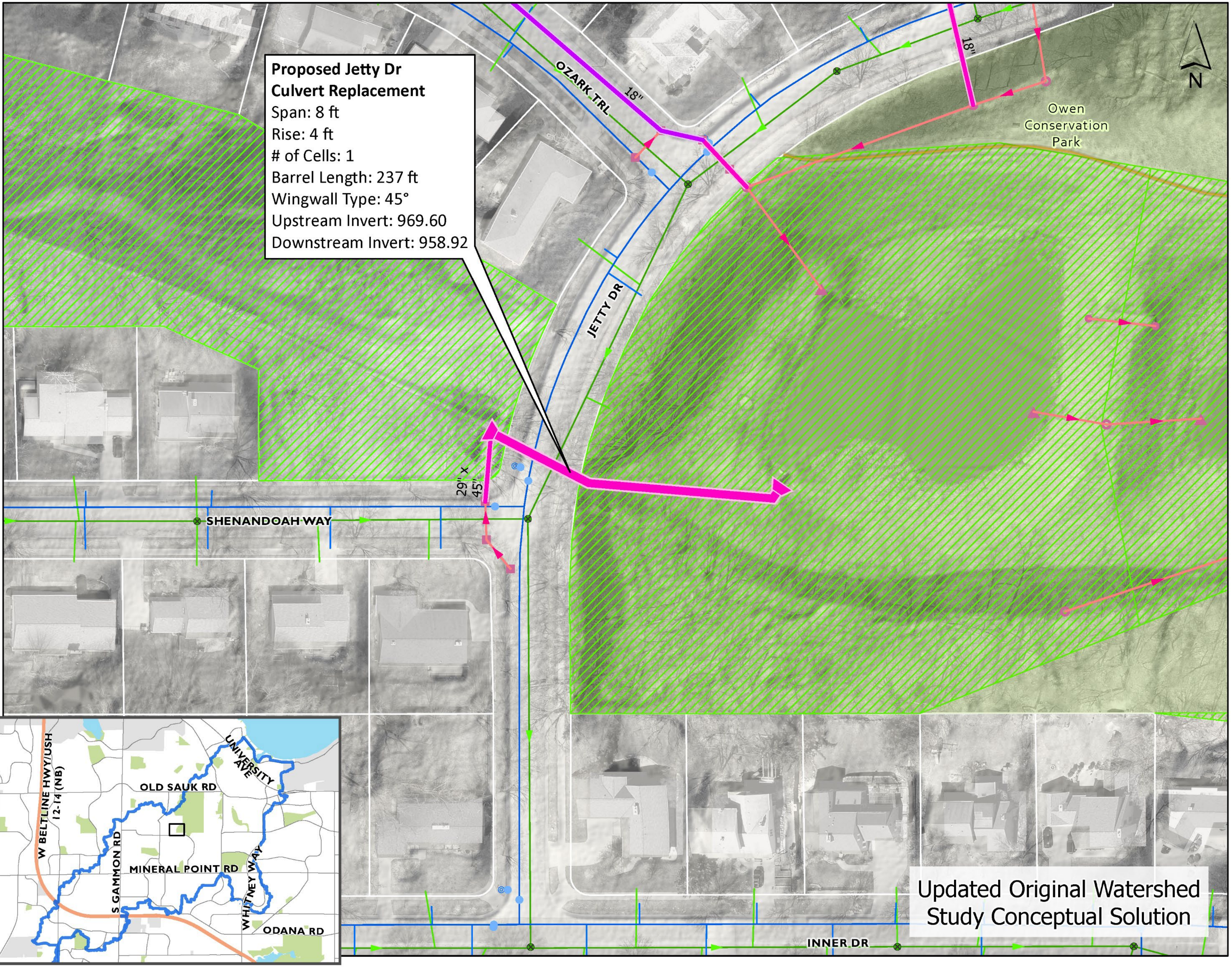

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Future Hypothetical Solution - Jetty Box Culvert

Amendment: 1
Figure: xxxi

Spring Harbor Watershed Study
City of Madison

Recommended Solutions
- New Box
- Parallel Box
- Removal Box
- Special Box
- Upsize Box
- New Pipe
- Parallel Pipe
- Removal Pipe
- Special Pipe
- Upsize Pipe
- Channel
- Pond
- Berm
- Floodwall
- Other
- 1' Project Contour
- Project Area of Interest

Other Data
- Ponds and Greenways
- Parks
- Railroads
- Park Paths

Storm Sewer
- Storm Pipe
- Inlet
- Headwall
- Other
- Apron End
- Access Structures
- Storm_Lift_Stations
- PVT Storm Structure -Approx.
- PVT Storm Pipe -Approx.

Other Utilities
- Water Value
- Water Main
- Water Service
- Water Hydrant
- SAS
- Sanitary Main
- Sanitary Lateral
- MMSD SAS
- MMSD Main

0 15 30 60 Feet

CITY OF MADISON ENGINEERING

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Future Hypothetical Solution - Masthead Greenway Pond

Amendment: 1
Figure: xxxii

Spring Harbor Watershed Study
City of Madison

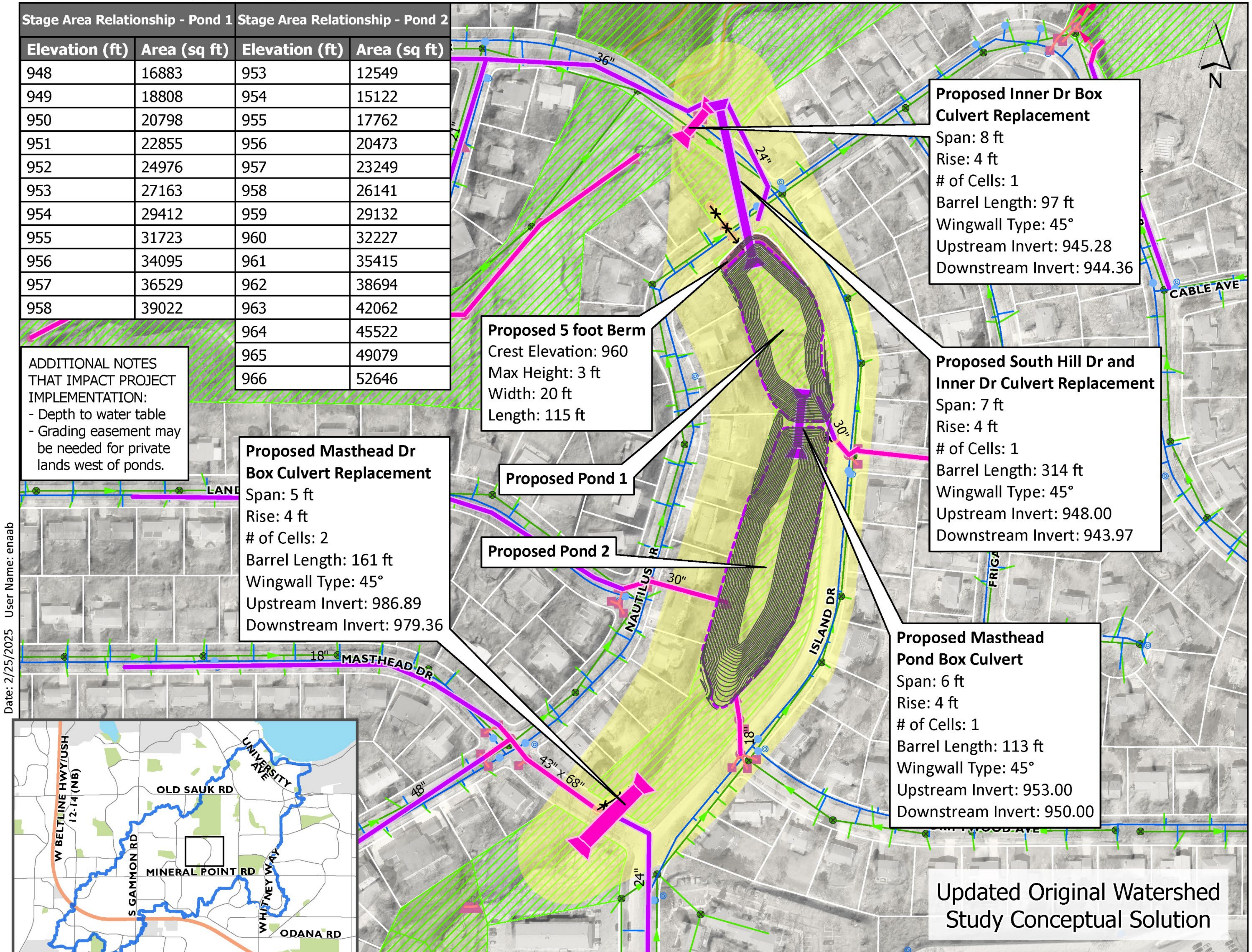
Stage Area Relationship - Pond 1

Elevation (ft)	Area (sq ft)
948	16883
949	18808
950	20798
951	22855
952	24976
953	27163
954	29412
955	31723
956	34095
957	36529
958	39022

Stage Area Relationship - Pond 2

Elevation (ft)	Area (sq ft)
953	12549
954	15122
955	17762
956	20473
957	23249
958	26141
959	29132
960	32227
961	35415
962	38694
963	42062
964	45522
965	49079
966	52646

ADDITIONAL NOTES THAT IMPACT PROJECT IMPLEMENTATION:
- Depth to water table
- Grading easement may be needed for private lands west of ponds.



Recommended Solutions
- New Box
- Parallel Box
- Removal Box
- Special Box
- Upsize Box
- New Pipe
- Parallel Pipe
- Removal Pipe
- Special Pipe
- Upsize Pipe
- Channel
- Pond
- Berm
- Floodwall
- Other
- 1' Project Contour
- Project Area of Interest

Other Data
- Ponds and Greenways
- Parks
- Railroads
- Park Paths

Storm Sewer
- Storm Pipe
- Inlet
- Headwall
- Other
- Apron End
- Access Structures
- Storm_Lift_Stations
- PVT Storm Structure -Approx.
- PVT Storm Pipe -Approx.

Other Utilities
- Water Value
- Water Main
- Water Service
- Water Hydrant
- SAS
- Sanitary Main
- Sanitary Lateral
- MMSD SAS
- MMSD Main

0 37.5 75 150 Feet

CITY OF MADISON ENGINEERING

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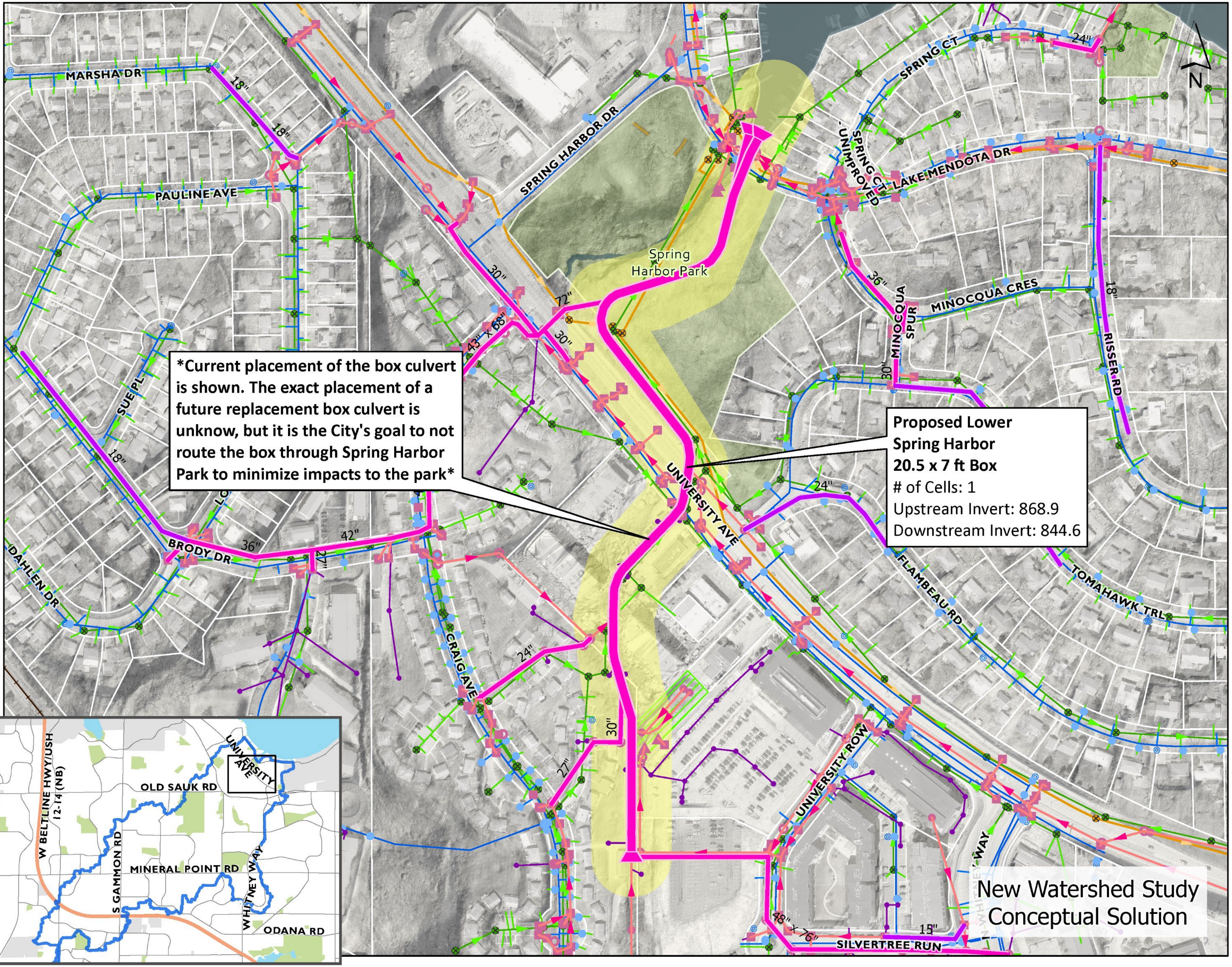
Future Hypothetical Solution - Upsized Lower Spring Harbor Box

Amendment: 1
Figure: xxxiii

Spring Harbor Watershed Study
City of Madison



Date: 2/25/2025 User Name: enaab

Recommended Solutions
- New Box
- Parallel Box
- Removal Box
- Special Box
- Upsize Box
- New Pipe
- Parallel Pipe
- Removal Pipe
- Special Pipe
- Upsize Pipe
- Channel
- Pond
- Berm
- Floodwall
- Other
- 1' Project Contour
- Project Area of Interest

Storm Sewer
- Storm Pipe
- Inlet
- Headwall
- Other
- Apron End
- Access Structures
- Storm_Lift_Stations
- PVT Storm Structure -Approx.
- PVT Storm Pipe -Approx.

Other Utilities
- Water Value
- Water Main
- Water Service
- Water Hydrant
- SAS
- Sanitary Main
- Sanitary Lateral
- MMSD SAS
- MMSD Main

Other Data
- Ponds and Greenways
- Parks
- Railroads
- Park Paths

0 45 90 180 Feet

CITY OF MADISON ENGINEERING

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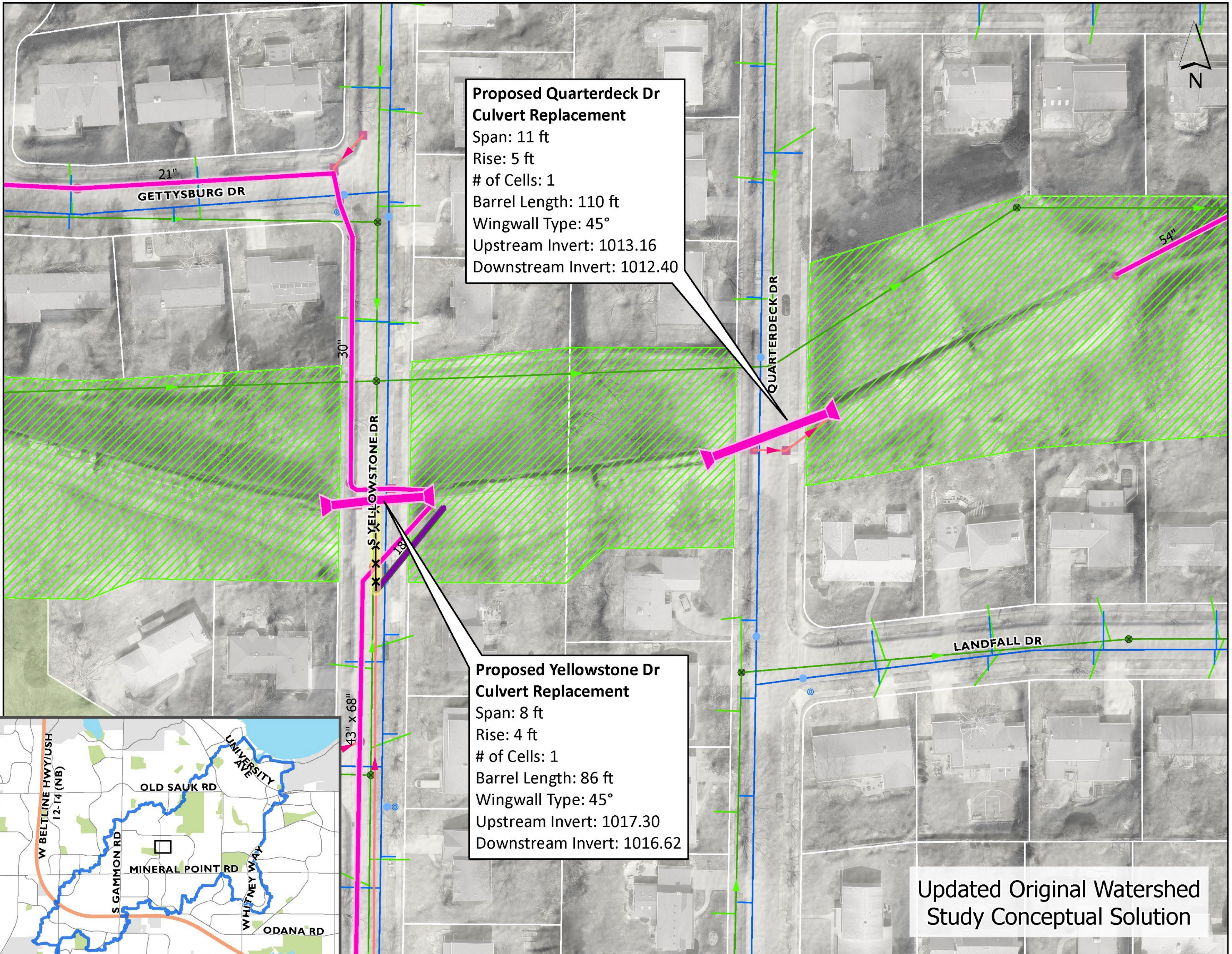
Future Hypothetical Solution - Yellowstone and Quarterdeck Box Culverts

Amendment: 1
Figure: xxxiv

Spring Harbor Watershed Study
City of Madison



Recommended Solutions
- New Box
- Parallel Box
- Removal Box
- Special Box
- Upsize Box
- New Pipe
- Parallel Pipe
- Removal Pipe
- Special Pipe
- Upsize Pipe
- Channel
- Pond
- Berm
- Floodwall
- Other
- 1' Project Contour
- Project Area of Interest

Other Data
- Ponds and Greenways
- Parks
- Railroads
- Park Paths

Storm Sewer
- Storm Pipe
- Inlet
- Headwall
- Other
- Apron End
- Access Structures
- Storm_Lift_Stations
- PVT Storm Structure -Approx.
- PVT Storm Pipe -Approx.

Other Utilities
- Water Value
- Water Main
- Water Service
- Water Hydrant
- SAS
- Sanitary Main
- Sanitary Lateral
- MMSD SAS
- MMSD Main

0 15 30 60 Feet

CITY OF MADISON ENGINEERING

Date: 2/25/2025 User Name: enaab

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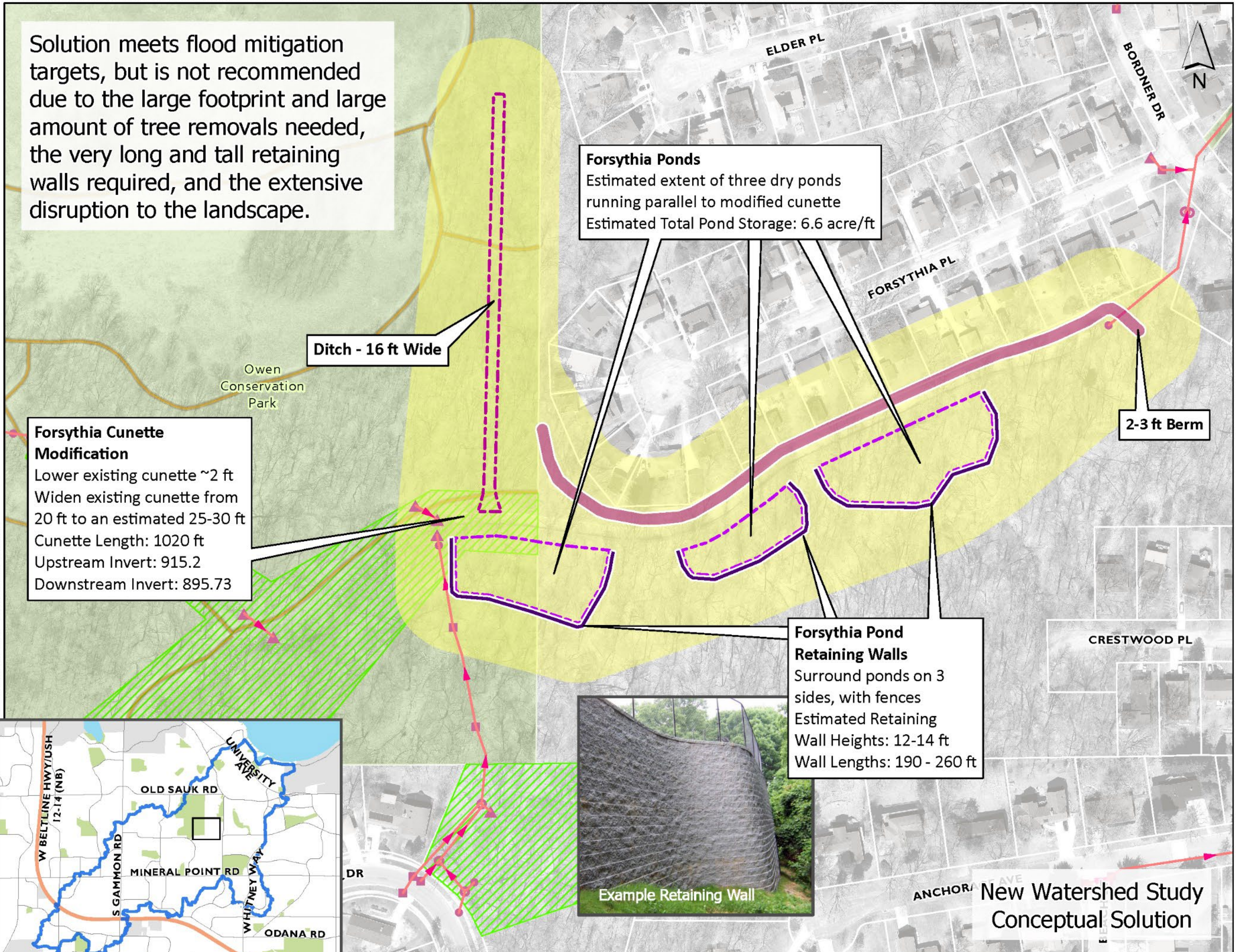

Date: 2/25/2025 User Name: enaab

Not Recommended - Forsythia Pond

Amendment: 1
Figure: xxxv

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0 25 50 100 Feet

CITY OF MADISON ENGINEERING

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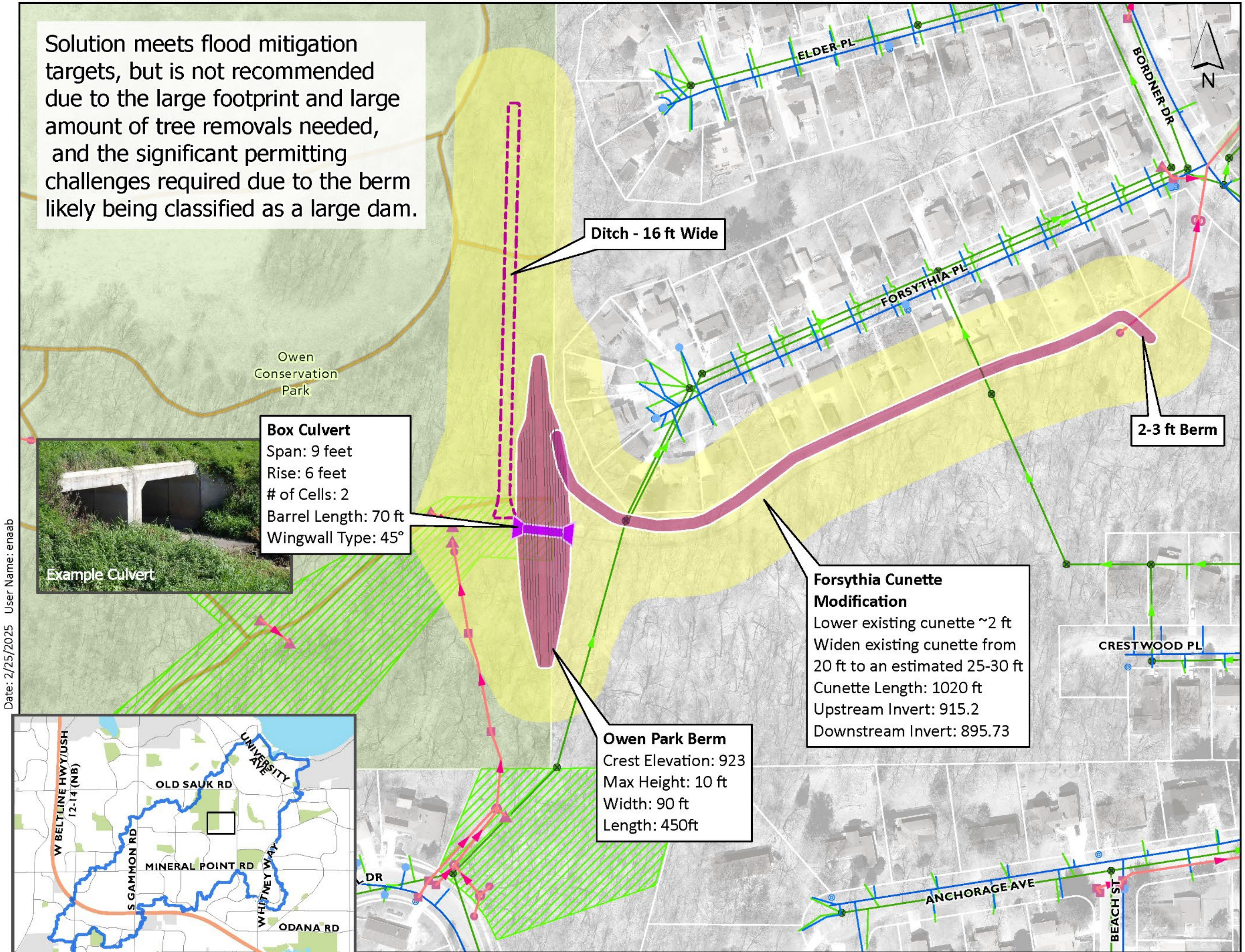

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Amendment: 1
Figure: xxxvi

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