Metropolitan Nashville and Davidson County

Stormwater Masterplan

BARGE DESIGN SOLUTIONS

Metro Water Services
JUNE 2025

DRAFT






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1.0 PROJECT INTRODUCTION AND BACKGROUND

1.1 Project Purpose

The objective of the Stormwater Masterplan is to evaluate performance of Nashville's existing drainage network to develop a multitude of alternatives to address goals for controlling stormwater and flooding throughout the Metropolitan Government of Nashville and Davidson County (Metro) service area. Additionally, the physical condition of the existing stormwater assets will be documented so that improvements can be planned for and included in a capital improvement plan (CIP). The Masterplan gives Metro Water Services (MWS) the tools needed to select practical and achievable stormwater management solutions.

1.2 Metro Stormwater Drainage History

In the 1890s and early 1900s, large diameter brick and clay pipes were tunneled under the City of Nashville (the City) to carry combined sewage and stormwater runoff untreated to the river (Figure 1.1). Treatment of the flow began in the 1950s, but in the 1950s and 1960s, the strategy to address stormwater remained to put all sewage and stormwater in combined pipes.

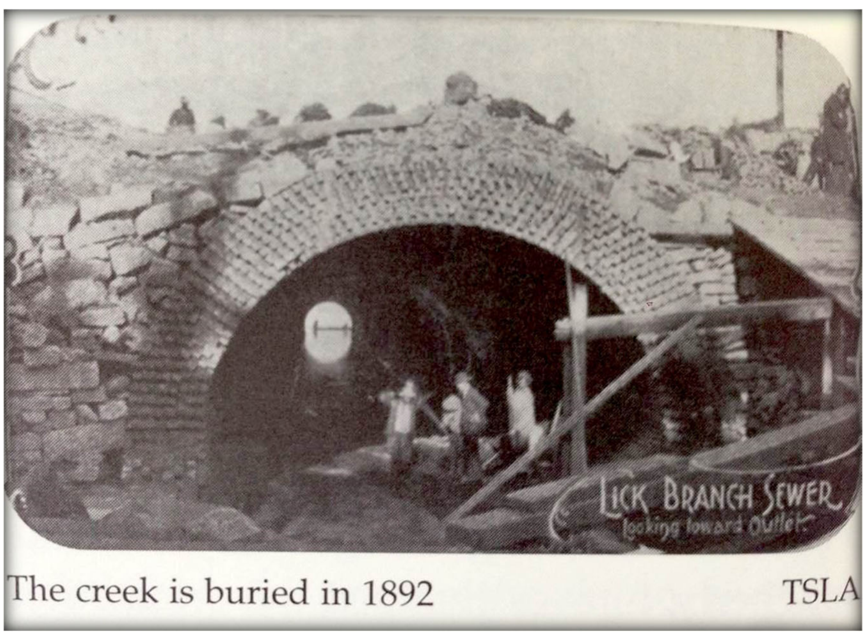


Figure 1.1 – Nashville's Brick Pipes

In the 1960s until the mid-1970s, as Nashville grew outside of the urban center, stormwater management focused on developing efficient drainage conveyance from paved surfaces and developments to the nearest stream primarily through curb and gutter neighborhoods. Then from the mid-1970s until the mid-1980s, the City began requiring that most new development within the Metro Nashville area detain stormwater in ponds in an attempt to reduce downstream flooding.

Beginning in the mid-1980s until the mid-1990s, MWS developed watershed-based masterplans for most of the major watersheds in the City. Through the masterplans MWS sought to solve flooding problems on a larger scale and in a comprehensive and coordinated fashion. However, due to lack of funding, not all recommended and needed capital improvements were addressed, and the more minor systems were never studied.

In the mid-1990s until the early 2000s, the focus shifted to stormwater quality control. The National Pollutant Discharge Elimination System (NPDES) required MWS to implement a set of programs and standards to attempt to control pollution from runoff to the "maximum extent practical" and prohibit non-stormwater from entering the stormwater system and waters of the State. With implementation of NPDES Program came Low Impact Development (LID) and Green Infrastructure (GI) concepts, which were intended to reduce stormwater runoff volume using infiltration, evapotranspiration, and/or rainwater reuse (Figure 1.2).

Figure 1.2 – Green Infrastructure

In recent years, Metro Nashville has experienced unprecedented economic and physical growth while facing real, growing, and unresolved stormwater problems. The unresolved problems can be categorized in two main areas: flooding and infrastructure. MWS desires to develop strategies to address flooding and undersized infrastructure issues at a basin level and to create CIPs that prioritize improvements based on engineered studies.

1.3 Masterplan Organization

Barge Design Solutions, Inc. (Barge) was selected by MWS to design and implement a watershed-based masterplan for the City's stormwater system. The components of the stormwater master planning project include infrastructure inventory, improvement of the quality of stormwater geographic information systems (GIS) data across Nashville, evaluation of existing conditions, evaluation of future conditions, alternative development, recommended improvements, and project prioritization. The project was divided into a basin-by-basin effort as discussed in Section 3.

This Masterplan report includes discussion of advisory committee involvement, agreed-upon decision criteria, basin prioritization, a summary of the hydrologic and hydraulic modeling approach, results of the inventory and condition assessment, a summary of the model results, and discussion of project prioritization. Detailed discussion of the hydrologic and hydraulic approach is included as Appendix A to this report, and detailed discussion of the basins is included in individual watershed reports.

Watershed reports were prepared for each basin and are included at the end of this report. The watershed reports discuss the existing basin conditions and known future conditions. Modeling of the basins was performed, and the results are presented in each watershed report. Problem areas were identified where infrastructure has insufficient capacity from results of the existing conditions model. Alternatives were proposed to address the issues in each problem area. Engineer's opinion of probable construction cost (OPCC) estimates were prepared for each alternative. The alternatives were evaluated against agreed-upon decision criteria. Recommended alternatives for each problem area in each basin are summarized in Section 7 of this report.

2.0 ADVISORY COMMITTEE INVOLVEMENT

Flooding mitigation solutions require broad consensus and support from various members of the community. Therefore, a point of emphasis of this effort is developing consensus among a set of informed Metro employees and other leaders regarding decisions made through the master planning process in the form of an advisory committee. Some examples of these decisions are determining what level of service should be obtained through the alternatives evaluated and the relative importance of the various criteria used to evaluate the suitability of a specific alternative for a given area. Considering and addressing the perspectives of a wide cross-section of the community, including elected officials, regulators, and leaders, will allow the Masterplan to represent the community. Plans developed with this type of broad support are generally more successful than plans crafted in isolation.

2.1 Committee

The Advisory Committee should be made up of individuals from organizations that have technical expertise, permitting authority, or special interest in flooding impacts in Metro Nashville. As documented in Reference 1, Barge provided a list of potential group members and recommended selecting a group made up of Metro staff, a business community leader, a local official, and a representative from at least one government entity, critical service provider, and environmental group so that the committee is of manageable size but different groups have a representative for their interests and considerations. Table 2.1 lists the Advisory Committee Members that MWS chose based on the recommendations.

Table 2.1 Advisory Committee

Name	Organization
Kendra Abkowitz	Mayor's Office
Steve Mishu	Metro Codes Administration
Heidi Mariscal	Metro Office of Emergency Management
Cindy Harrison	Metro Parks and Recreation
Dustin Shane	Metro Planning Department
Derek Hagerty	Nashville Department of Transportation
Matt Tays	Metro Water Services
Sean Parker	Chair of Transportation and Infrastructure Committee
Andy Reese	Andy Reese, LLC

2.2 Role of the Advisory Committee

An important role of the members on the Advisory Committee is to help Metro make key decisions during the master planning process. The Advisory Committee participates in discussions, completes survey forms, and provides feedback on different aspects of the project which will ultimately lead to recommendations to the Project Management Team. The Project Management Team is comprised of Metro Water Services (MWS) employees who will ultimately make the decisions regarding the project direction.

Three primary decisions for which Metro needs agreement on are:

1. Agreement is needed of an appropriate level of service to be obtained through the Stormwater Masterplan improvements. Level of service includes the design storm to be modeled and designed for as well as performance of infrastructure. Examples of performance of infrastructure could be whether some level of ponding is acceptable in a roadway or no ponding is acceptable, or pipes are allowed to surcharge during design storm events or no surcharge is allowed.

2. Input is required regarding the criteria developed to identify and determine the watershed priority areas. Criteria presented may include the rate of development in an area, density of development, community complaints, or data quality. The committee should provide feedback regarding the criteria presented and recommend other criteria that should be considered.

3. Input will be needed on future issues such as the appropriateness of future flood mitigation solutions. These alternatives will have different advantages and disadvantages in terms of cost, schedule, environmental impacts, and social considerations. The committee will

help to decide the importance of each of these criteria in a way that reflects the community's values. The committee members should provide feedback regarding the different impacts and recommend other criteria that should be considered during discussions.

To facilitate agreement with the level of service decisions, as well as to provide overall input into the master planning process, the Advisory Committee is anticipated to be engaged throughout the program to provide input and feedback on major decisions which will ultimately drive project scope.

2.3 Advisory Committee Workshops

Once the committee membership was established, a series of workshops was initiated with the group. The workshops were conducted as follows:

Workshop 1- Introduction

At the first workshop, the committee members were introduced to each other and the MWS/consultant team that is working on the Masterplan. The overall background and objectives of the program were presented and discussed with committee members. The members were advised of their role in the process and had an opportunity to provide comments, ideas, or questions about the program. At this meeting the process of inventory and asset assessment was discussed, as well as the modeling process that was used to generate alternatives. The results of the pilot basin assessment and alternatives developed were presented. At the first meeting Barge also introduced the topic of stormwater level of service and the criteria used to rank the basins to be studied and facilitated a discussion to solicit committee input.

Workshop 2- Decision Criteria

During the second workshop more details were provided about the decision criteria. The approach to evaluating the relative importance of each criterion was discussed as well as how the weighted criteria will ultimately be used to prioritize projects. A survey was provided to Advisory Committee members to gather their opinion on the relative importance and level of importance of each criterion.

Additional specifics of the master planning process were discussed including review of potential solutions that will be considered in the alternatives analysis.

Workshop 3- Criteria Weighting Results

This workshop presented the results of the criteria weighting process. The survey results and subsequent criteria weights were discussed. Additionally, the ranking of a sample set of projects was presented to demonstrate how the criteria weights would be applied. The Advisory Committee provided feedback for refining the scoring of each criteria and made recommendations on effective ways to present and document the prioritization of projects.

Workshops 4 through N

The remaining workshops will be scheduled to review the results of subsequent basin assessment, modeling, and alternatives analysis. The exact number of workshops will be based on how the basin planning is being implemented, and it is possible that large basins may require more than a single workshop, or multiple smaller basins may be combined into the same workshop. These workshops may also include an overall progress report of how the work in other basins is being implemented.

Final workshop

It is anticipated that a final workshop will be held to summarize the work of the master planning effort, review the status of program implementation, and thank the committee members for their service.

Documentation

Workshops 1-4 were documented with meeting minutes reflecting the overall discussion as well as specific comments or questions and any follow-up or action items that resulted from the discussions. Follow-up may have been through email distribution to the committee members or discussion at the next subsequent workshop. Minutes were provided to the committee members following each workshop. Each of the workshop minutes and presentations are included in Appendix B of this masterplan report. Any future workshop will be documented in the same manner.

3.0 SUB-BASIN PRIORITIZATION

As documented in Reference 2, Barge developed a Watershed Prioritization Matrix based on information available to assist the stormwater master planning process by comparing the different stormwater basins and providing a ranking. The general approach using the Prioritization Matrix includes:

- Determining important metrics and criteria
- Establishing a weighted factor for each criterion
- Determining the individual score for each criterion for each watershed
- Calculating the weighted score for each criterion
- Totaling the weighted scores for each watershed
- Ranking watersheds according to weighted scores

The Prioritization Matrix is one tool used for decision making. Engineering judgement and experience were also major factors in determining prioritization.

Table 3.1 provides the project team recommendation, agreed upon by the Advisory Committee, for prioritization criteria, the method of defining the criteria, and the weighted factor for combining each criterion into an overall score. Additionally, a fifth criterion is that preference is given to basins neighboring combined sewer systems (CSSs) that are being studied.

Table 3.1 Prioritization Criteria and Weighted Factor

	Criteria	Criteria Definition	Weighted Factor
1	Development Density	Number of Parcels	0.2
2	Experiencing Growth	Number of Active Development Permits	0.3
3	Existing Issues	Number of Service Requests	0.3
4	Data Quality	Age and Source of Data	0.2

Development density, experiencing growth, and existing issues were determined to be critical factors for prioritizing the watershed basins. These factors highlight areas where the Stormwater Masterplan will impact the most people, will allow for improvements to be installed with development, and will address existing issues with the stormwater system.

Additionally, a goal of the Masterplan project is to improve the overall quality of stormwater GIS data across Nashville. Since improving data quality is a goal, Barge considered the current quality of GIS data as a factor to guide the prioritization.

The weighted scoring for development density, active development permits, number of service requests, and the quality of GIS data for each basin is detailed in Reference 2 (Appendix C). A visual representation of the prioritization results is shown in Figure 3.1.

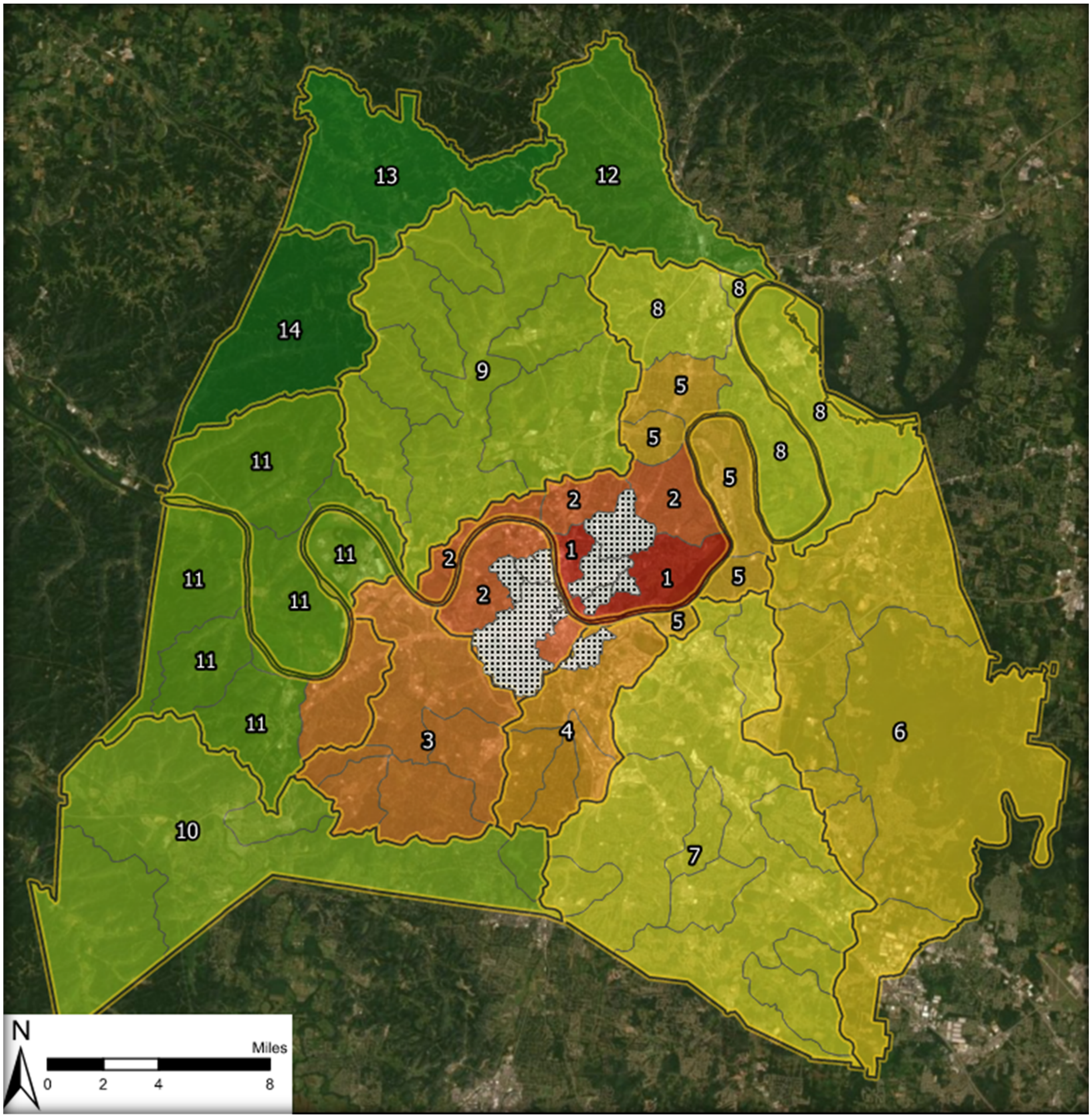


Figure 3.1 - Location Map for Prioritization Ranking

Based on this rating, Barge began with Metro's Shelby Park and East Nashville watersheds, shown as Area #1. Besides ranking high on the Watershed Prioritization Matrix, these basins neighbor a CSS and future development is planned for both areas. By understanding issues now, MWS will be able to plan for any needed stormwater improvements and have them implemented as a part of the developments.

Upon completion of the inventory and modeling in these areas, MWS and the Barge team evaluated the results and reporting and agreed on a path forward. Other field crews were then trained and deployed to additional watersheds. Table 3.2 summarizes the status of each sub-basin.

Table 3.2 Summary of Sub-Basin Completion*

Sub-Basin Name	Basin Number	Inventory	Condition Assessment	GIS to MWS	Modeling	Alternatives Evaluation
East Nashville	25	X	X	X	X	X
Shelby Park A	29	X	X	X	X	X
Shelby Park B	29	X	X	X	X	X
Shelby Park C	29	X	X	X	X	X
Shelby Park D	29	X	X	X	X	X
Richland Creek A	31	X	X		X	X
Richland Creek B	31	X	X		X	X
Richland Creek C	31	X	X		X	X
Richland Creek D	31	X	X		X	X
Richland Creek E	31	X	X		X	X
Nashville A	24	X	X	X	X	X
Nashville B	24	X	X	X	X	X
Nashville C	24	X	X	X	X	X
Nashville D	24	X	X	X	X	X
Nashville E	24	X	X	X	X	X
Nashville F	65	X	X	X	X	X
Apex Basin	65	X	X	X	X	X
Trinity A	28	X	X		X	X
Trinity B	28	X	X		X	X
Trinity C	28	X	X		X	X
Pages Branch A	23	X	X	X	X	X
Pages Branch B	23	X	X	X	X	X
Pages Branch C	23	X	X	X	X	X

Sub-Basin Name	Basin Number	Inventory	Condition Assessment	GIS to MWS	Modeling	Alternatives Evaluation
Coopers Creek A	20	X	X	X	X	X
Coopers Creek B	20	X	X	X	X	X
Coopers Creek C	20	X	X	X	X	X
Cleeces Ferry A	39	X	X		X	X
Cleeces Ferry B	39	X	X			
Sugartree Creek	42	X	X		X	X
Jocelyn Hollow	48	X	X		X	X
Vaughns Gap	51	X	X		X	X
Browns Creek A	38	X	X			
Browns Creek B	38	X	X			
Browns Creek C	38	X	X			
Browns Creek D	38	X	X			
W Fork Browns Creek	46					
E Fork Browns Creek	44					
Mansker Creek A	2					
Mansker Creek B	2					
Mansker Creek C	2					
Sycamore Creek A	3					
Sycamore Creek B	3					
Claylick Creek	4					
Whites Creek A	5					
Whites Creek B	5					
Whites Creek C	5					
Whites Creek D	5					
Whites Creek E	5					
Marrowbone Creek	6					
Earthman	7					

Sub-Basin Name	Basin Number	Inventory	Condition Assessment	GIS to MWS	Modeling	Alternatives Evaluation
Dry Creek A	8					
Dry Creek B	8					
Little Creek A	10					
Little Creek B	10					
Old Hickory A	11					
Old Hickory B	11					
Dry Fork	12					
Neelys Bend A	13					
Neelys Bend B	13					
Ewing Creek A	14					
Ewing Creek B	14					
Ewing Creek C	14					
Ewing Creek D	14					
Gibson Creek	15					
Eatons Creek	16					
Scottsboro	17					
Loves Branch	18					
Pennington Bend A	19					
Pennington Bend B	19					
Stones River A	21					
Stones River B	21					
Stones River C	21					
Stones River D	21					
Stones River E	21					
Bells Bend A	22					
Bells Bend B	22					
Cub Creek	26					

Sub-Basin Name	Basin Number	Inventory	Condition Assessment	GIS to MWS	Modeling	Alternatives Evaluation
Cockrill Bend	27					
Percy Priest C	27					
Windermere	30					
Mill Creek A	33					
Mill Creek B	33					
Mill Creek C	33					
Mill Creek D	33					
Mill Creek E	33					
Sims Branch	33					
Indian Creek E.	34					
Indian Creek W.	34					
Mccrory Creek A	35					
Mccrory Creek B	35					
Mccrory Creek C	35					
River Hill	36					
Percy Priest A	37					
Percy Priest B	37					
Overall Creek	40					
Harpeth River A	43					
Harpeth River B	43					
Harpeth River C	43					
Harpeth River D	43					
Sevenmile Creek A	49					
Sevenmile Creek B	49					
Sorghum Branch	52					
W Fork Hamilton Creek	53					
Flat Creek	54					

Sub-Basin Name	Basin Number	Inventory	Condition Assessment	GIS to MWS	Modeling	Alternatives Evaluation
E Fork Hamilton Creek	55					
Trib #1 Mill Creek	55					
S. Harpeth River	57					
Sevenmile Brentwood Branch	60					
Whittemore Branch	61					
Hurricane Creek A	62					
Hurricane Creek B	62					
Turkey Creek	63					
Gallatin	8/9					

*As of 6/28/2025

4.0 DECISION CRITERIA

A primary objective of the Stormwater Masterplan is a comprehensive analysis of the physical drainage system and developing solutions for addressing stormwater issues throughout the Metro Nashville service area. With multiple methods available, alternative solutions for flood mitigation should be considered while balancing economic considerations, social considerations, schedule, environmental impacts, and flood reduction benefits. Therefore, to prioritize stormwater improvements throughout the service area, the various factors or decision criteria that influence a project must be identified and weighted in a way that reflects the communities' values. The Advisory Committee is being utilized in determining the appropriate decision criteria and weights.

4.1 Decision Criteria Weighting

As described in detail in Reference 5 (Appendix C), once the decision criteria are determined, the relative importance of each criterion will be established. Because relative importance of various factors that influence the decision criteria can involve specific or technical knowledge, the weights of the various criteria will be determined by the Advisory Committee. An effective way to establish these weights is using paired choice ranking. The Advisory Committee members were provided a survey and asked to first consider how important five primary criteria are by assigning points, totaling to 100.

Sub-criteria were then identified to further define the components of the primary criteria and addressed in a similar manner by Metro's project team with input from the Advisory Committee. Through the survey, the Advisory Committee members were asked to first consider which of two criteria is more important. Next, they considered the degree to which one criterion is more important than the other by assigning a numerical score as follows:

Mildly More Important:	1
Clearly More Important:	2
Overwhelmingly More Important:	3

The total number of points awarded to a criterion was the criterion's score. The weight assigned to each criterion is the criterion's score divided by the total number of points awarded for all the criteria. The result is a final weighted factor for each sub-criterion.

4.2 Decision Criteria Scoring

The decision sub-criteria identified and agreed upon by MWS and the Advisory Committee will be used to evaluate potential alternative projects. Each alternative project will be assigned a score for how it performs against each sub-criterion based on scoring guidelines to be recommended by Barge and reviewed by the Advisory Committee then grouped into high priority, moderate priority and low priority categories.

4.3 Level of Service and Risk Analysis

With agreement from MWS and the Advisory Committee, projects proposed in this Masterplan meet a level of service corresponding to a 10-year 24-hour design storm event where water elevation remains below the rim. Out of the design storm events, the 10-year storm is considered the minimum level of service criteria based on the Metro Nashville Stormwater Management Manual.

Projects considered addressed flooding on public property such as roads overtopping or flooding on multiple adjacent private properties. If a single driveway culvert was undersized causing overtopping of a private driveway or property, an alternative was not proposed.

Proposed projects are also reviewed for effectiveness in a future buildout scenario for the 10-year storm event. Additionally, the 100-year 24-hour design storm event was analyzed to determine the system's performance for the current and future buildout scenarios. While flooding may not be completely contained during the 100-year event, there is an expectation that the system should be capable of passing the 100-year design flow within the drainage easement and the level of service does not flood buildings.

5.0 GIS INVENTORY

A review of MWS's existing GIS data was performed and documented in Reference 2 (Appendix C). Based on the data review, Barge recommended using the existing stormwater infrastructure geodatabase to locate existing features (manholes, inlets, catch basins, etc.) and collect accurate XYZ coordinates for the structure. Simultaneously, photos were taken, and a condition assessment was performed.

5.1 Inventory

For each basin, Barge field crews located and determined the condition of pipes, open channels, catch basins, inlets, junction boxes, outfalls, and other stormwater structures in a GIS format. To determine the number of features expected and where to begin the inventory, Barge utilized the existing Metro Stormwater GIS. Prior to inventory and assessment, Barge developed a GIS database schema that was reviewed and approved by Metro. This schema, described in Appendix D, collected the pertinent feature geometry and attributes. It contains domains to allow field staff to utilize dropdowns and other data standardization during the data collection process. The data collection workflow was GIS-based and leveraged Global Positioning System (GPS) devices connected to Android or iOS tablets for data entry.

System connectivity and attributes were developed by collecting data on the stormwater system features necessary to complete a contiguous stormwater system network from the stormwater systems' outfalls (at connection with stream) upstream to the stormwater structures connected by 15-inch diameter pipes and larger (includes open channels between 15-inch pipes and outfalls). MWS requires storm drains connecting to the MWS system be at least 15 inches. Additionally, MWS does not maintain private storm drainage systems or yard piping. For this reason, the field data collection and modeling effort included storm infrastructure connected with pipes 15 inches in diameter and larger. This also limits the recommendations to infrastructure with significant enough flows to have measurable flood mitigation benefits to the public.

Data gathered during field surveying are as listed below:

- Unique stormwater structure identifier
- Horizontal coordinates (x, y) and elevation data (rim elevation for structures and invert elevation of pipes)
- Flow direction for conveyance structures
- Dimensions of conveyance structures and open channels (top bank to top bank) at headwall locations
- Road crossings, to consist of headwall inverts and pipe dimensions
- Drainage structures (manholes, inlets, end walls, etc.) on pipes 15 inches in diameter or larger
- Photographs of the following:
    - All major structures
    - Open/closed system transitions
    - Roadway stream crossings
    - Point discharges to modeled streams
    - Other features impacting modeling efforts and results

The photographs were associated with the GIS feature and stored in the geodatabase. This allows the photos to stay "connected" to the points, lines, and polygons that they pertain to.

As a part of the inspection process, Barge staff identified and notified the Metro project manager of priority structures that:

- Required immediate cleaning.
- Appeared to have an illicit discharge.
- Appeared in immediate threat of collapse.

The collected data was synced to a Barge-hosted web GIS where it was reviewed (Figure 5.1). Once the data collection process was complete, the data was delivered to Metro as a geodatabase to be included into Metro's existing GIS.

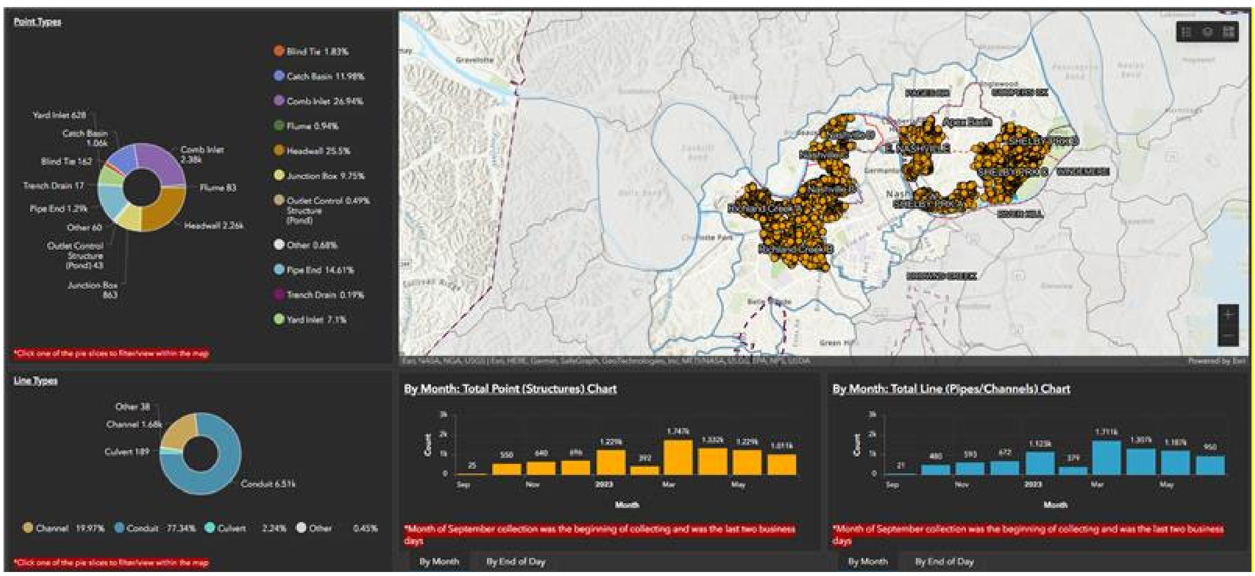


Figure 5.1 – GIS Inventory Dashboard

5.2 Condition Assessment

As a part of the inventory process, Barge performed a condition assessment of each structure (outlet control structures, junction boxes, inlets, headwalls, pipe ends, flumes). A condition assessment was not completed for pipes, culverts, and conduits. A 1 to 5 scale was selected because it provides a descriptive assessment of the asset's condition. This allows for greater forecasting for replacement and maintenance. The results and effectiveness of this rating system were reviewed at the conclusion of the pilot study and determined to be effective.

For the condition assessment, structure ratings were based on the following definitions:

- Grade 0 – Excellent – (Figure 5.2): The asset is in excellent condition and has no documented defects. It is similar to that of new construction with no installation defects. This asset is at or near the beginning of its design life.
- Grade 1 – Good - (Figure 5.3): The asset is in good condition with only minor installation defects or defects which are minor in nature as a result of its service life so far. This asset is expected to have 20 or more years of remaining service life.
- Grade 2 – Moderate - (Figure 5.4): The asset is in moderate condition with several minor defects. These minor defects, although not currently affecting its intended use, will likely impact the overall length of the asset's service life. This asset is expected to have 10-20 years of remaining service life.
- Grade 3 – Fair - (Figure 5.5): The asset is in fair condition and has one or more moderate defects, but such defect(s) do not appear to be ones that would be considered of imminent risk of failure. This asset is less than 10 years from the end of its useful or design life.
- Grade 4 – Poor - (Figure 5.6): Although the asset is partially or fully serving its intended purpose, the asset is in poor condition and has significant defects which are of imminent risk of failure. Failure may occur at any time, resulting in this asset being upgraded to a Grade 5. This asset is at the end of its useful or design life.
- Grade 5 – Failed - (Figure 5.7): The asset has already failed and is no longer serving its intended purpose. This asset has already surpassed its useful or design life.

Figure 5.2 – Example of Grade 0 – Excellent Condition (new construction, no defects)

Figure 5.3 – Example of Grade 1 – Good Condition (minor defects, most of service life left)

Figure 5.4 – Example of Grade 2 – Moderate Condition (several minor defects)

Figure 5.5 – Example of Grade 3 – Fair Condition (moderate defects, exposed aggregate)

Figure 5.6 – Example of Grade 4 – Poor Condition (significant cracking, near failure)

Figure 5.7 – Example of Grade 5 – Failed Condition (pipe completely separated)

5.3 Inventory and Condition Assessment Results

Inventory data were collected and condition assessments have been performed for over 50,000 structures in the MWS service area. Table 5.1 shows the results of the conditions assessment by basin.

Table 5.1 Summary of Inventory and Condition Assessment Results**

Basin	Number of Structures	Number of Structures Rated 0	1	2	3	4	5	NA*
Shelby Park A	234	0	60	114	34	7	1	18
Shelby Park B	399	1	126	203	31	6	0	32
Shelby Park C	2103	1	444	910	337	81	60	270
Shelby Park D	833	0	303	242	130	54	20	84
Sugartree Creek	5549	8	931	3049	879	128	60	494
East Nashville	877	1	203	348	176	48	13	88
Jocelyn Hollow A	1055	0	159	544	201	41	12	98
Richland Creek A	1087	0	480	420	100	13	9	65
Richland Creek B	1143	0	104	351	580	28	2	78
Richland Creek C	2624	1	212	1045	908	104	14	340
Richland Creek D	2301	1	291	955	716	136	29	173
Richland Creek E	2904	0	213	1843	421	84	45	298
Nashville A	880	0	244	368	157	19	2	90
Nashville B	1167	0	105	443	437	39	5	138
Nashville C	278	0	57	130	69	2	0	20
Nashville D	1192	0	278	492	314	7	6	95
Nashville E	407	0	68	205	70	16	4	44
Nashville F	1941	0	53	1179	414	30	2	263
Overall Creek	13	0	5	7	1	0	0	0
Pages Branch A	796	0	78	366	229	15	7	101
Pages Branch B	615	2	37	194	174	34	8	166
Pages Branch C	1235	0	144	515	302	50	10	214
Coopers Creek A	2115	2	239	777	586	174	40	297
Coopers Creek B	1444	0	532	476	209	47	3	177
Coopers Creek C	2859	5	459	1221	494	137	19	524
Apex	2296	0	458	855	520	72	11	380
Trinity A	409	17	127	171	42	6	1	45
Trinity B	677	0	98	309	180	34	3	53
Trinity C	617	2	149	194	157	43	2	70
Vaughns Gap A	1517	23	134	976	313	46	25	0
Browns Creek B	199	1	43	90	35	4	1	25
Browns Creek C	1490	11	414	762	159	26	13	105
Cleeces Ferry A	4192	15	510	2285	783	135	99	365

Basin	Number of Structures	Number of Structures Rated						
		0	1	2	3	4	5	NA*
Cleeces Ferry B	3273	21	657	1578	589	118	56	254
Cockrill Bend	11	0	4	4	0	0	0	3
W. Fork Browns	40	0	23	10	3	0	0	4
Whites Creek A	10	0	0	10	0	0	0	0

*Structures rated “NA” were “Not Accessible” due to debris

** As of 6/28/2025

6.0 HYDROLOGIC AND HYDRAULIC APPROACH

Upon completion of the GIS inventory and condition assessment for each sub-basin, a stormwater management model (SWMM) (Figure 6.1) was prepared for the sub-basin’s existing conditions. Existing hydrology data was collected and utilized including topography, soil type, land use, land cover, and impervious surfaces. Curve numbers were determined for pervious surfaces. Impervious areas were input as a percentage of the total area. The existing drainage infrastructure as determined in the inventory process was evaluated for the 24-hour duration storm events having rainfall amounts for the return frequencies of 10 and 100 years. Analysis extended to upstream locations to include pipes 15 inches in diameter or larger. Once the existing conditions model was developed, the model was used to simulate proposed alternatives to address any areas where the existing drainage infrastructure is not adequate to prevent above-ground ponding or overland flow for the modeled storm events. A detailed description of the model development and approach is provided in Appendix A.

Figure 6.1 – Example of SWMM Model

7.0 BASIN PROJECT SUMMARY

Based on results of the existing conditions models, areas where the existing drainage infrastructure is not adequate to prevent above-ground ponding or overland flow for the modeled storm events were identified in each sub-basin. For each of the identified areas of interest, remedial measures were evaluated to mitigate flooding in the existing drainage infrastructure system. In general, the following types of remedial alternatives were considered:

- Increase the capacity of the pipes and associated structures to alleviate the capacity restriction to the outfalls.
- Provide storage to detain the peak flows and release flow as capacity returns.
- Reroute a portion of the network to a parallel pipe system with available capacity.
- Extend the stormwater system where there is no existing infrastructure.
- Bypass a portion of the stormwater system to avoid existing houses or buildings.

Multiple alternatives were evaluated for each area of interest. As discussed above, alternatives were designed to accommodate the 10-year return frequency flood event, but in accordance with the Metro Stormwater Manual (Reference 6) where the 10-year flow exceeded 100 cfs, the alternative was designed to accommodate the 100-year return frequency flood event. An OPCC was prepared for each alternative. The alternatives were evaluated according to flood mitigation performance, cost, and other potential benefits consistent with the decision criteria, summarized in a project page (Figure 7.1).

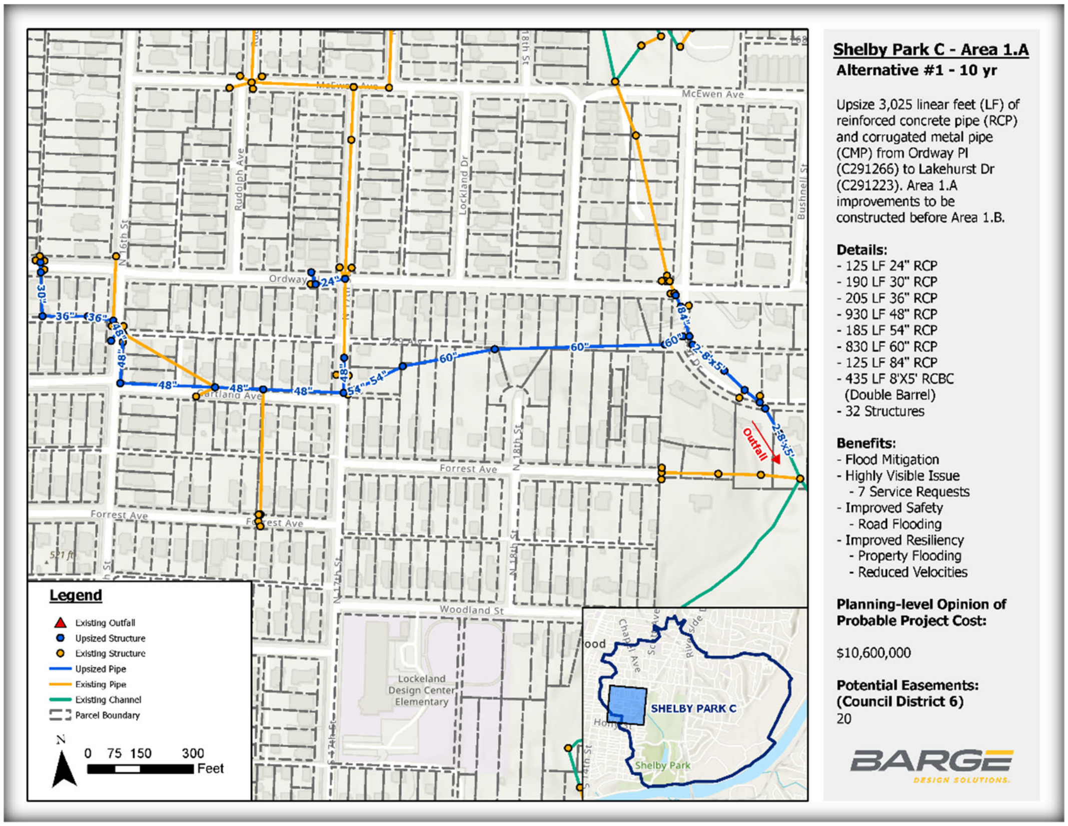
Additionally, alternatives were evaluated for performance under future land use conditions. The Nashville Next concept map was used to estimate future development conditions. Future impervious conditions and associated runoff values, if different than current values, were input into the model. If the future conditions 10-year frequency flood volume was less than 10% greater than the existing 10-year flood volume, the future conditions flows were used in alternative design. For flood volumes more than 10% greater than existing volumes, the performance of the proposed alternatives was evaluated and compared in each Watershed Report. Known Metro projects, such as combined sewer separation, and private development projects were also considered in evaluation of alternatives.

Based on the evaluation, an alternative was recommended for each area of interest. Each watershed report presents the alternatives analysis for the sub-basin. The recommended projects resulting from the alternatives analyses are summarized in Table 7.1.

Table 7.1 Summary of Recommended Projects

Basin	Recommended Upsizing	Recommended Storage	Recommended Other	Cost
Shelby Park A*	3 projects*	0 projects*	NA	$11.9M*
Shelby Park B	1 project	1 project	1 project	$25.6M*
Shelby Park C	17 projects	2 projects	NA	$24.3M
Shelby Park D	7 projects	0 projects	NA	$6.3M
East Nashville	4 projects	0 projects	NA	$106.0M*
Richland Creek A	11 projects	0 projects	NA	$194.4M
Richland Creek B	1 project	2 projects	NA	$154.4M
Richland Creek C	16 projects	0 projects	NA	$92.4 M
Richland Creek D	15 projects	0 projects	NA	$14.6 M
Richland Creek E	12 projects	0 projects	NA	$11.1 M
Nashville A	5 projects	1 project	NA	$15.1M
Nashville B	5 projects	0 projects	NA	$118.3M
Nashville C	3 projects	0 projects	NA	$17.2M
Nashville D	3 projects	4 projects	NA	$33.6M
Nashville E	2 projects	0 projects	1 project	$6.6M
Nashville F	2 projects	0 projects	NA	$142.2 M
Apex	3 projects	0 projects	NA	$137.6 M
Coopers Creek A	8 projects	0 projects	NA	$4.9 M
Coopers Creek B	2 projects	0 projects	NA	$17.7 M
Coopers Creek C	8 projects	0 projects	NA	$7.3 M
Pages Branch A	3 projects	1 project	1 project	$20.0 M
Pages Branch B	12 projects	2 projects	NA	$29.7 M
Sugartree Creek	19 projects	2 projects	NA	$80.2 M
Cleeces Ferry A	24 projects	1 project	NA	$32.1 M
Trinity A	4 projects	0 projects	NA	$1.4 M
Trinity B	5 projects	0 projects	NA	$11.1 M
Trinity C	4 projects	0 projects	NA	$7.7M
Jocelyn Hollow/Vaughns Gap	14 projects	2 projects	NA	$64.7M

*Recommended projects should be incorporated into known or proposed future projects or development.



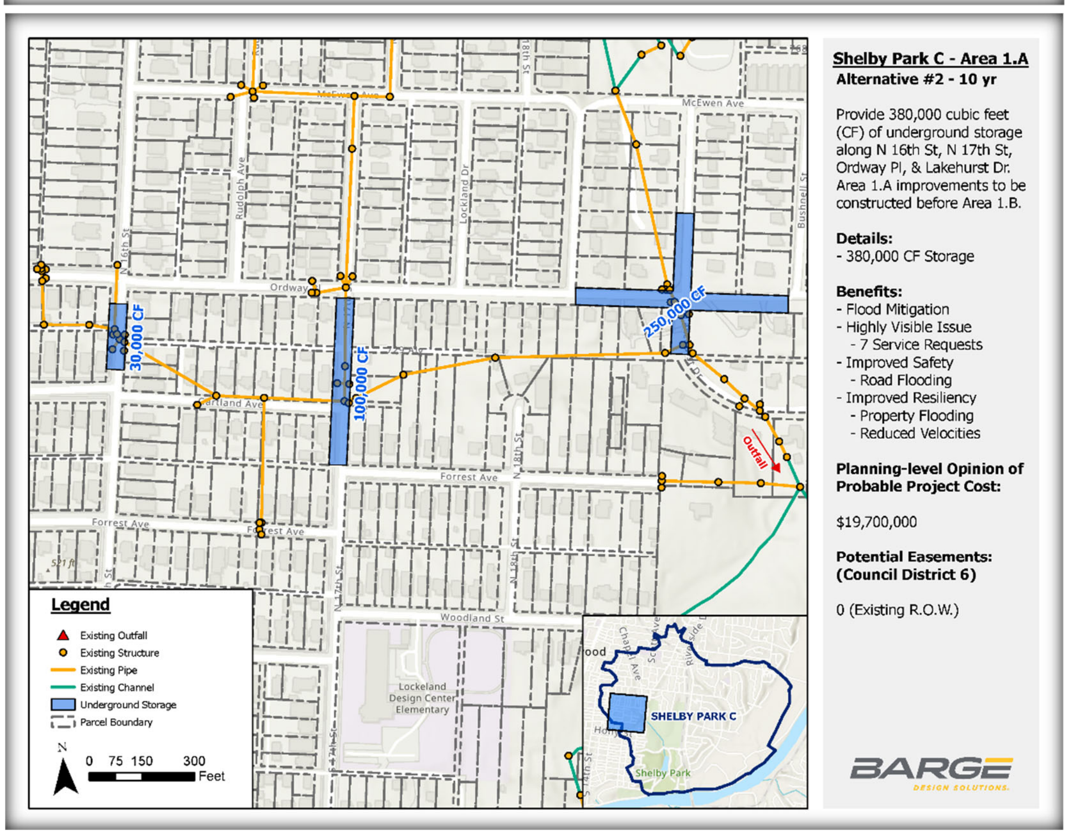


Figure 7.1 – Example Project Pages

8.0 PROJECT PRIORITIZATION

Prioritization of projects allows for identifying, scheduling, and funding CIPs in order to cost effectively extend the life of the stormwater system while reducing flooding occurrences. The project prioritization should guide long-term investment in the stormwater system, allowing MWS to plan projects according to need determined by the project ranking and yearly budgets or special funding sources.

8.1 Prioritization Approach

The general approach using the decision criteria for project prioritization includes:

- Determining important decision criteria
- Establishing a weighted factor for each criterion
- Determining the individual score for each criterion for each project
- Calculating the weighted score for each criterion
- Totaling the weighted scores for each project
- Ranking projects according to weighted scores

The decision criteria weighting is a tool used in decision making. Engineering judgement and experience were also major factors in determining project prioritization. The weighted calculations for each project are described in Appendix E.

9.0 CLIMATE RESILIENCY ANALYSIS

Changing climate is forecasted to significantly impact rainfall patterns around the world. Given the lifespan of flood control infrastructure, it is important to account for future conditions to ensure effective and efficient design of these systems. Each watershed report evaluates projected future development conditions and how the associated future runoff conditions would impact the effectiveness of the existing stormwater system and proposed improvements. Additionally, a climate change analysis was performed using current and projected future design storms for downtown Nashville (Appendix F). The analysis projected increases in rainfall depth for 24-hour design storms ranging from 20%-24% for the future 10-year storm and 28%-35% for the future 100-year storm.

10.0 SCHEDULE

There are approximately 100,000 structures in the Metro GIS. Based on and anticipated to be at total of 235,000 structures to be inventoried. Barge anticipates completing the inventory and data collection phase in 2026 and completing the modeling and alternatives phase in 2028.

Figure 9.1 depicts the process for inventory, condition assessment, modeling, and alternatives evaluation as well as Barge's progress to date.

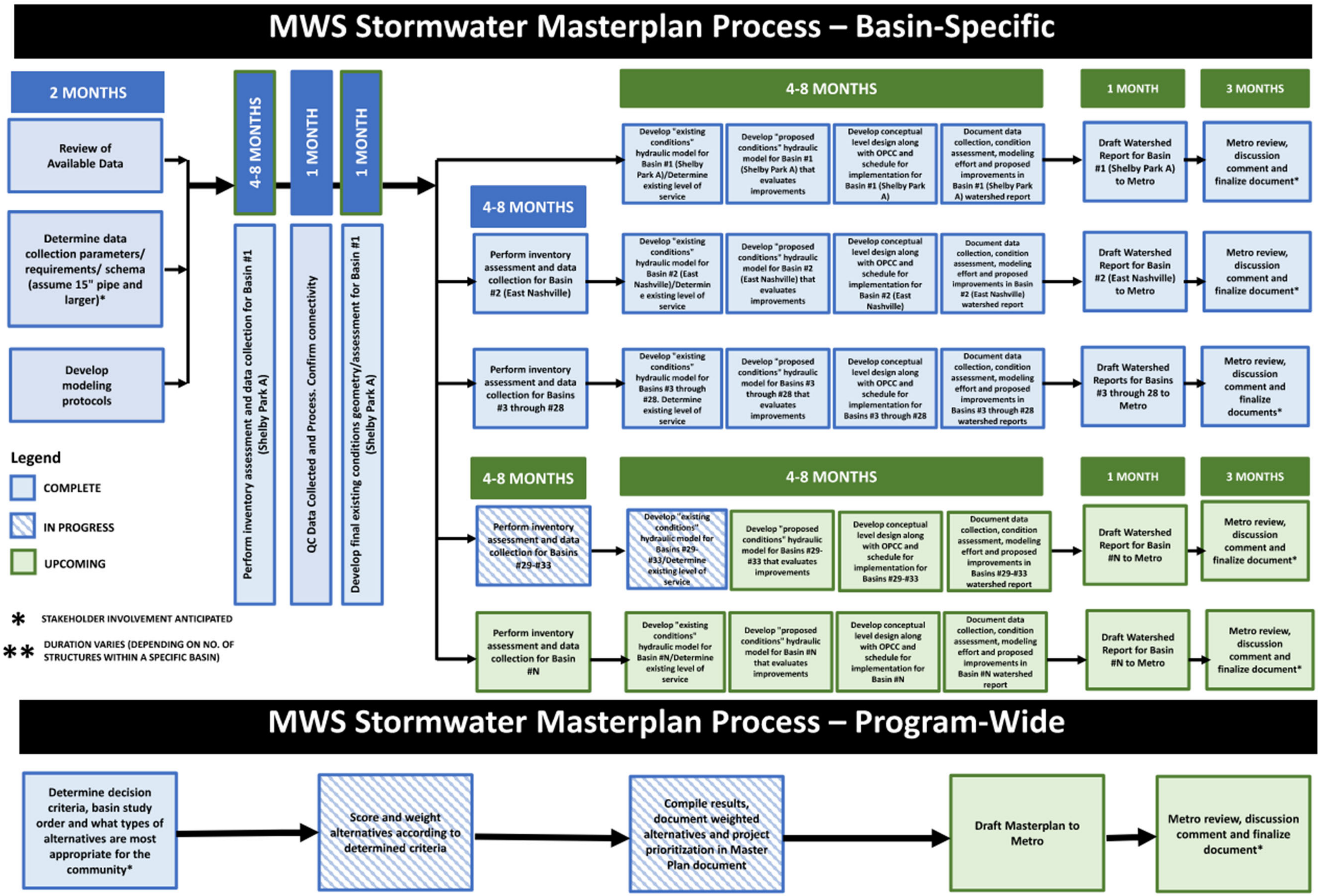


Figure 9.1 – Masterplan Process Flow Chart (as of 6/28/2025)

11.0 REFERENCES

1. Barge Design Solutions, Memorandum to Matt Tays, Stormwater Masterplan Advisory Committee, November 30, 2022, Revision 1.
2. Barge Design Solutions, Data Review and Watershed Prioritization, August 2022.
3. UFPP
4. Barge Design Solutions, Memorandum to Matt Tays, Standardized Condition Assessment Rating System, September 26, 2022.
5. Barge Design Solutions, Technical Memorandum, Decision Model for Alternatives Evaluation, TBD.
6. Metropolitan Government Nashville and Davidson County, Stormwater Management Manual, 2001.

APPENDIX A – Hydrology and Hydraulics Approach

DRAFT

APPENDIX A

HYDROLOGY AND HYDRAULICS APPROACH

Prepared For: Metro Water Services

File Number 3787505
June 2025

CONTENTS

FIGURES

TABLES

APPENDICES

1.0 HYDROLOGIC APPROACH

The stormwater characteristics, also known as hydrology, depend on the topography, soil types, and land use of the watershed.

1.1 Precipitation

The National Oceanic and Atmospheric Administration (NOAA) Atlas 14 point precipitation data and Metro's Stormwater Management Manual Volume 2 rainfall depths were evaluated as potential sources for rainfall depth information. For stormwater infrastructure design Metro prefers the rainfall depths in Figure 2-1 of Volume 2 of the Stormwater Manual. However, for the purpose of evaluating the existing system NOAA Atlas 14 provides a more accurate evaluation of existing conditions. Rainfall was determined from the Nashville airport gage and shown in Table 1.0.

Table 1.0 Design Storm Rainfall – Nashville WSO Airport (40-6402)

Storm Event	Rainfall Depth
10-YR/24 HR	4.70 inches
100-YR/24 HR	6.89 inches

A Soil Conservation Service (SCS) Type II distribution was utilized. The SCS Type II distribution, shown in Figure 1.0, places the peak rainfall in the middle of the storm over a short time interval, resulting in a conservative peak rainfall value.

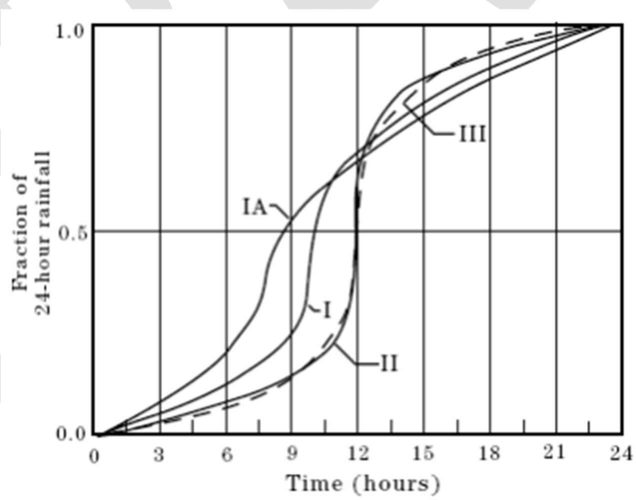


Figure 1.0 SCS 24-Hour Rainfall Distributions

1.2 Topography

The State of Tennessee LiDAR program was utilized to download the USGS 3D Elevation Program digital elevation model (DEM) for the Metro Nashville and Davidson County area.

1.3 Soils

Soil classification data was obtained from the U.S. Department of Agriculture (USDA) National Resource Conservation Service (NRCS) Web Soil survey.

1.4 Land Use

USGS's 2021 National Land Cover Database (NLCD) was utilized in conjunction with Metro Nashville zoning data. Vegetative cover was evaluated utilizing publicly available aerial imagery including ESRI imagery, Google Earth and Google Street View.

1.5 Impervious Surfaces and Infiltration Parameters

Impervious surface GIS layers were provided by MWS. Outlet routing to pervious services was utilized in the hydraulic model. For pervious surfaces in the sub-basin area, infiltration estimates are based on land cover and soil types. The soils classification data were retrieved from the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Soil Survey. For purposes of estimating infiltration, the hydrologic curve number parameters are summarized in Table 1-1 for the pervious areas within the sub-basins.

Table 1.1 – Sub-Basin Curve Number Summary for Pervious Areas

Cover Description	Hydrologic Soil Group	Curve Number
Open space (fair condition)	A	49
Open space (fair condition)	B	69
Open space (fair condition)	C	79
Open space (fair condition)	D	84
Woods (fair condition)	A	36
Woods (fair condition)	B	60
Woods (fair condition)	C	73
Woods (fair condition)	D	79

Manning's n values were assigned utilizing the land cover data as shown in Table 1-2

Table 1.2 – Manning's n Determination

2021 NLCD Land Use Category	Subarea Routing	Percent Routed (%)	Pervious Manning's n (N Perv)
Deciduous Forest Evergreen Forest Mixed Forest Shrub/Scrub	PERVIOUS	100	0.4
Developed, Open Space Barren Land Herbaceous Hay/Pasture Cultivated Crops	PERVIOUS	80	0.3
Developed, Low Intensity Developed, Medium Intensity	PERVIOUS	34	0.25
Developed, High Intensity	PERVIOUS	21	0.25
Developed, Low Intensity Developed, Medium Intensity	PERVIOUS	10	0.25
Developed, High Intensity	PERVIOUS	10	0.25

2.0 HYDRAULIC APPROACH

2.1 Existing Conditions

A stormwater management model (SWMM) was prepared for the sub-basin's existing conditions using the PCSWMM software. Each basin was subdivided into hydrologically distinct subcatchments, or hydrologic units, based on a combination of topographic, drainage infrastructure, and aerial photography data. Hydrologic parameters such as area, width, slope, impervious area, surface roughness, and loss parameters were assigned to each subcatchment. The precipitation was then applied in the model across the hydrologic units to estimate the resulting runoff and routing through the components of the hydraulic system. Within the model, only the primary stormwater conveyance system is represented with infrastructure associated with storm pipes 15 inches and larger (smaller pipes may be included for connectivity).

The existing drainage infrastructure system was evaluated for 24-hour duration storm events having rainfall amounts for the return frequencies of 10 and 100 years. Results were then evaluated to determine areas where the existing infrastructure was inadequate to carry the 10-year 24-hour design storm event.

2.2 Alternatives Development

In developing infrastructure improvement alternatives, an outfall-based approach was used. Alternatives were developed for a stormwater system beginning at the outfall and working upstream. This ensured that small stormwater improvement projects upstream in the system, would not negatively impact a downstream area. The downstream improvements must be completed first to allow upstream improvements to function as designed.

Proposed improvements considered addressed flooding on public property such as roads overtopping or flooding on multiple adjacent private properties. If a single driveway culvert was undersized causing overtopping of a private driveway or property, an alternative was not proposed.

In general, two types of alternatives were evaluated: (1) increase the capacity of the pipes and associated structures to alleviate the capacity restriction to the outfalls and (2) provide storage to detain the peak flows and release flow as capacity is available. In many cases, a feasible storage location did not exist. However, the storage alternative was still presented to illustrate the volume of storage that would be required if a viable storage option were to become available in the future. Another alternative considered was to reroute a portion of the network to a parallel pipe system with available capacity. In a few cases, a potential regional storage location was identified that would reduce the amount of pipe upsizing for a portion of a sub-basin so a combined alternative of storage and pipe upsizing was presented.

Alternative improvements were sized to accommodate the 10-year return period storm event. However, if a portion of the existing drainage system was carrying over 100 cubic feet per second (cfs) in the 10-year return period, it was considered a “major” system per the MWS Stormwater Management Manual (Reference 6) and was sized to accommodate the 100-year design storm peak flows. Both the sizing for the 10-year and the 100-year return period storm events are included for the major systems to provide flexibility to MWS in implementing stormwater improvement retrofits.

Service requests submitted by property owners to MWS were also used to inform the development and evaluation of remedial measures. Not all service requests resulted in a corresponding project to address the issue. This was often because the hydraulic model indicated sufficient system capacity for the evaluated flood events. In many cases, service requests stemmed from issues unrelated to capacity limitations such as clogged pipes.

2.3 Boundary Conditions

For outfalls discharging to the Cumberland River, downstream boundary conditions were set at the outfall elevation and assumed to be normal discharge. This assumption is appropriate because the Cumberland River has a very large drainage area and is also a regulated river system. Therefore, the peak storm flow on the Cumberland River would lag any peak discharge from the stormwater system.

Outfalls discharging to tributaries were evaluated on a case-by-case basis. Some smaller streams had significant backwater which would affect the ability of the stormwater system to discharge its design capacity. In those cases, hydrologic and hydraulic models were obtained from the U.S. Army Corps of Engineers Nashville District and the flood elevations at the outfall locations were considered in determining downstream boundary conditions.

2.4 Future Conditions

Each alternative was evaluated considering the proposed future conditions. The Nashville Next Concept Map layer was used to determine the future impervious conditions and associated runoff values and the revised runoff values were input to the model. If the future conditions 10-year frequency flood volume was more than 10% greater than existing volumes, the performance of the proposed alternatives was evaluated to determine whether the improved system capacity was adequate for the proposed condition. If the proposed condition had the equivalent impervious area as the existing condition, there was no change between existing and future conditions.

2.5 Other Considerations

2.5.1 Large Developments

In areas with large pervious developed areas, as-built drawings of the development’s stormwater system were requested. If the as-built drawings were available, the underground storage was accounted for in the model to obtain a more accurate simulation of the peak flows from the development.

2.5.2 Coordination with CSS Development

Nashville's combined sewer system basins are adjacent to several of the MWS stormwater sub-basins. Coordination between Clean Water Nashville's combined sewer separation program and the MWS/Barge stormwater team has occurred to ensure appropriate consistency in the modeling protocols between the Masterplan and the sewer separation. Additionally, coordination has helped identify issues between the basins and has assisted with design and planning to support the sewer separation. The models have been used to determine capacity for accepting separated storm flow and to assist in the design.

2.6 2D Modeling

Two-dimensional modeling of the existing and proposed conditions was performed in PCSWMM to demonstrate inundation resulting from the 10-year and 100-year storm events. Inundation greater than 6" is shown in figures in the Watershed Reports for each sub-basin. Six inches was selected to allow focus on areas that may be experiencing ponding or flooding. Six inches is the approximate depth of a curb and may indicate where more significant roadway or property flooding occurs.

APPENDIX A – NOAA Atlas 14

NOAA Atlas 14, Volume 2, Version 3 NASHVILLE WSO AIRPORT
Station ID: 40-6402
Location name: Nashville, Tennessee, USA*
Latitude: 36.1253°, Longitude: -86.6764°
Elevation:
Elevation (station metadata): 600 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.381 (0.352-0.413)	0.446 (0.414-0.485)	0.514 (0.473-0.559)	0.568 (0.523-0.617)	0.636 (0.583-0.691)	0.687 (0.625-0.746)	0.736 (0.666-0.800)	0.784 (0.704-0.853)	0.843 (0.749-0.920)	0.888 (0.782-0.973)
10-min	0.608 (0.563-0.659)	0.714 (0.661-0.776)	0.823 (0.758-0.895)	0.908 (0.837-0.987)	1.01 (0.929-1.10)	1.09 (0.996-1.19)	1.17 (1.06-1.27)	1.24 (1.12-1.35)	1.33 (1.18-1.46)	1.40 (1.23-1.53)
15-min	0.760 (0.704-0.824)	0.897 (0.831-0.975)	1.04 (0.959-1.13)	1.15 (1.06-1.25)	1.28 (1.18-1.40)	1.38 (1.26-1.50)	1.48 (1.34-1.61)	1.57 (1.41-1.71)	1.68 (1.49-1.83)	1.76 (1.54-1.92)
30-min	1.04 (0.965-1.13)	1.24 (1.15-1.35)	1.48 (1.36-1.61)	1.66 (1.53-1.81)	1.90 (1.74-2.07)	2.09 (1.90-2.26)	2.26 (2.05-2.46)	2.44 (2.19-2.66)	2.67 (2.37-2.92)	2.84 (2.50-3.11)
60-min	1.30 (1.20-1.41)	1.56 (1.44-1.69)	1.90 (1.75-2.06)	2.17 (2.00-2.36)	2.54 (2.32-2.75)	2.83 (2.57-3.07)	3.12 (2.82-3.39)	3.42 (3.08-3.73)	3.83 (3.40-4.18)	4.15 (3.65-4.54)
2-hr	1.54 (1.42-1.67)	1.83 (1.69-1.99)	2.22 (2.06-2.41)	2.54 (2.34-2.76)	2.97 (2.72-3.22)	3.31 (3.02-3.60)	3.66 (3.31-3.98)	4.03 (3.61-4.38)	4.52 (4.00-4.93)	4.91 (4.30-5.37)
3-hr	1.67 (1.54-1.82)	1.99 (1.84-2.17)	2.41 (2.23-2.62)	2.76 (2.54-3.00)	3.23 (2.95-3.51)	3.61 (3.28-3.93)	4.01 (3.61-4.36)	4.41 (3.94-4.81)	4.97 (4.38-5.43)	5.41 (4.72-5.92)
6-hr	2.00 (1.84-2.20)	2.38 (2.19-2.62)	2.88 (2.64-3.18)	3.31 (3.02-3.64)	3.90 (3.53-4.28)	4.38 (3.93-4.81)	4.88 (4.35-5.37)	5.41 (4.78-5.96)	6.15 (5.35-6.79)	6.73 (5.79-7.46)
12-hr	2.37 (2.19-2.59)	2.82 (2.60-3.08)	3.42 (3.15-3.73)	3.92 (3.60-4.27)	4.62 (4.20-5.03)	5.19 (4.69-5.64)	5.78 (5.19-6.30)	6.41 (5.70-6.98)	7.28 (6.37-7.94)	7.96 (6.89-8.74)
24-hr	2.83 (2.67-3.00)	3.37 (3.19-3.59)	4.11 (3.88-4.36)	4.70 (4.44-4.99)	5.53 (5.21-5.87)	6.20 (5.82-6.57)	6.89 (6.44-7.30)	7.61 (7.08-8.06)	8.60 (7.95-9.09)	9.37 (8.61-9.92)
2-day	3.37 (3.18-3.59)	4.02 (3.80-4.28)	4.92 (4.64-5.23)	5.65 (5.33-6.00)	6.69 (6.28-7.08)	7.53 (7.05-7.97)	8.41 (7.84-8.89)	9.34 (8.66-9.87)	10.6 (9.78-11.2)	11.7 (10.6-12.4)
3-day	3.56 (3.37-3.79)	4.25 (4.02-4.52)	5.18 (4.90-5.50)	5.94 (5.60-6.29)	6.99 (6.58-7.39)	7.84 (7.35-8.28)	8.73 (8.15-9.21)	9.64 (8.96-10.2)	10.9 (10.1-11.5)	11.9 (10.9-12.6)
4-day	3.76 (3.55-3.99)	4.48 (4.24-4.75)	5.45 (5.15-5.77)	6.23 (5.88-6.58)	7.30 (6.87-7.70)	8.15 (7.66-8.60)	9.04 (8.45-9.54)	9.94 (9.26-10.5)	11.2 (10.3-11.8)	12.1 (11.2-12.8)
7-day	4.56 (4.31-4.84)	5.44 (5.13-5.78)	6.62 (6.24-7.03)	7.58 (7.13-8.03)	8.92 (8.37-9.44)	10.0 (9.35-10.6)	11.1 (10.4-11.8)	12.3 (11.4-13.0)	14.0 (12.8-14.8)	15.3 (13.9-16.2)
10-day	5.24 (4.96-5.54)	6.24 (5.91-6.60)	7.51 (7.12-7.94)	8.53 (8.06-9.01)	9.91 (9.34-10.5)	11.0 (10.3-11.6)	12.1 (11.4-12.8)	13.3 (12.4-14.0)	14.8 (13.7-15.6)	16.0 (14.7-16.9)
20-day	7.08 (6.75-7.46)	8.39 (7.99-8.83)	9.90 (9.42-10.4)	11.0 (10.5-11.6)	12.6 (11.9-13.2)	13.7 (13.0-14.4)	14.8 (14.0-15.6)	15.9 (15.0-16.8)	17.3 (16.3-18.3)	18.4 (17.2-19.4)
30-day	8.72 (8.32-9.13)	10.3 (9.80-10.8)	12.0 (11.4-12.6)	13.3 (12.7-13.9)	15.0 (14.3-15.7)	16.3 (15.5-17.1)	17.6 (16.6-18.4)	18.9 (17.8-19.8)	20.5 (19.2-21.5)	21.7 (20.2-22.8)
45-day	10.9 (10.4-11.4)	12.8 (12.2-13.3)	14.7 (14.0-15.4)	16.2 (15.4-16.9)	18.0 (17.2-18.9)	19.5 (18.5-20.4)	20.8 (19.8-21.8)	22.1 (20.9-23.2)	23.7 (22.4-24.9)	24.9 (23.4-26.2)
60-day	13.1 (12.5-13.6)	15.3 (14.7-16.0)	17.6 (16.8-18.3)	19.2 (18.4-20.0)	21.3 (20.3-22.2)	22.8 (21.7-23.8)	24.2 (23.0-25.3)	25.5 (24.2-26.6)	27.1 (25.7-28.3)	28.2 (26.7-29.5)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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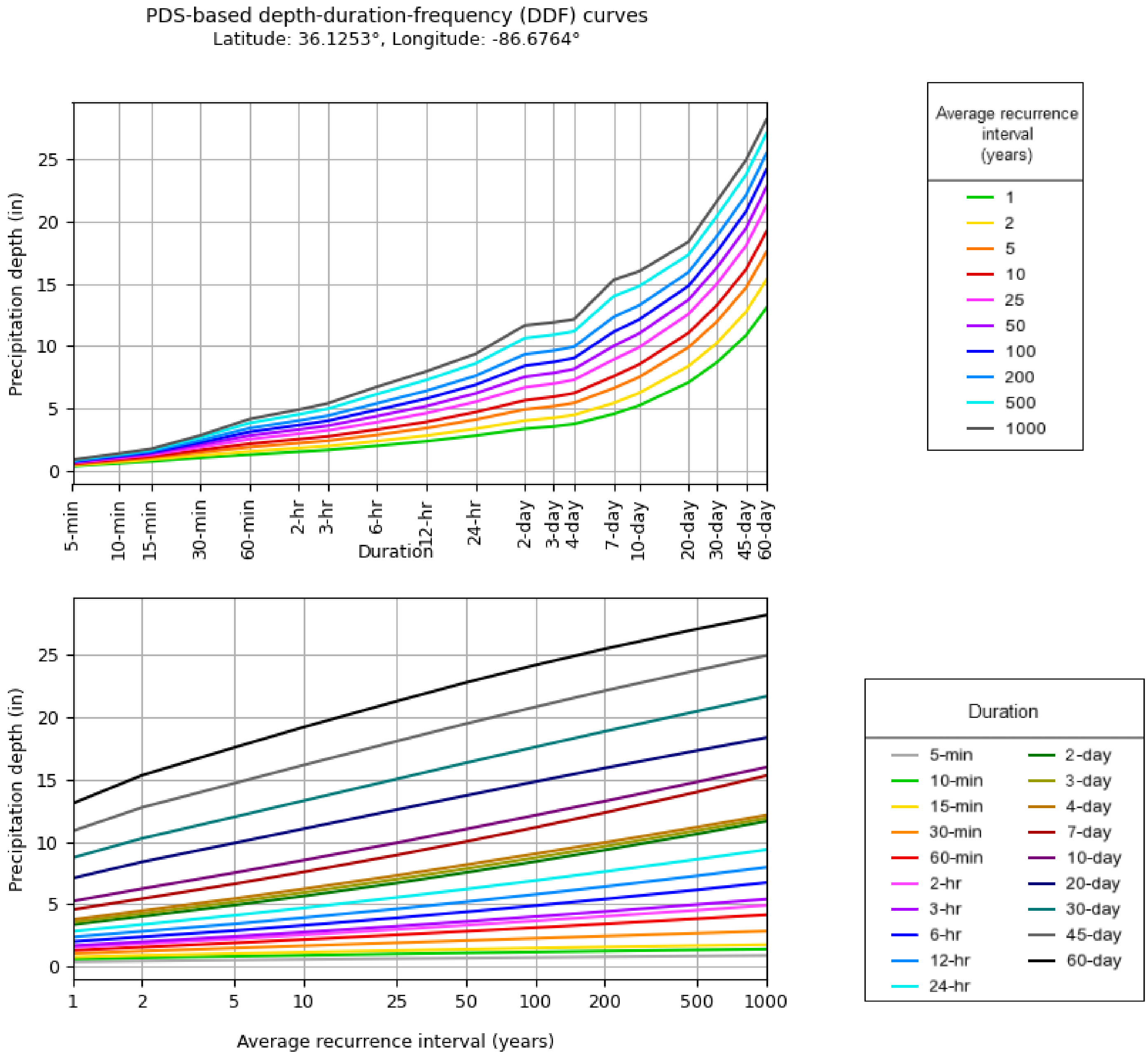
PF graphical



NOAA Atlas 14, Volume 2, Version 3 Created (GMT): Wed Sep 20 17:47:30 2023

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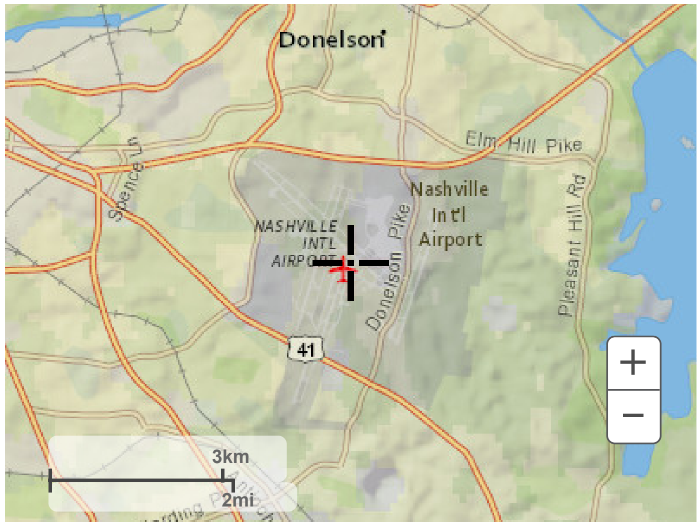
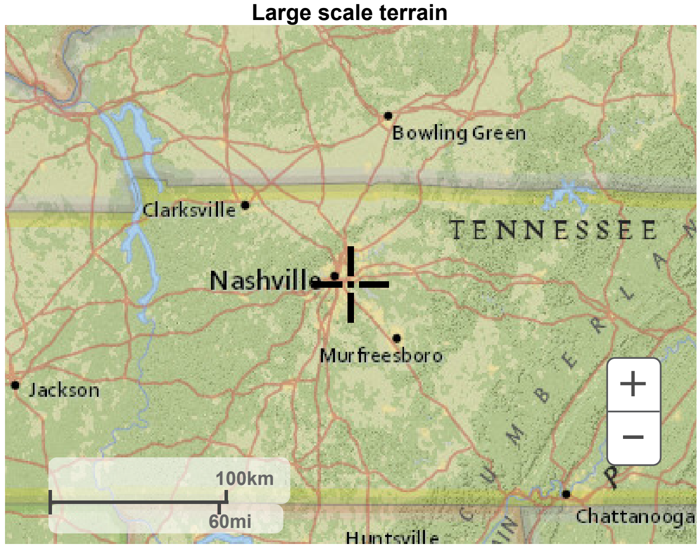
Maps & aerials

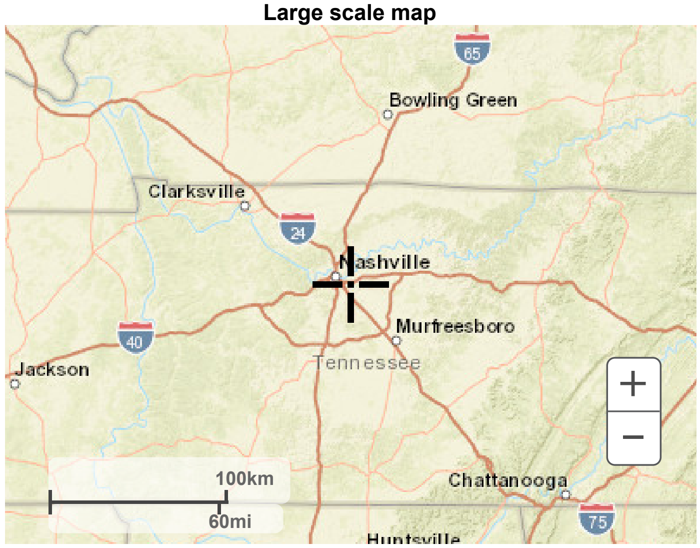
Small scale terrain



Large scale terrain



Large scale map



Large scale aerial

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National Weather Service
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Questions?: HDSC.Questions@noaa.gov

APPENDIX B – Advisory Committee Workshop Minutes

MEETING SUMMARY

MWS Stormwater Master Plan
Advisory Committee Kick Off

MEETING DATE:	May 30, 2023
MEETING TIME:	2:00 PM
LOCATION:	MWS – Biosolids Conference Room

ATTENDEES:

Matt Tays – MWS
Tom Palko – MWS
Ricky Swift - MWS
Derek Haggerty – NDOT
Andy Reese – AR LLC
Roger Lindsey – MWS
Heidi Mariscal – OEM
Cindy Harrison - Parks
Kendra Abkowitz – Mayor's Office
Jim Snyder – MWS
Steve Mishu – Codes
David Tucker – MWS
Russ Pulley – Metro Council
Chris Provost - Barge
Adrian Ward - Barge
Clayton Foster – Barge

Comments from Advisory Committee

- Kendra Abkowitz – would like us to evaluate a more aggressive rain event for future planning to account for changing weather patterns.
- Evaluate how to link video to asset.
- Important to keep the model/geodatabase updated. What is the best way?
- Andy Reese – does our design storm account for moving storm events?
  - Barge response – we are using SCS storm events which occur all at once
  - Andy recommends review of actual rain events used to verify model results with Nexrad to determine actual return period. This will help determine if the model is over or under performing.
- Kendra Abkowitz – for basin prioritization, how did Barge incorporate equity into basin prioritization?
- Barge will provide PDF of presentation to group.
- Barge will set up sharepoint site for sharing of information between parties
- Steve Mishu – how do we plan for developers planning for Metro code of 100 year storm event but we are designing to 10 year storm event?
  - *Follow up on this - We currently plan to evaluate for the 100-year storm event if the 10-year storm discharges exceed 100 cfs. That will be the threshold for switching to 100-year.*
- Kendra Abkowitz – what differences are there between Nashville Next planning and what has actually been constructed or changed in terms of zoning?
  - *We will provide the table used developed for our study.*
- Cindy Harrison – partnerships with other Metro agencies should be considered particularly when crossing railroads, interstates, etc. for stormwater related projects

Metro Water Services Stormwater Master Plan

METRO WATER SERVICES

BARGE DESIGN SOLUTIONS

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Agenda

- Project Team
- Advisory Committee
- Background and Objectives
- Planning
- Inventory & Condition Assessment
- Model Setup
- Analysis
- Capital Improvements Plan (CIP)
- System Improvements
- Future Meetings and Topics

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Project Team

Name	Organization
Tom Palko	Metro Water Services
Matt Tays	Metro Water Services
Ricky Swift	Metro Water Services
Chris Provost	Barge Design Solutions
Adrian Ward	Barge Design Solutions
Clayton Foster	Barge Design Solutions

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Advisory Committee

Name	Organization
Kendra Abkowitz	Mayor's Office
Steve Mishu	Metro Codes Administration
Heidi Mariscal	Metro Office of Emergency Management
Cindy Harrison	Metro Parks and Recreation
Dustin Shane	Metro Planning Department
Derek Haggerty	Nashville Department of Transportation
Matt Tays	Metro Water Services
Russ Pulley	Chair of Transportation and Infrastructure Committee
Andy Reese	Andy Reese, LLC

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Role of the Advisory Committee

- Understand and knowledgeable of the project
- Provide input and advise on key decisions

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Stormwater Program Evolution

- 1950s and 1960s: focus was on putting all sewage and stormwater runoff into combined pipes

1950s | 1960s | 1970s | 1980s | 1990s | 2000s | 2010s | 2020s

6

Stormwater Program Evolution

- 1960s until the middle 1970s: focus was on developing efficient drainage conveyance from paved surfaces and developments to the nearest stream primarily through curb and gutter neighborhoods.

1950s | 1960s | 1970s | 1980s | 1990s | 2000s | 2010s | 2020s

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Stormwater Program Evolution

- Middle 1970s until the mid-1980s: focus was on requiring that most development within the Metro Nashville area detain stormwater in ponds attempting to reduce downstream flooding

1950s | 1960s | 1970s | 1980s | 1990s | 2000s | 2010s | 2020s

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Stormwater Program Evolution

- From the mid-1980s until the mid-1990s, the focus was on stormwater master planning.
  - MWS developed watershed-based master plans for most of the major watersheds.
  - Sought to solve flooding problems on a larger scale and in a comprehensive and coordinated fashion.
  - Due to lack of funding, not all capital improvements were addressed, and the more minor systems were never master planned.

1950s | 1960s | 1970s | **1980s** | **1990s** | 2000s | 2010s | 2020s

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Stormwater Program Evolution

- Mid-1990s until the early 2000s: the focus was on stormwater quality control.
  - NPDES permit required a set of programs and standards to attempt to control pollution from runoff to the "maximum extent practical" and prohibit non-stormwater from entering the stormwater system and waters of the state.
  - Next came Low Impact Development (LID) and Green Infrastructure (GI), working to reduce stormwater runoff volume using infiltration, evapotranspiration, and/or rainwater reuse.
  - Focus on floodplain management and purchasing homes in the flood plain with FEMA support
  - Created a stormwater enterprise fund to address stormwater issues county wide

1950s | 1960s | 1970s | 1980s | **1990s** | **2000s** | 2010s | 2020s

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Stormwater Program Evolution

- Today, Metro Nashville is experiencing unprecedented economic growth while facing real, growing, and unresolved stormwater problems. These issues can be placed into two broad categories for consideration: flooding and infrastructure.
- MWS desires to develop strategies to address flooding and undersized infrastructure issues at a basin level and to create capital improvement plans that prioritize improvements based on engineered studies.

1950s | 1960s | 1970s | 1980s | 1990s | 2000s | 2010s | **2020s**

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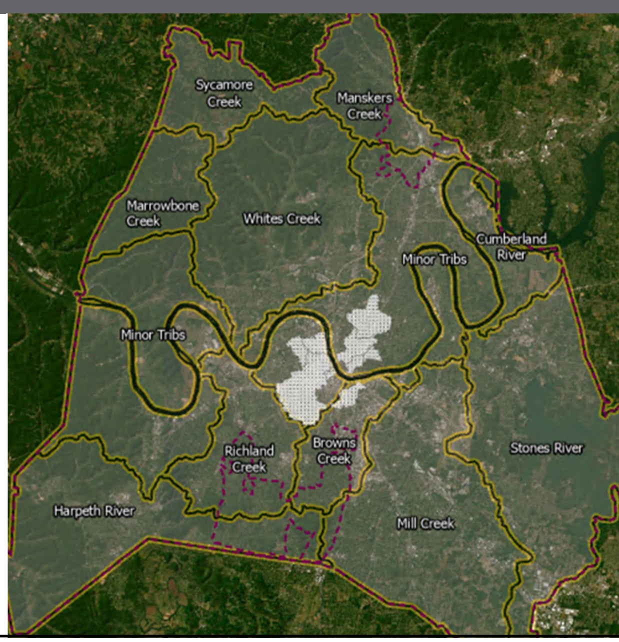
USACE Basins



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Project Objective

The overall objective of the Stormwater Masterplan is to study existing infrastructure and develop alternatives to reduce or abate flooding throughout the Metro service area.

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Process

- Planning
- Inventory/ Condition Assessment
- Model Setup
- Analysis
- CIP
- System Improvements

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Planning

24” AND GREATER → ~30,000 STRUCTURES

15” AND GREATER → ~80,000 STRUCTURES

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Basin Prioritization

Development Density	**Experiencing Growth**	**Existing Issues**	**Data Quality**

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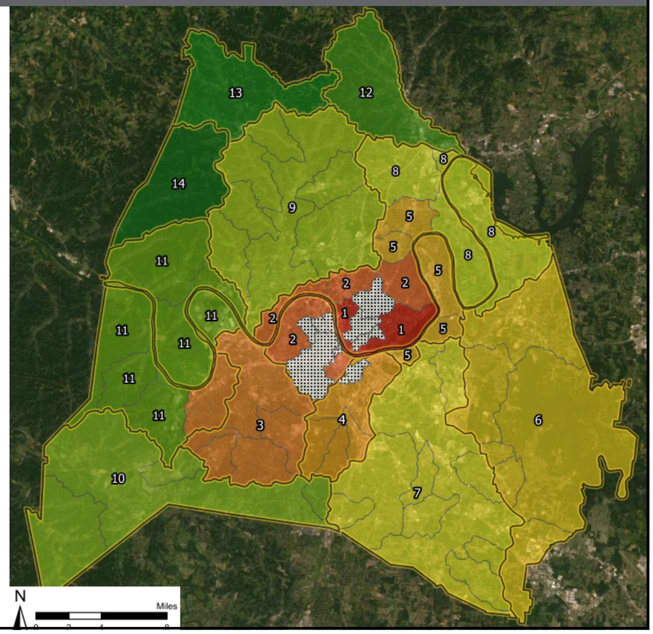
Basin Prioritization

Priority		Watershed	Area (Sq. Mi.)	Weighted Score for Dvlpmnt Density	Weighted Score for Active Dvlpmnt	Weighted Score for Service Requests	Weighted Score for Data Quality	Total Weighted Score
1	Minor Tribs	East Nashville	6	1.14	0.80	1.83	0.61	8.94
		Shelby Park	2	1.48	5.76	2.20	0.65	4.09
2	Minor Tribs	Nashville	7	1.53	3.78	1.33	0.59	6.92
		Unnamed Basin (north of Nashville Basin)	3	0.80	2.45	1.26	0.65	4.94
		Pages Branch	3	1.06	2.70	1.74	0.63	5.86
		Coopers Creek	10	0.61	0.81	0.63	0.64	8.19
3		Richland Creek	16	0.60	0.52	0.99	0.64	6.07
	MT	Cleese Ferry	6	0.84	0.57	0.90	0.65	2.82
4		Browns Creek	4	1.22	0.82	1.95	0.66	4.83
5	Minor Tribs	Gibson Creek	5	1.63	0.97	5.54	0.66	4.38
		Windemere	8	0.29	0.46	0.00	0.64	4.32
		River Hill	2	0.84	0.74	2.36	0.65	4.33
		Pennington Bend	9	0.50	0.24	1.02	0.66	1.48
		Loves Branch	1	0.47	2.65	0.73	0.66	4.00
6		Stones River	1	0.65	1.70	0.39	0.65	3.64
7		Mill Creek	5	0.02	0.11	0.00	0.61	2.99
8	Minor Tribs	Dry Creek	6	0.49	0.09	0.29	0.66	2.57
		Old Hickory	2	0.90	0.46	2.23	0.67	2.60
		Neely's Bend	13	0.02	0.12	0.00	0.66	2.28
		Unnamed Basin (north of Old Hickory Basin)	6	0.03	0.00	0.00	0.64	3.26
9		Whites Creek	11	0.03	0.05	0.07	0.65	2.04
10		Harpeth River	15	0.05	0.04	0.10	0.66	1.43
11	Minor Tribs	Overall Creek	71	0.89	0.69	0.49	0.65	1.36
		Cockrill Bend	78	0.58	0.58	0.47	0.63	0.74
		Bells Bend	63	0.31	0.43	0.30	0.65	0.79
		Indian Creek W.	16	1.08	1.38	0.24	0.62	0.68
		Cub Creek	28	1.20	0.73	2.58	0.64	0.80
		Scottsboro	56	0.36	0.15	0.33	0.64	0.83
12		Mansker Creek	21	0.10	0.17	0.00	0.66	1.11
13		Sycamore Creek	21	0.21	0.07	0.03	0.65	0.96
14		Marrowbone Creek	19	0.07	0.00	0.00	0.66	0.76
		TOTAL	514	20.00	30.00	30.00	20.00	100.00



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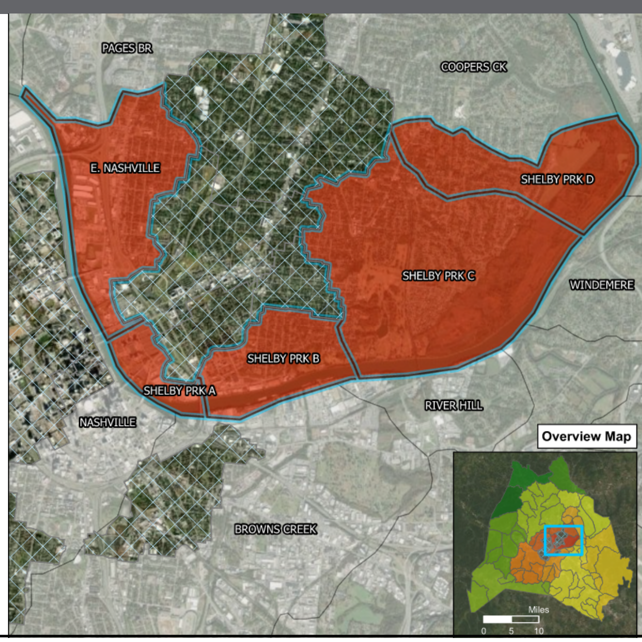
Basin Prioritization



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Process

Planning → Inventory/ Condition Assessment → Model Setup

Analysis → CIP → System Improvements

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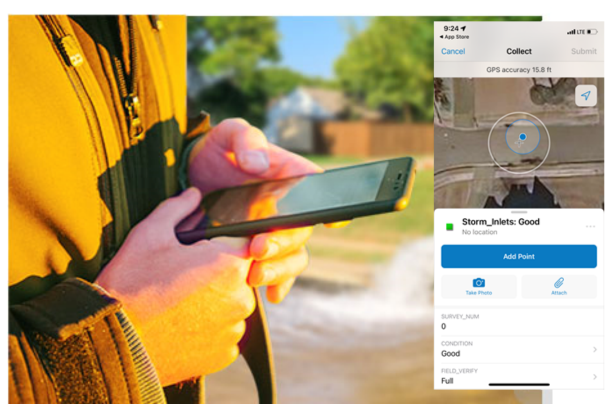
Field Data Collection

Survey Grade

Mobile



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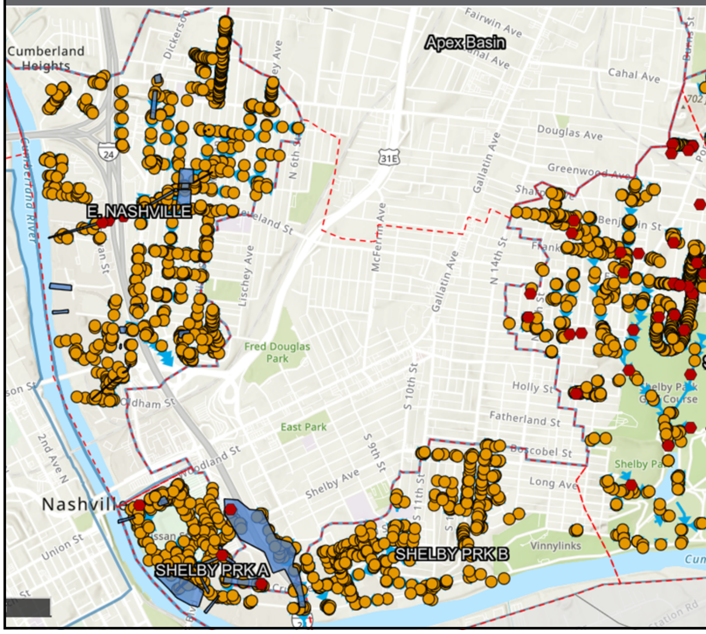
Inventory & Condition Assessment



- Culverts
- Inlets
- Manholes
- Road Crossings
- Open Channels

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Inventory & Condition Assessment

Unique ID	Inverts/Depths	Structure / Piping Sizes	360 Degree Video

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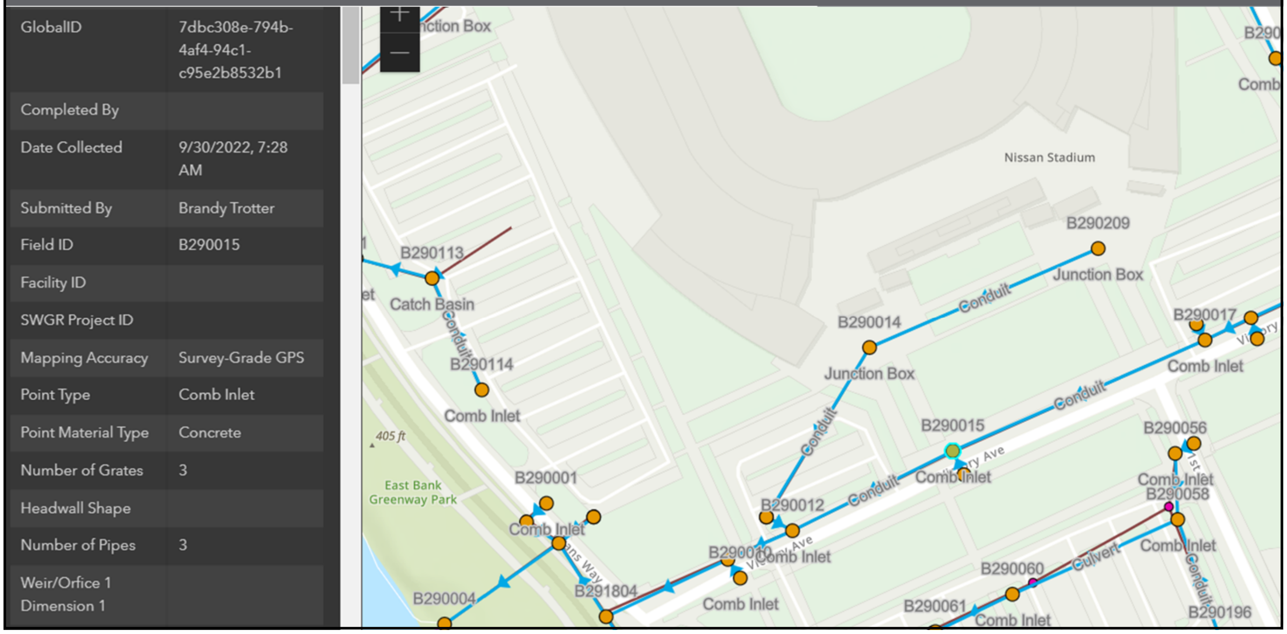
Inventory and Condition Assessment



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Major Issues

Description	Number
Structural Failure	129
Safety Issue	26
Illicit Discharge	6
Clogged	497

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360 DEGREE VIDEO DEMO

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Inventory & Condition Assessment

GRADE	COMMON DEFECTS
Other	Roof drains or underdrains
Incomplete	Pipe unable to be evaluated due to inability to access
0	None
1	Poor grouting in joints, Small cracks
2	Poor grouting in joints, Medium cracks, Joint separation, Infiltration, Cracked coating, Aggregate showing
3	Medium cracks, Joint separation, Infiltration, Damaged coating, Aggregate showing, Roots in pipe, Exposed/rusted reinforcement, Surface rusted, Signs of surcharging, Small holes
4	Joint separation, Infiltration leading to sinkholes, Missing coating, Surface rusted, Settled deposits, Medium holes
5	Collapse

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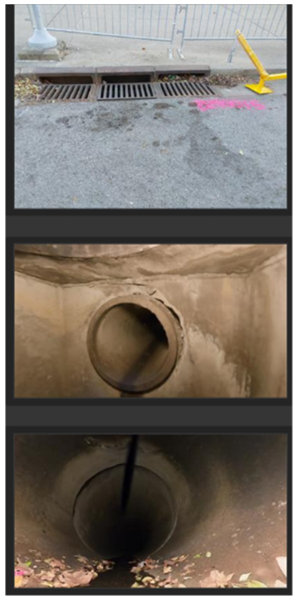
Inventory & Condition Assessment

Rim Elevation	416.995
Bottom Elevation	397.595
Notes	
My Source	BargeDesignSolutions
Bike Friendly Grate?	YES
Slot Type	Perpendicular
Grate Level	Flush
Infield Offset	
In Combined Storm Sewer	
Is Outfall?	
Is Outlet?	
Is Inlet?	YES



Length	20.00
Width	32.000
Depth	19.400
Owner	
Condition Assessment	Grade 3 - Fair
Major Issues	None

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Process

- Planning
- Inventory/ Condition Assessment
- Model Setup
- Analysis
- CIP
- System Improvements

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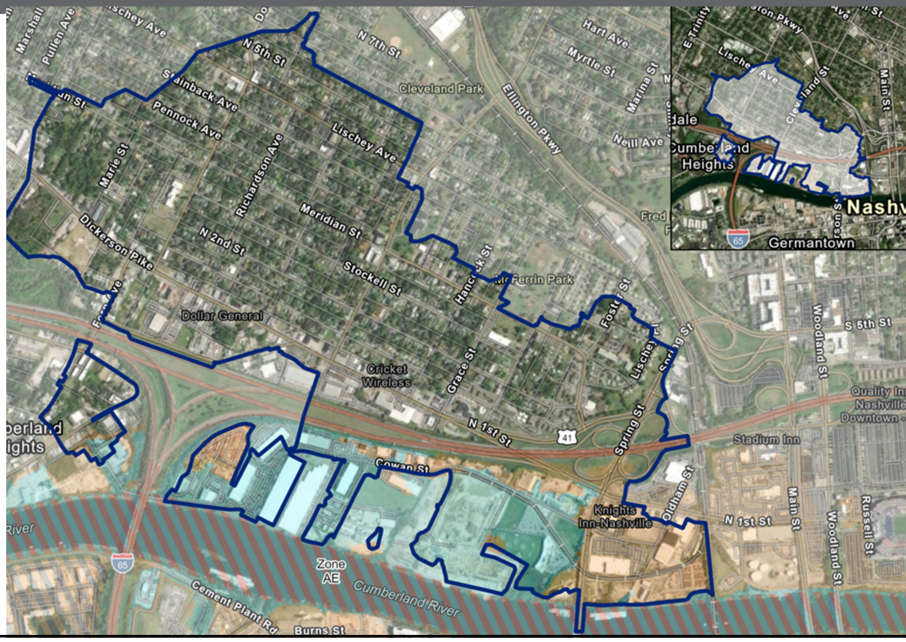
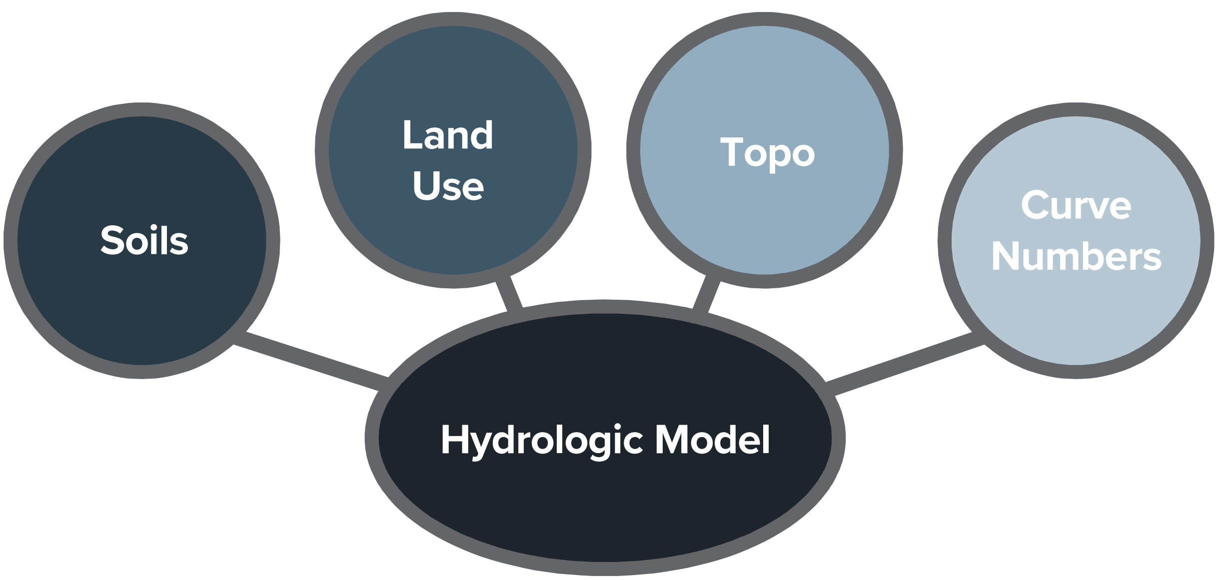
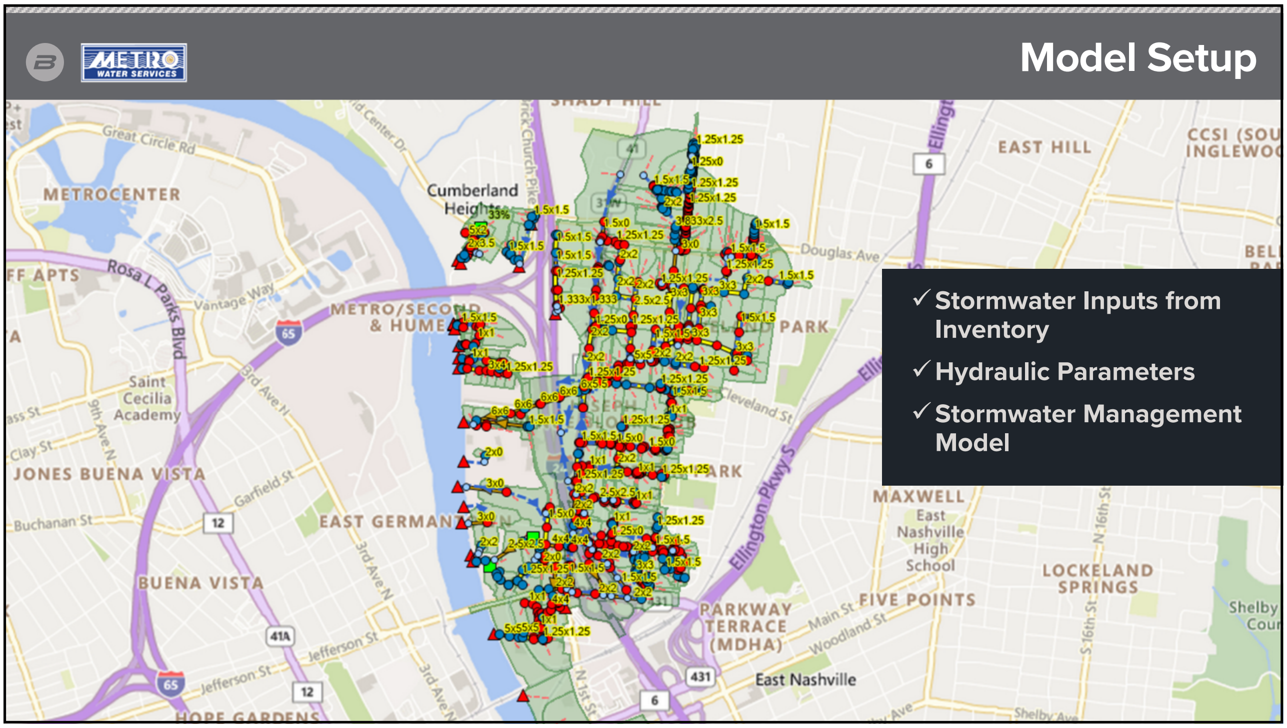
Study Area



Hydrology




METRO WATER SERVICES
Model Setup
✓Stormwater Inputs from Inventory
✓Hydraulic Parameters
✓Stormwater Management Model
METROCENTER
Cumberland Heights
EAST HILL
JONES BUENA VISTA
BUENA VISTA
EAST GERMANTOWN
METRO/SECOND & HUME
MAXWELL
East Nashville High School
LOCKELAND SPRINGS
FIVE POINTS
PARKWAY TERRACE (MDHA)
East Nashville
HOPE GARDENS
Saint Cecilia Academy

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METRO WATER SERVICES
Model Setup
Curb Inlet
Junction Box
Stockell St
Richardson

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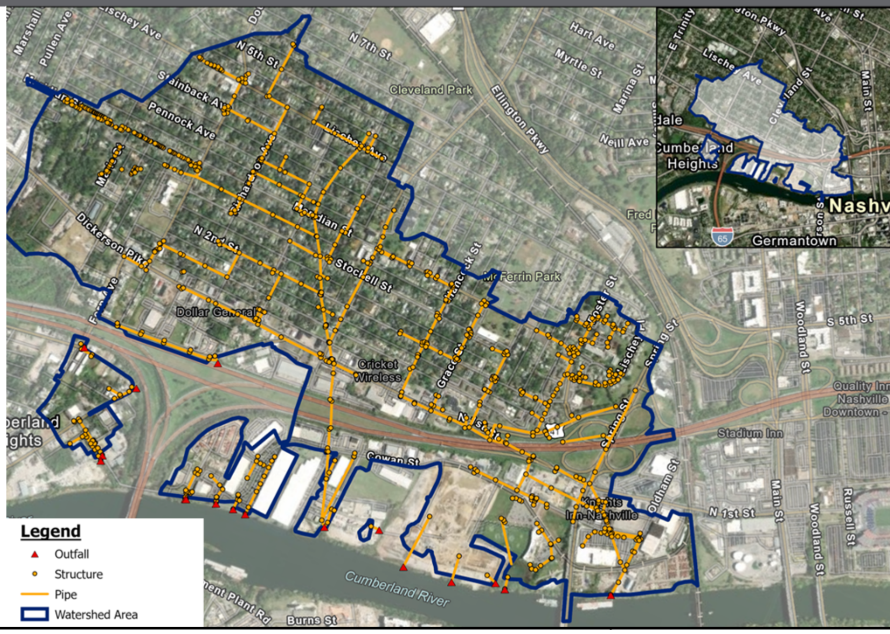
Hydraulic Model Creation



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Process

- Planning
- Inventory/ Condition Assessment
- Model Setup
- **Analysis**
- CIP
- System Improvements

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Analysis

DESIGN STORM EVENT	10-YEAR
LEVEL OF SERVICE	WATER ELEVATION BELOW RIM
BUILDING FLOODING	100-YEAR
INUNDATION EXTENT	FLOOD DEPTHS
FUTURE CONDITIONS	NASHVILLE NEXT

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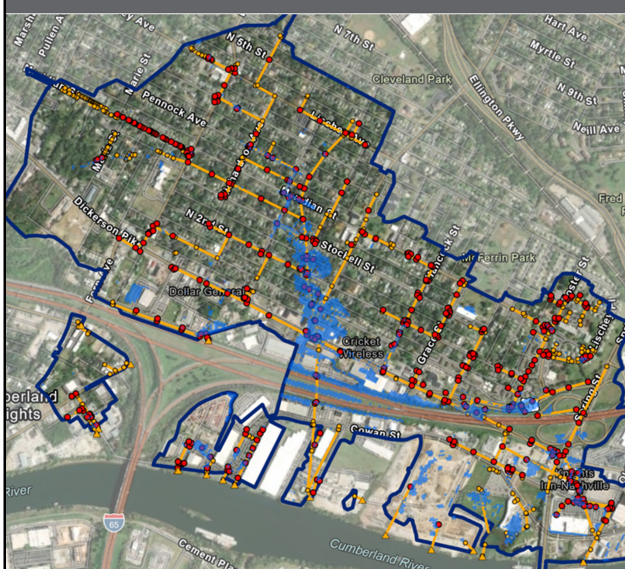
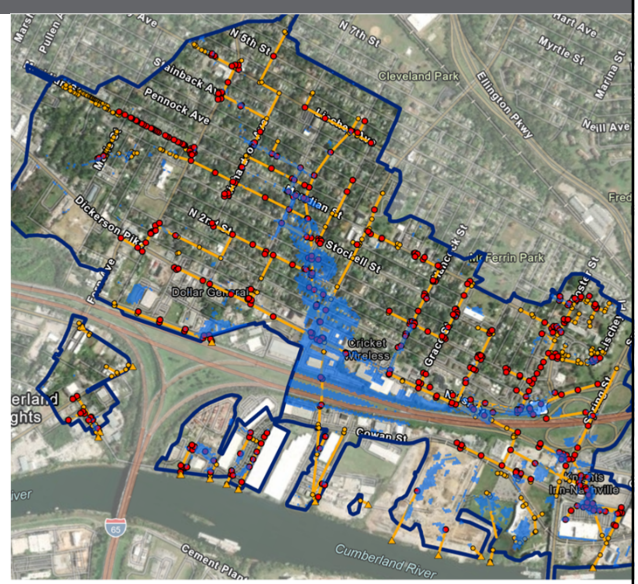
Existing Condition 10/100 Year Inundation Maps





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Model Verification

- Site Visits during Rain Event
- Signs of Flooding on Structures
- Complaint Reviews

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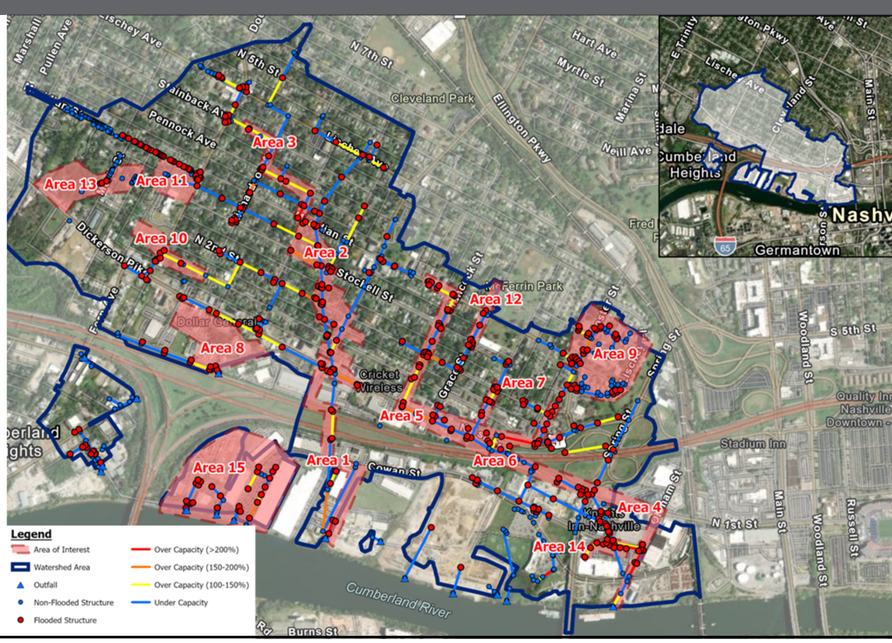
Alternatives Analysis Project Areas



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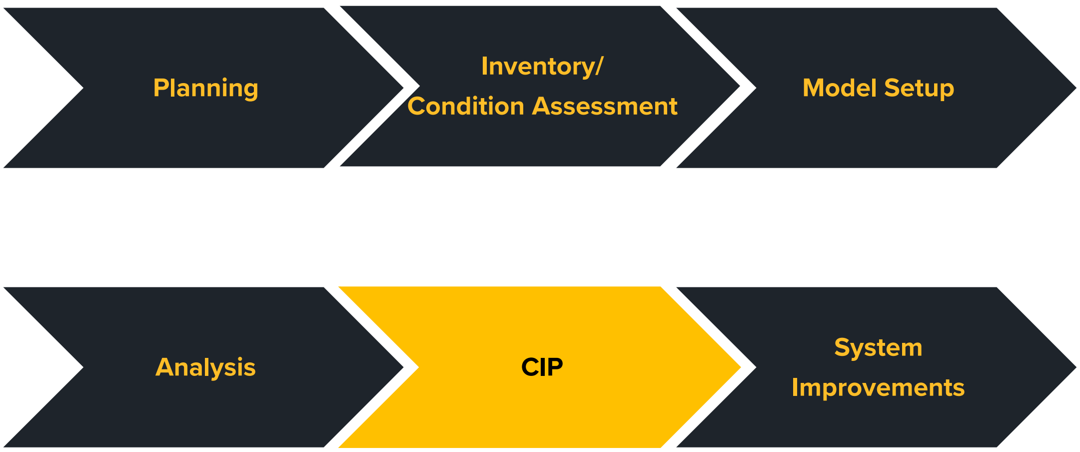
Process



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Capital Improvement Plan (CIP)

East Nashville - Area 1
Alternative #1

Install 2,386 linear feet (LF) of new reinforced concrete pipe (RCP).

Details:
- 285 LF 9'x6' RCB
- 2,101 LF 9'x9' RCB
- 7 Structures

Benefits:
- Flood Mitigation
- Improved Safety
  - Road Flooding
- Highly Visible Issue
- Improved Resiliency
  - Reduced Velocities

Planning-level Opinion of Probable Project Cost:

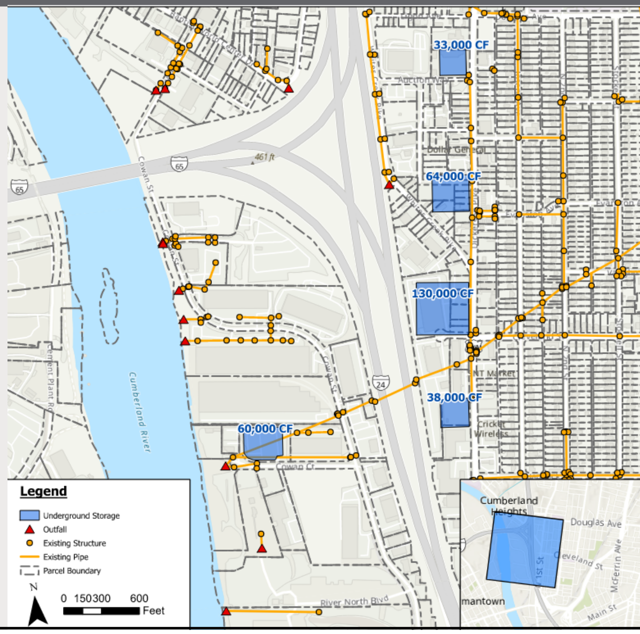
$19,285,000

Potential Easements: (Council District 5)

3 affected parcels

40

Capital Improvement Plan (CIP)



Shelby Park A - Area 1
Alternative #2

Provide 325,000 cubic feet (CF) of underground storage along Dickerson Pike at the I-24/I-65 interchange.

Details:
- 325,000 CF Storage

Benefits:
- Flood Mitigation
- Improved Safety
  - Road Flooding
  - Residential Lot Flooding
  - Parking Lot Flooding
- Highly Visible Issue

Planning-level Opinion of Probable Project Cost:

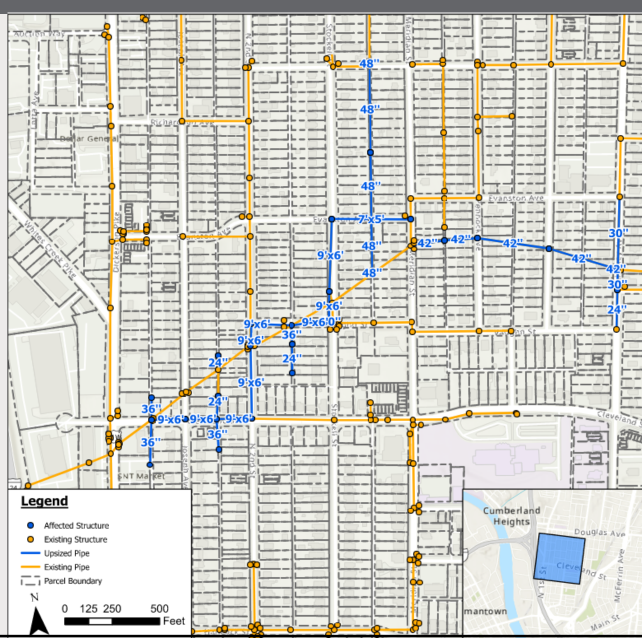
$16,385,000

Potential Easements: (Council District 5)

18 affected parcels

41

Capital Improvement Plan (CIP)



East Nashville - Area 2
Alternative #1

Upsize 5,075 linear feet (LF) of reinforced concrete pipe (RCP). Install 2,368 LF of new RCP.

Details:
- 559 LF 24" RCP
- 517 LF 30" RCP
- 615 LF 36" RCP
- 1,115 LF 42" RCP
- 2,247 LF 48" RCP
- 416 LF 7x5 RCB
- 1,974 LF 9x6 RCB
- 26 Structures

Benefits:
- Flood Mitigation
- Improved Safety
  - Road Flooding
- Highly Visible Issue
- Improved Resiliency
  - Reduced Velocities

Planning-level Opinion of Probable Project Cost:

$22,515,000

Potential Easements: (Council District 5)

5 affected parcels

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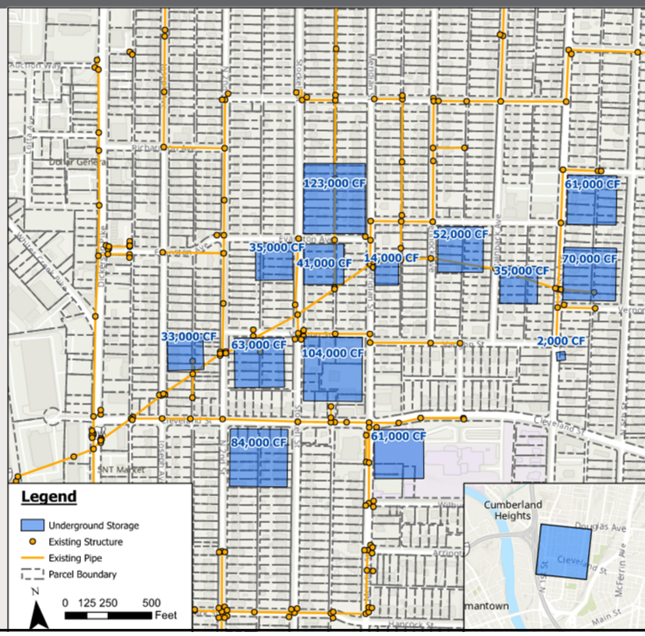
Capital Improvement Plan (CIP)



East Nashville - Area 2
Alternative #2

Provide 778,000 cubic feet (CF) of underground storage around the residential neighborhoods north of Cleveland Street and east of Dickerson Pike.

Details:
- 778,000 CF Storage

Benefits:
- Flood Mitigation
- Improved Safety
  - Road Flooding
  - Residential Lot Flooding
- Highly Visible Issue

Planning-level Opinion of Probable Project Cost:

$40,720,000

Potential Easements: (Council District 5)

159 affected parcels

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Process

Planning → Inventory/ Condition Assessment → Model Setup

Analysis → CIP → System Improvements

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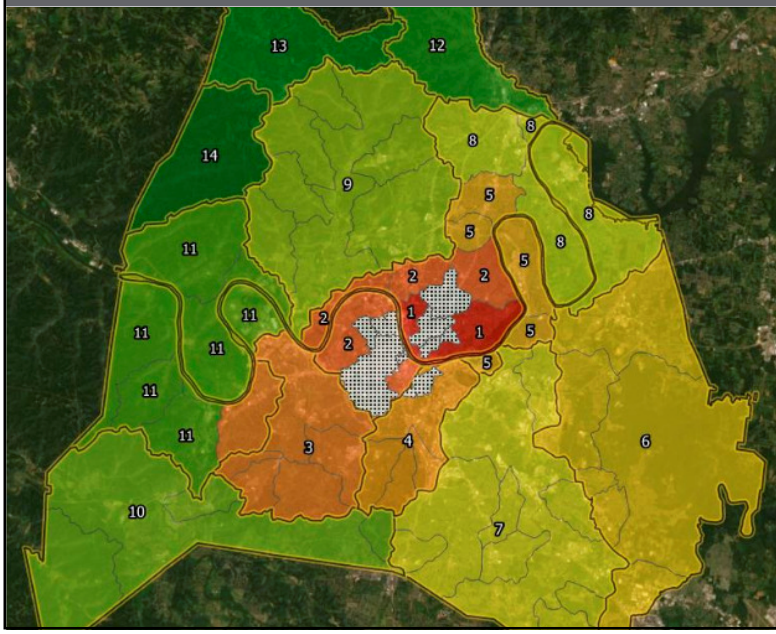
Status



- ✓ Inventory complete on all the “1” areas
- ✓ Reports complete on East Nashville, Shelby Park A
- ✓ Model Remaining Shelby Park Areas
- ✓ Inventory started in Richland Creek and Nashville areas

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Q&A

Questions?

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Basin Prioritization Moving Forward

Decision Matrix	Future Metro Project Coordination	Rural / Downtown	Social Vulnerability Index

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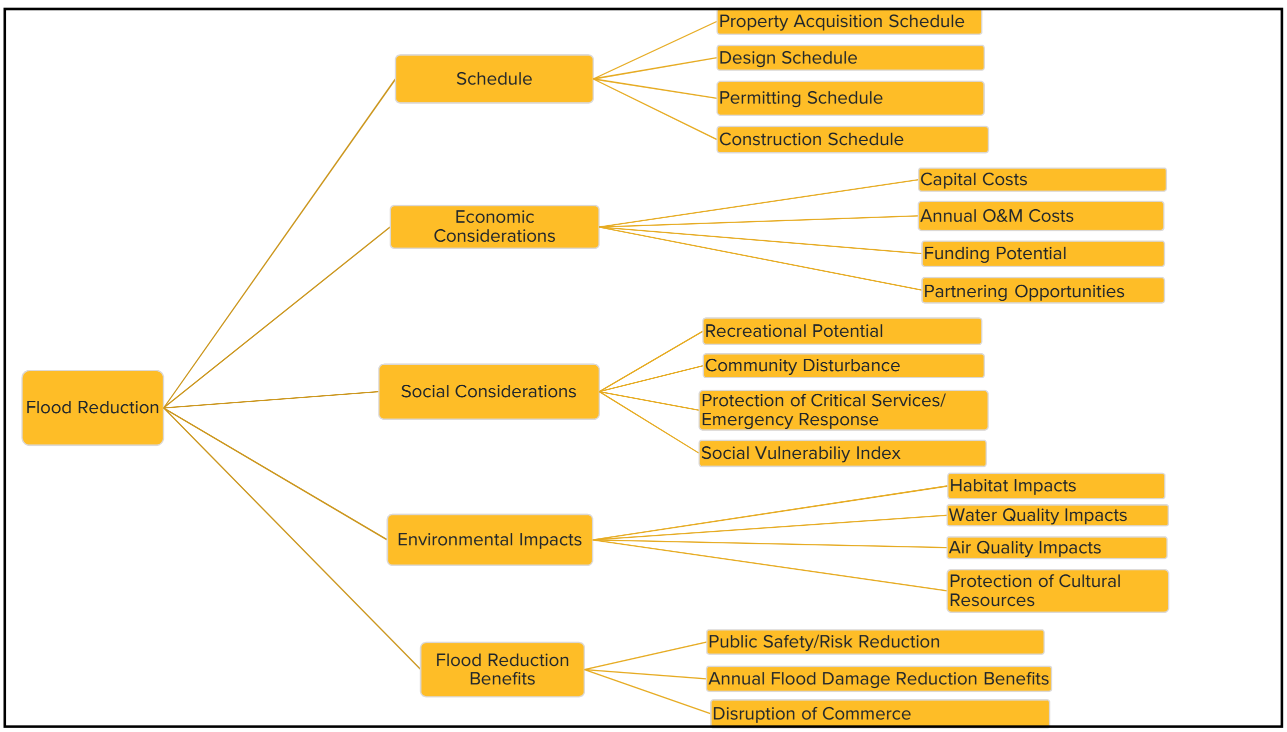

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Schedule / Next Meeting

- Basin Prioritization
- Alternatives Ranking

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Thank you.

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MEETING SUMMARY

MWS Stormwater Master Plan Advisory Committee Kick Off

MEETING DATE:	June 29, 2023
MEETING TIME:	2:00 PM
LOCATION:	MWS – Biosolids Conference Room

ATTENDEES:

Matt Tays – MWS
Tom Palko – MWS
Ricky Swift – MWS
Dustin Shane - Planning
Derek Haggerty – NDOT
Erica Greene – Greenways
David Diaz-Barriga - Greenways
Andy Reese – AR LLC
Roger Lindsey – MWS
Kendra Abkowitz – Mayor's Office
Jim Snyder – MWS
Steve Mishu – Codes
Michael Hunt – MWS
Sonia Allman – MWS
Tiffany Pace – MWS
Janelle Schlamp - Barge
Clayton Foster – Barge

Comments from Advisory Committee:

Discussion of Questions from Prior Meeting

- In response to the question of being able to use a more aggressive rainfall, Andy Reese suggested that Atlas 15 is slated to come out in 2027, and perhaps there are some preliminary numbers available. Atlas 15 will incorporate climate change estimates.

Discussion of Basin Prioritization

- Andy Reese – Consider depth-damage curves in prioritization. Some areas my sustain higher damage due to depth of water than nearby areas
- Roger Lindsey – The Assessors office has a tool based on the 2010 flood, an interactive map for level of damage.
- Kendra Abkowitz – Overlay SVI data on the basin prioritization map as a tool to see how the prioritization relates to SVI areas. SVI data is publicly available from CDC
    - Are community planning efforts, or upcoming development other than what's currently in progress being considered?
- Dustin Shane – Planning currently has Kimley Horn studying infill and zoning and recommending changes. The study is due this fall.

Discussion of Decision Criteria

Schedule:

- Ricky Swift – Will Metro be starting to purchase easements for these projects? – Tom Palko indicated Metro may have to start, it was done for Clean Water Nashville projects.
- Andy Reese – One of the schedule sub-criteria may end up being the driver for the whole schedule
- Kendra Abkowitz – There may be some overlap and compounding of the property acquisition question between the schedule and cost criteria. How do you account for that?

Economic:

- There was a comment to consider FEMA funding for some projects.
- Jim Snyder – The new capacity fee may provide additional opportunities or overlap with partnership opportunities with development.

Environmental Impacts:

- Andy Reese – Some areas designate ponding areas in neighborhoods that are expected to pond during storms
- Steve Mishu – Are you looking at stream bank erosion?
    - Consider detention zones outside the stream banks, in adjacent low-lying areas.

Political:

- Tom Palko – MWS tracks council district for all projects.
- Jim Snyder – MWS told the council the study would be managed by basin, not district and it made sense to the council at the time.
- Multiple comments – do not show the final rankings with points due to politics.

Decision Criteria Weighting Approach

- Andy Reese – Consider looking at ranges of points, high risk, low risk, etc.
- Multiple comments – There should not be a specific project score. It causes people to say “my project is only 1 point lower, how come it’s not being done?”

Metro Water Services Stormwater Master Plan

METRO WATER SERVICES

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Agenda

- Project Team / Advisory Committee
- Objectives
- Question Review
- Decision Criteria
- Example Decision Matrix
- Example Results

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Project Team

Name	Organization
Tom Palko	Metro Water Services
Matt Tays	Metro Water Services
Roger Lindsey	Metro Water Services
Ricky Swift	Metro Water Services
Chris Provost	Barge Design Solutions
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Clayton Foster	Barge Design Solutions

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Advisory Committee

Name	Organization
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Steve Mishu	Metro Codes Administration
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Cindy Harrison	Metro Parks and Recreation
Dustin Shane	Metro Planning Department
Derek Haggerty	Nashville Department of Transportation
Matt Tays	Metro Water Services
Russ Pulley	Chair of Transportation and Infrastructure Committee
Andy Reese	Andy Reese, LLC

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Project Objective

The overall objective of the Stormwater Masterplan is to study existing infrastructure and develop alternatives to reduce or abate flooding throughout the Metro service area.

5

Questions from Previous Meeting

- **How do we plan for developers planning for Metro code of 100-year storm event if we are designing to the 10-year?**
- We currently plan to evaluate the 100-year storm event if the 10-year storm discharges exceed 100-cfs. That will be the threshold for switching to 100-year.

6

Questions from Previous Meeting

- **Could we evaluate a more aggressive rain event for future planning to account for changing weather patterns?**
- Yes, we would need feedback on what event that would be. We currently plan to evaluate the 100-year storm event if the 10-year storm discharges exceed 100-cfs.

7

Questions from Previous Meeting

- **How did the basin prioritization incorporate equity?**
- The current basin prioritization does not consider equity as a factor. The prioritization used development, growth, existing issues, and data quality as criteria to determine the basin prioritization rankings.

8

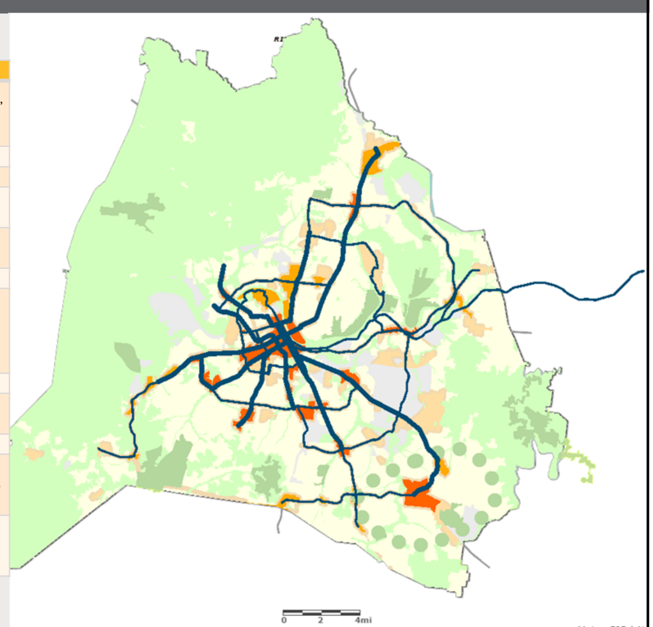
Questions from Previous Meeting

- **What differences are there between Nashville Next planning and what has been actually constructed or changed in terms of zoning?**
- We used the Nashville Next Concept Map for future conditions and then assigned an impervious surface ratio (ISR) number to each area, table next slide. We did review specific rezoning plans in growing areas which were used to feed into the ISR recommendations.

9

Nashville Next Concept Map

Category	Impervious Surface Ratio (ISR)	Additional Information
Anchor Park	.10	Depends on if community centers, special use facilities are in the park – then the ISR is higher
Center		Varies by Center classification
• Downtown	.95	Most intense center
• Tier 1	.90	Varies in intensity by center level examples is Green Hills
• Tier 2	.85	Examples are Metro Center, Dickerson Pike/ Trinity Lane
• Tier 3	.80	Examples – Opry Mills
Green Network	.05	2-5 acre lots mostly in this area. Lack of sewer and steep slopes characterize much of this area and keep development opportunities lower.
Neighborhood		
• UZO (inside 440/Briley)	.60-.70	Closer to downtown, smaller lots, more lot coverage
• Outer Ring	.40	Larger lots, less coverage
Special Uses	.70-.90	Depends – Airport is going to be closer to 1.0, Cockrill Bend will be on the lower end.
Transitions and Infill	.7	SP projects in the example areas are all seeming to use .7 as their max impervious ratio.



10

Process

Planning

Inventory/ Condition Assessment

Model Setup

Analysis

CIP

System Improvements

11

Planning

Development Density

Experiencing Growth

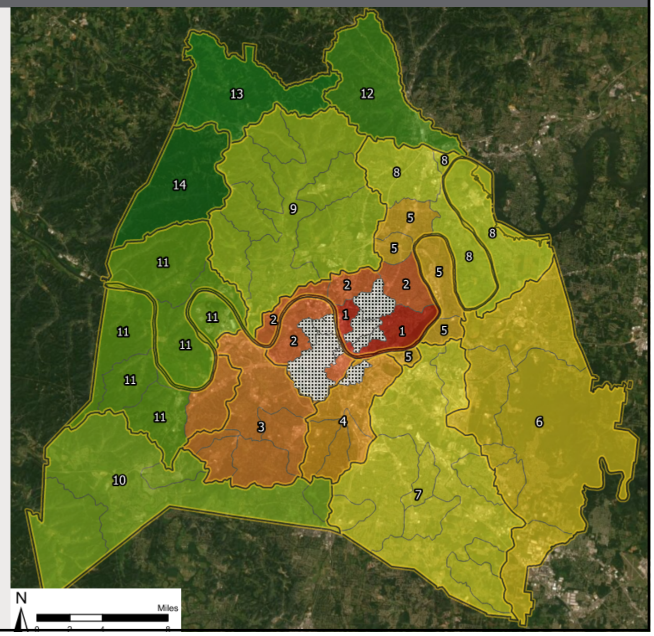
Existing Issues

Data Quality

12

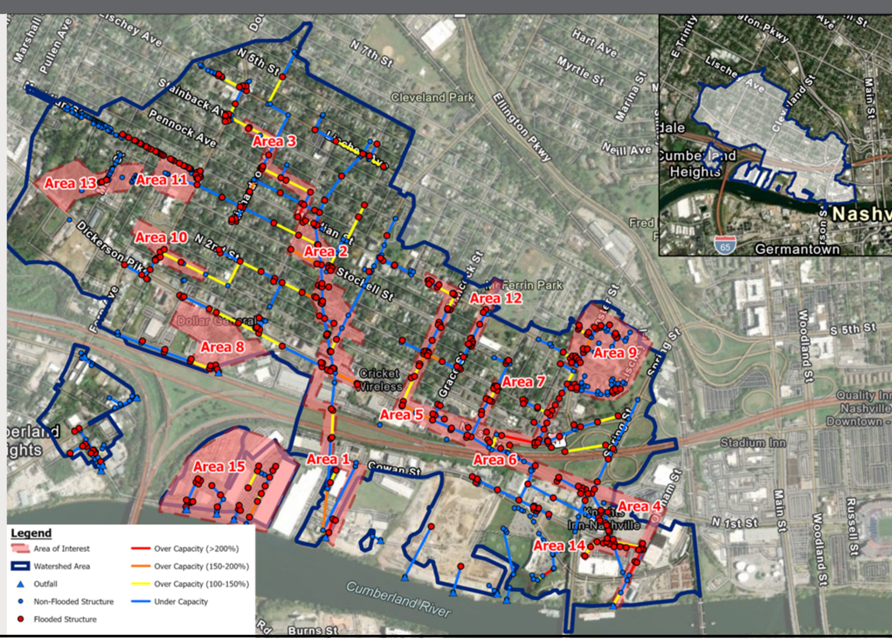
Planning

Priority		Watershed	Area (Sq. Mi.)	Weighted Score for Dvlpmnt Density	Weighted Score for Active Dvlpmnt	Weighted Score for Service Requests	Weighted Score for Data Quality	Total Weighted Score
1	Minor Tribs	East Nashville	6	1.14	0.80	1.83	0.61	8.94
		Shelby Park	2	1.48	5.76	2.20	0.65	4.09
2	Minor Tribs	Nashville	7	1.53	3.78	1.33	0.59	6.92
		Unnamed Basin (north of Nashville Basin)	3	0.80	2.45	1.26	0.65	4.94
		Pages Branch	3	1.06	2.70	1.74	0.63	5.86
		Coopers Creek	10	0.61	0.81	0.63	0.64	8.19
3		Richland Creek	16	0.60	0.52	0.99	0.64	6.07
	MT	Cleese Ferry	6	0.84	0.57	0.90	0.65	2.82
4		Browns Creek	4	1.22	0.82	1.95	0.66	4.83
5	Minor Tribs	Gibson Creek	5	1.63	0.97	5.54	0.66	4.38
		Windemere	8	0.29	0.46	0.00	0.64	4.32
		River Hill	2	0.84	0.74	2.36	0.65	4.33
		Pennington Bend	9	0.50	0.24	1.02	0.66	1.48
		Loves Branch	1	0.47	2.65	0.73	0.66	4.00
6		Stones River	1	0.65	1.70	0.39	0.65	3.64
7		Mill Creek	5	0.02	0.11	0.00	0.61	2.99
8	Minor Tribs	Dry Creek	6	0.49	0.09	0.29	0.66	2.57
		Old Hickory	2	0.90	0.46	2.23	0.67	2.60
		Neely's Bend	13	0.02	0.12	0.00	0.66	2.28
		Unnamed Basin (north of Old Hickory Basin)	6	0.03	0.00	0.00	0.64	3.26
9		Whites Creek	11	0.03	0.05	0.07	0.65	2.04
10		Harpeth River	15	0.05	0.04	0.10	0.66	1.43
11	Minor Tribs	Overall Creek	71	0.89	0.69	0.49	0.65	1.36
		Cockrill Bend	78	0.58	0.58	0.47	0.63	0.74
		Bells Bend	63	0.31	0.43	0.30	0.65	0.79
		Indian Creek W.	16	1.08	1.38	0.24	0.62	0.68
		Cub Creek	28	1.20	0.73	2.58	0.64	0.80
		Scottsboro	56	0.36	0.15	0.33	0.64	0.83
12		Mansker Creek	21	0.10	0.17	0.00	0.66	1.11
13		Sycamore Creek	21	0.21	0.07	0.03	0.65	0.96
14		Marrowbone Creek	19	0.07	0.00	0.00	0.66	0.76
		TOTAL	514	20.00	30.00	30.00	20.00	100.00



13

System Improvements



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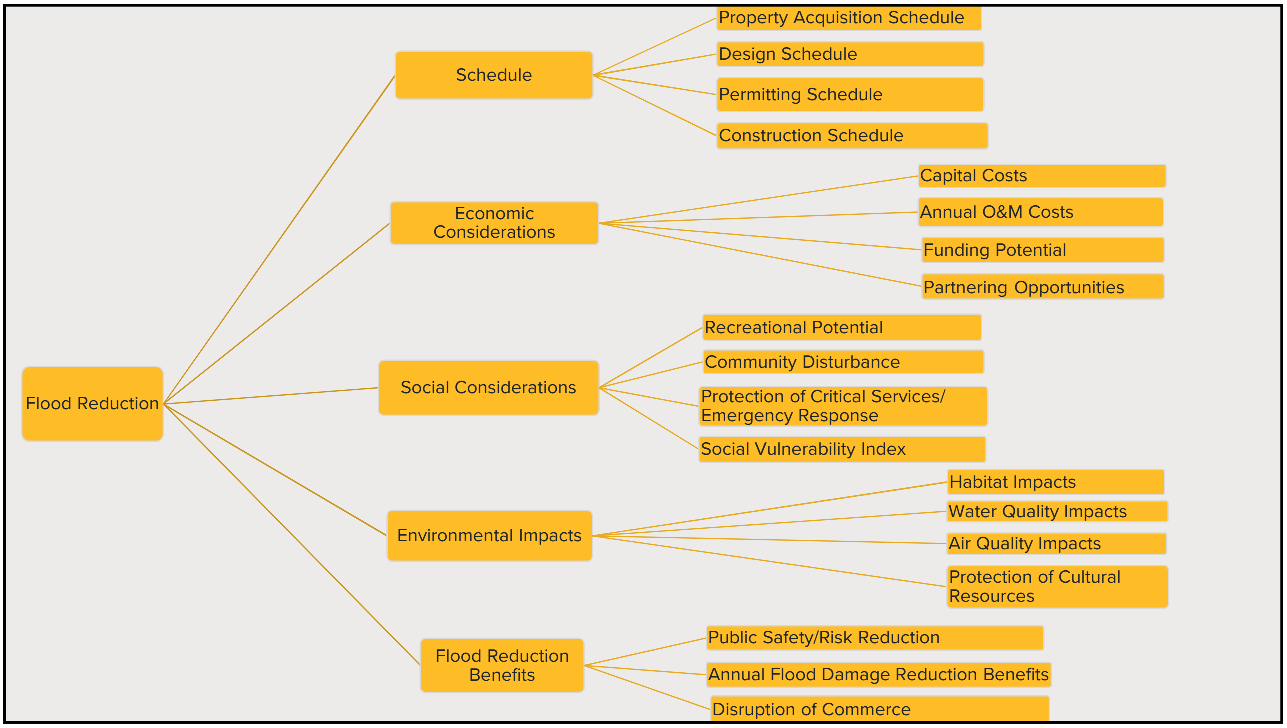
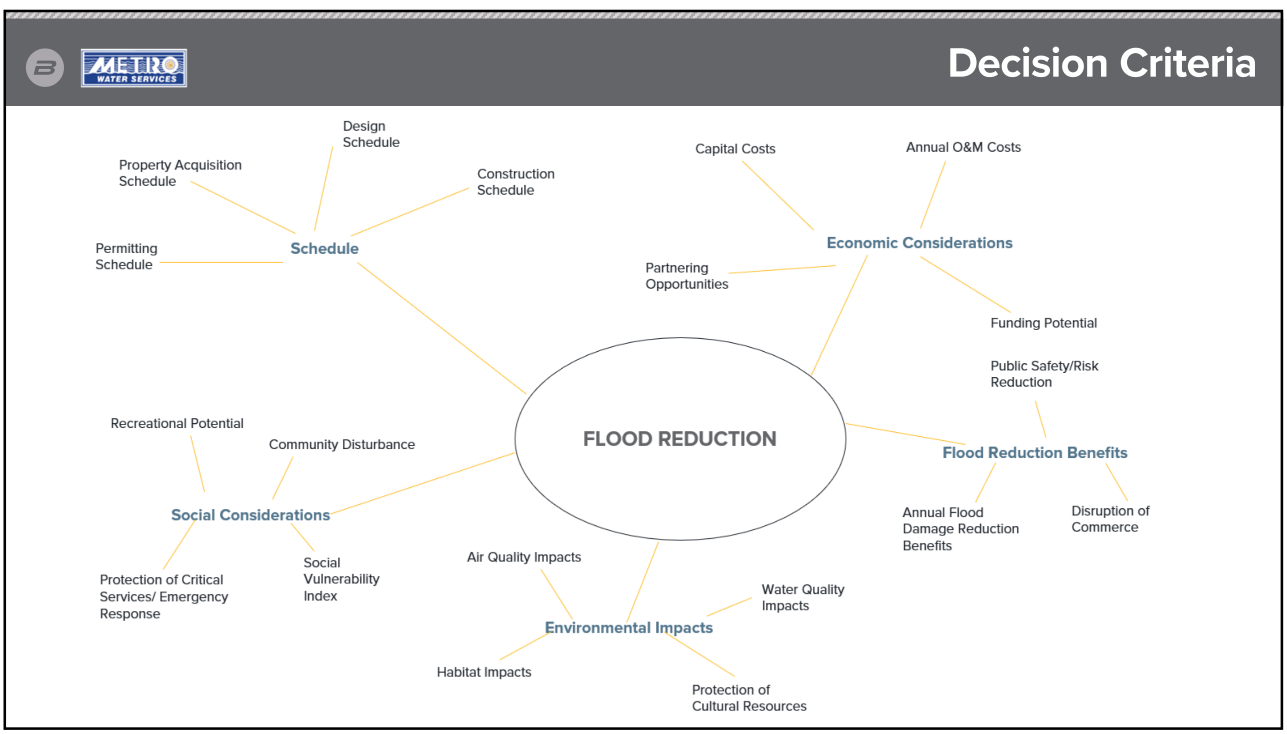

Flood Reduction
Schedule
Property Acquisition Schedule
Design Schedule
Permitting Schedule
Construction Schedule
Economic Considerations
Capital Costs
Annual O&M Costs
Funding Potential
Partnering Opportunities
Social Considerations
Recreational Potential
Community Disturbance
Protection of Critical Services/ Emergency Response
Social Vulnerability Index
Environmental Impacts
Habitat Impacts
Water Quality Impacts
Air Quality Impacts
Protection of Cultural Resources
Flood Reduction Benefits
Public Safety/Risk Reduction
Annual Flood Damage Reduction Benefits
Disruption of Commerce

15


Decision Criteria
METRO WATER SERVICES
FLOOD REDUCTION
Schedule
Property Acquisition Schedule
Design Schedule
Construction Schedule
Permitting Schedule
Economic Considerations
Capital Costs
Annual O&M Costs
Partnering Opportunities
Funding Potential
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Recreational Potential
Community Disturbance
Protection of Critical Services/ Emergency Response
Social Vulnerability Index
Environmental Impacts
Air Quality Impacts
Water Quality Impacts
Habitat Impacts
Protection of Cultural Resources

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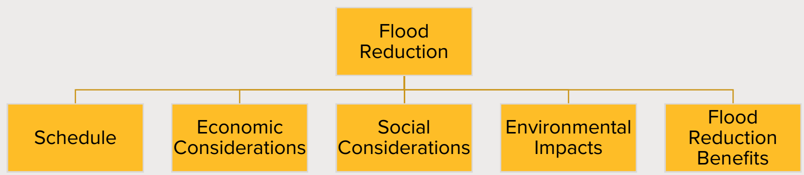
Decision Criteria



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Example Criteria Weighting

Primary Criteria

Weight the Primary Criteria below based on how important you feel each factor should be in the decision-making process. Move the slider bars using your mouse or the arrow keys to the percentage which you feel each Primary Criteria should be weighted. The total of all Primary Criteria must equal 100%.

A	Economic Considerations		15
B	Operational Considerations		15
C	Environmental Considerations		20
D	Social Considerations		25
E	Sustainability Considerations		25
		Total Percent:	100

Score: The score counts the amount of times a criterion was ranked as more important.

Percentage (Pct): The percentage represents the score for an individual criterion divided by the sum of all the scores. The higher the percentage, the more important the criteria. (Relative to user inputs)

Score & Submit

18

Schedule Considerations

Property Acquisition Schedule	Will Additional Easements Be Required?
Design Schedule	How does the design schedule compare to other Alternatives being evaluated?
Permitting Schedule	Are there any issues that could drastically lengthen or shorten the permitting schedule?
Construction Schedule	How long will construction take?

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Economic Considerations

Capital Costs	What are the costs to permit, design, purchase, install, and start up the Alternative?
Annual O&M Costs	What are the estimated costs for necessary to operate and maintain the system?
Funding Potential	Has MWS already allocated funding or planned for the Alternative?
Partnership Opportunities	Is there the potential for cost sharing with other groups or Metro departments?

20

Social Considerations

Recreation Potential	Is there a potential to couple use with a greenway or park?
Community Disturbance	How long and to what degree will existing traffic, neighbors, etc. be impacted?
Protection of Critical Services/Emergency Response	Is access to critical infrastructure being protected and/or improved? Is resiliency being added to these critical sites?
Social Vulnerability Index	Are At-Risk populations benefiting?

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Environmental Impacts

Habitat Impacts	Does the Alternative impact aquatic or terrestrial habitats?
Water Quality Impacts	Does the Alternative impact water quality?
Air Quality Impacts	Does the proposed Alternative impact the air quality?
Protection of Cultural Resources	Does the Alternative impact cultural or historic sites?

22

Flood Reduction Benefits

Public Safety/Risk Reduction	Does Alternative improve public roadway safety?
Annual Flood Damage Reduction Benefits	Does Alternative improve capacity in the SW system?
Disruption of Commerce	Does alternative address service requests?

23

Political Considerations

Council Districts	Are projects spread around Metro service area?

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Example Matrix

	Capital Costs	Annual O&M Costs	Funding Potential	Partnering Opportunities
Capital Costs				
Annual O&M Costs				
Funding Potential				
Partnering Opportunities				

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Example Matrix

	Capital Costs	Annual O&M Costs	Funding Potential	Partnering Opportunities
Capital Costs		Capital Costs (3)	Capital Costs (2)	Capital Costs (1)
Annual O&M Costs			Funding Potential (1)	Partnering Opportunities (3)
Funding Potential				Partnering Opportunities (3)
Partnering Opportunities				

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Example Results

Capital Costs	Annual O&M	Funding Potential	Partnering Opportunities
(6 points)	(0 points)	(1 point)	(6 points)

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Example Matrix

Economic > Operational > Environmental > Social > Sustainability > Primary > Complete

Name:

E-mail:

Economic Considerations

Each row criterion should be compared to each column criterion. Input the corresponding letter of the more important criterion into the open cell based on the individual comparison. Score each letter entry by how much more important the chosen criterion is: 1: mildly more important; 2: clearly more important; 3: overwhelmingly more important.
Start at row 1 and do this for each row. Click on a criterion to view a definition of that criterion.

Economic Considerations		A	B	C	Score	Pct
		Captial Expense	O&M Expense	Economic Benefits		
A	Captial Expense		Criteria Score 1	Criteria Score		
B	O&M Expense			Criteria Score		
C	Economic Benefits					

Score: The score counts the amount of times a criterion was ranked as more important.

Percentage (Pct): The percentage represents the score for an individual criterion divided by the sum of all the scores. The higher the percentage, the more important the criteria. (Relative to user inputs)

Continue

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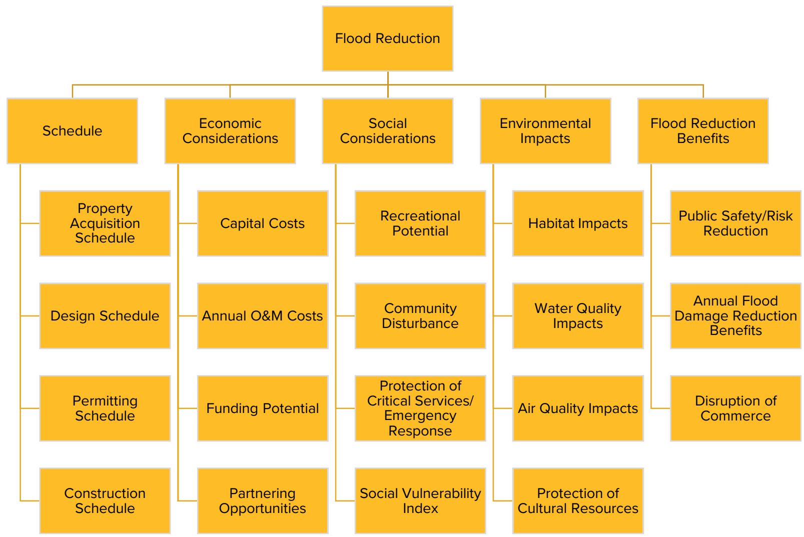
Decision Criteria



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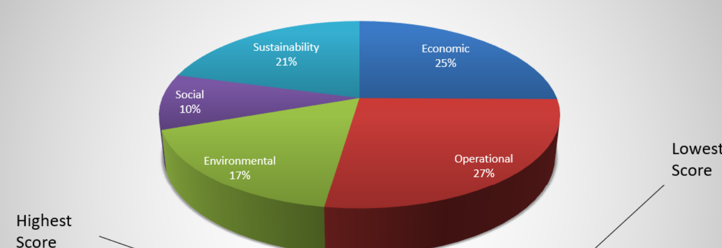
Example Results

Primary Criteria



	Economic	Operational	Environmental	Social	Sustainability
Average	25.2	27.2	17.3	9.6	20.8
Median	25.0	25.0	15.0	10.0	20.0
Max	36	50	35	15	45
Min	10	10	5	3	9

30

Example Results

Sub-Criteria

Primary Criteria	Subcriteria	Average Sub - Weighting	Primary Weighting	Extended Weighting
Economic	Capital Expense	31.5%	25.2%	7.9%
Economic	OM Expense	46.2%	25.2%	11.6%
Economic	Economic Benefits	22.2%	25.2%	5.6%
Operational	System Complexity	6.5%	27.2%	1.8%
Operational	References from Other Systems	6.5%	27.2%	1.8%
Operational	Manpower Requirements	13.5%	27.2%	3.7%
Operational	Liquid Treatment Impacts	25.2%	27.2%	6.9%
Operational	Maintenance Requirements	14.2%	27.2%	3.9%
Operational	Plant Optimization	16.6%	27.2%	4.5%
Operational	Technology Reliability	17.7%	27.2%	4.8%
Environmental	Water Quality	41.2%	17.3%	7.1%
Environmental	Air Quality	19.6%	17.3%	3.4%
Environmental	Ecosystems	13.0%	17.3%	2.2%
Environmental	Environmental Stewardship	26.2%	17.3%	4.5%
Social	APP End User	12.9%	9.6%	1.2%
Social	APP WWTP	21.8%	9.6%	2.1%
Social	Community Development	13.0%	9.6%	1.2%
Social	Property Acquisition	7.5%	9.6%	0.7%
Social	MWBE/SBE Participation	23.8%	9.6%	2.3%
Social	Job Creation	21.2%	9.6%	2.0%
Sustainability	Expandability	20.3%	20.8%	4.2%
Sustainability	Energy Reqs	17.5%	20.8%	3.6%
Sustainability	Product End Use	14.6%	20.8%	3.0%
Sustainability	Product Flexbility	22.8%	20.8%	4.7%
Sustainability	System Longevity	24.9%	20.8%	5.2%

Primary Criteria	Subcriteria	Average Sub - Weighting	Primary Weighting	Extended Weighting
Economic	OM Expense	46.2%	25.2%	11.6%
Economic	Capital Expense	31.5%	25.2%	7.9%
Environmental	Water Quality	41.2%	17.3%	7.1%
Operational	Liquid Treatment Impacts	25.2%	27.2%	6.9%
Economic	Economic Benefits	22.2%	25.2%	5.6%
Sustainability	System Longevity	24.9%	20.8%	5.2%
Operational	Technology Reliability	17.7%	27.2%	4.8%
Sustainability	Product Flexbility	22.8%	20.8%	4.7%
Environmental	Environmental Stewardship	26.2%	17.3%	4.5%
Operational	Plant Optimization	16.6%	27.2%	4.5%
Sustainability	Expandability	20.3%	20.8%	4.2%
Operational	Maintenance Requirements	14.2%	27.2%	3.9%
Operational	Manpower Requirements	13.5%	27.2%	3.7%
Sustainability	Energy Reqs	17.5%	20.8%	3.6%
Environmental	Air Quality			
Sustainability	Product End Use			
Social	MWBE/SBE Participation			
Environmental	Ecosystems	13.0%	17.3%	2.2%
Social	APP WWTP	21.8%	9.6%	2.1%
Social	Job Creation	21.2%	9.6%	2.0%
Operational	System Complexity	6.5%	27.2%	1.8%
Operational	References from Other Systems	6.5%	27.2%	1.8%
Social	Community Development	13.0%	9.6%	1.2%
Social	APP End User	12.9%	9.6%	1.2%
Social	Property Acquisition	7.5%	9.6%	0.7%

Criteria weighted above 4.2% kept. All others discarded.

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Q&A

Questions?

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Thank you.

METRO WATER SERVICES

BARGE DESIGN SOLUTIONS

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Metro Water Services Stormwater Master Plan

METRO WATER SERVICES

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1

Agenda

- Project Team / Advisory Committee
- Objectives
- Question Review
- Decision Criteria Results
- Alternative Scoring
- Example Results

2

Project Team

Name	Organization
Tom Palko	Metro Water Services
Matt Tays	Metro Water Services
Roger Lindsey	Metro Water Services
Ricky Swift	Metro Water Services
Chris Provost	Barge Design Solutions
Adrian Ward	Barge Design Solutions
Janelle Schlamp	Barge Design Solutions
Clayton Foster	Barge Design Solutions

3

Advisory Committee

Name	Organization
Kendra Abkowitz	Mayor's Office
Steve Mishu	Metro Codes Administration
Heidi Mariscal	Metro Office of Emergency Management
Cindy Harrison	Metro Parks and Recreation
Dustin Shane	Metro Planning Department
Derek Haggerty	Nashville Department of Transportation
Matt Tays	Metro Water Services
Russ Pulley	Chair of Transportation and Infrastructure Committee
Andy Reese	Andy Reese, LLC

4

Project Objective

The overall objective of the Stormwater Masterplan is to study existing infrastructure and develop alternatives to reduce or abate flooding throughout the Metro service area.

5

Questions from Previous Meeting

- **Can we overlay SVI data on the basin prioritization map?**

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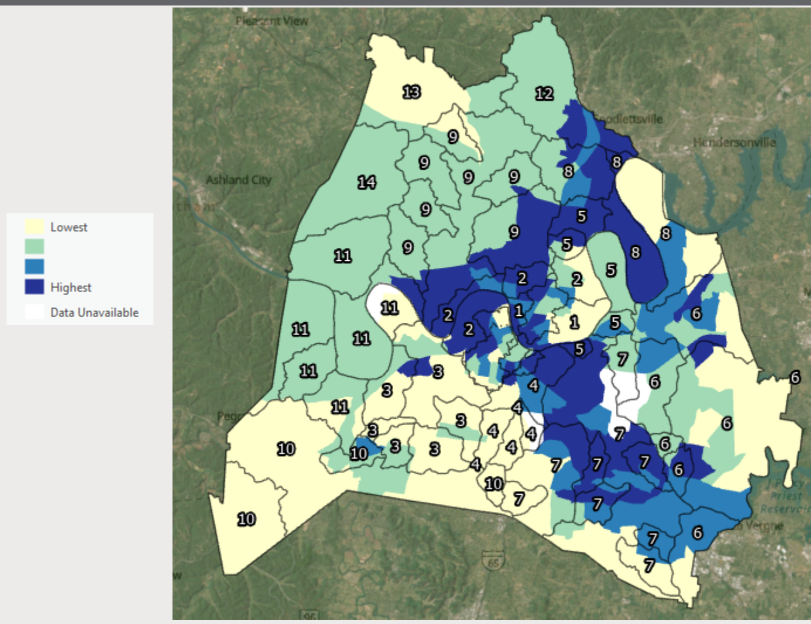
Social Vulnerability Index



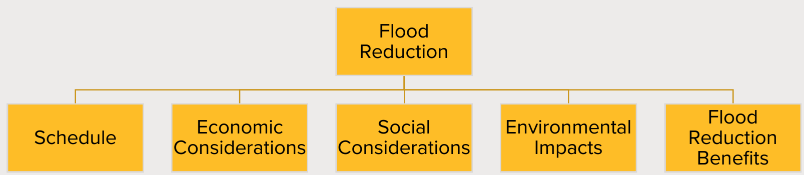
7

Questions from Previous Meeting

- Are community planning efforts, or upcoming development other than what's currently in progress being considered?

8

Decision Criteria



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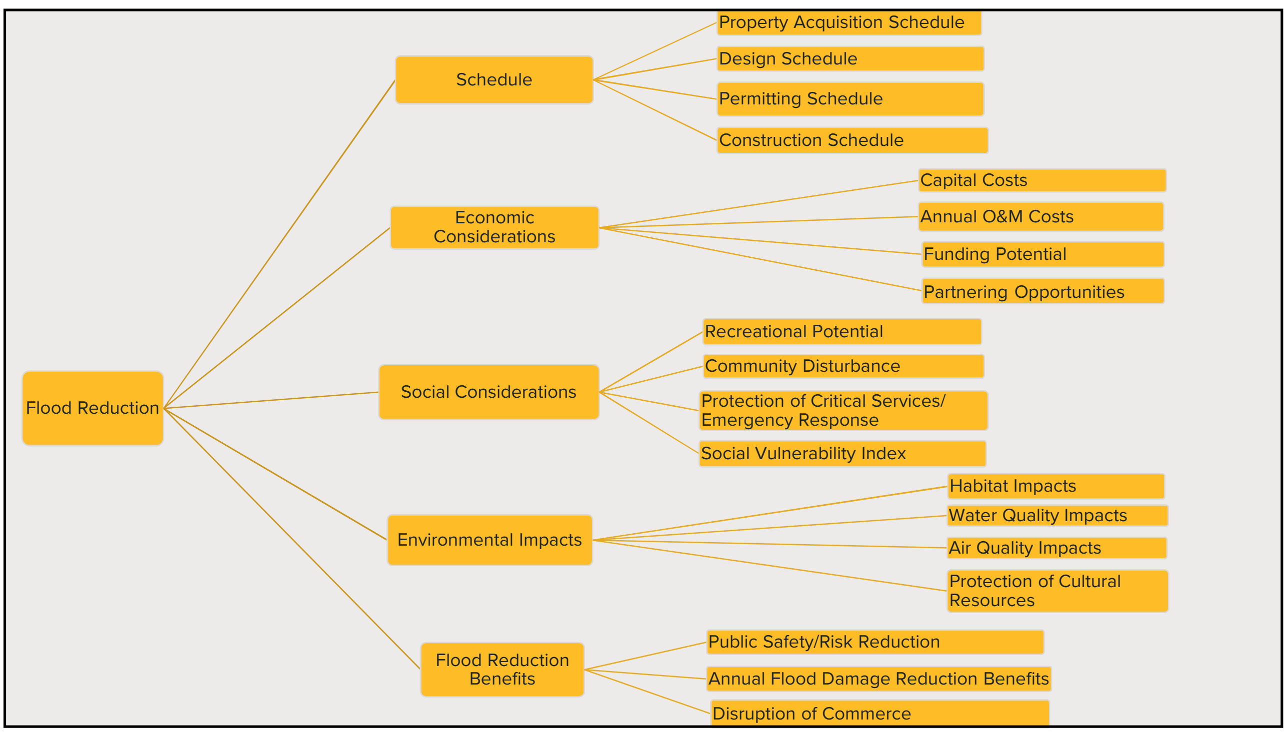

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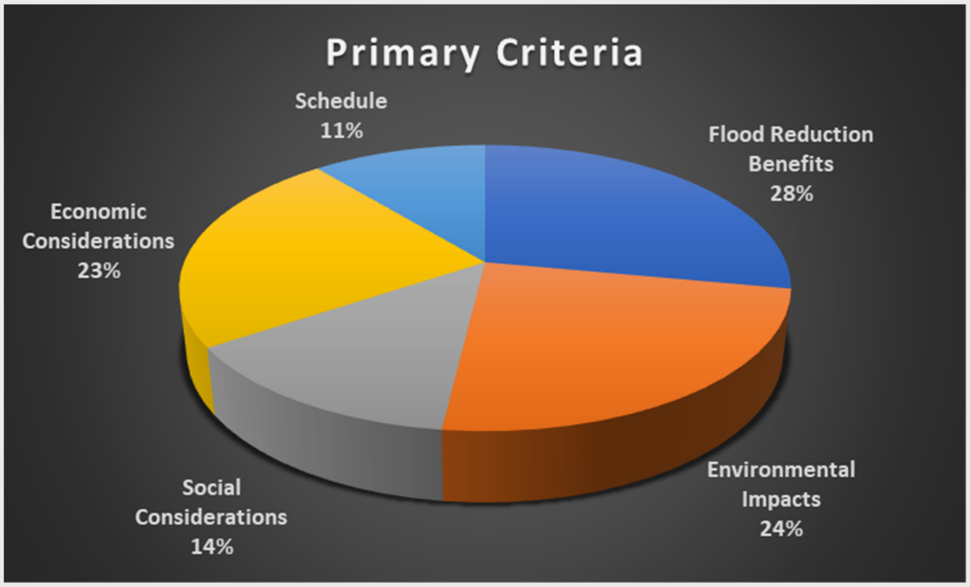
Primary Criteria Results



11

Secondary Criteria Results

Primary Criteria	Primary Percentage	Subcriteria	Subcriteria Percentage	Final Weight
Schedule	10.93%	Property Acquisition Schedule	44.40%	4.85%
Schedule	10.93%	Design Schedule	20.36%	2.22%
Schedule	10.93%	Permitting Schedule	8.89%	0.97%
Schedule	10.93%	Construction Schedule	26.35%	2.88%
Economic Considerations	23.68%	Capital Cost	22.63%	5.36%
Economic Considerations	23.68%	Annual O&M Costs	14.78%	3.50%
Economic Considerations	23.68%	Funding Potential	22.29%	5.28%
Economic Considerations	23.68%	Partnering Opportunity	40.31%	9.54%
Social Considerations	13.66%	Recreational Potential	17.92%	2.45%
Social Considerations	13.66%	Community Disturbance	16.88%	2.31%
Social Considerations	13.66%	Protection of Critical Services/Emergency Response	47.17%	6.44%
Social Considerations	13.66%	Social Vulnerability Index	18.04%	2.46%
Environmental Impacts	23.86%	Habitat Impacts	28.64%	6.83%
Environmental Impacts	23.86%	Water Quality Impacts	45.43%	10.84%
Environmental Impacts	23.86%	Air Quality Impacts	12.50%	2.98%
Environmental Impacts	23.86%	Protection of Cultural Resources	13.43%	3.21%
Flood Reduction Benefits	27.87%	Public Safety/Risk Reduction	64.86%	18.08%
Flood Reduction Benefits	27.87%	Annual Flood Damage Reduction Benefit	17.92%	4.99%
Flood Reduction Benefits	27.87%	Disruption of Commerce	17.22%	4.80%

12

Secondary Criteria Results

Primary Criteria	Primary Percentage	Subcriteria	Subcriteria Percentage	Final Weight
Flood Reduction Benefits	27.87%	Public Safety/Risk Reduction	64.86%	18.08%
Environmental Impacts	23.86%	Water Quality Impacts	45.43%	10.84%
Economic Considerations	23.68%	Partnering Opportunity	40.31%	9.54%
Environmental Impacts	23.86%	Habitat Impacts	28.64%	6.83%
Social Considerations	13.66%	Protection of Critical Services/Emergency Response	47.17%	6.44%
Economic Considerations	23.68%	Capital Cost	22.63%	5.36%
Economic Considerations	23.68%	Funding Potential	22.29%	5.28%
Flood Reduction Benefits	27.87%	Annual Flood Damage Reduction Benefit	17.92%	4.99%
Schedule	10.93%	Property Acquisition Schedule	44.40%	4.85%
Flood Reduction Benefits	27.87%	Disruption of Commerce	17.22%	4.80%
Economic Considerations	23.68%	Annual O&M Costs	14.78%	3.50%
Environmental Impacts	23.86%	Protection of Cultural Resources	13.43%	3.21%
Environmental Impacts	23.86%	Air Quality Impacts	12.50%	2.98%
Schedule	10.93%	Construction Schedule	26.35%	2.88%
Social Considerations	13.66%	Social Vulnerability Index	18.04%	2.46%
Social Considerations	13.66%	Recreational Potential	17.92%	2.45%
Social Considerations	13.66%	Community Disturbance	16.88%	2.31%
Schedule	10.93%	Design Schedule	20.36%	2.22%
Schedule	10.93%	Permitting Schedule	8.89%	0.97%

13

Scoring – Schedule Criteria

Property Acquisition Schedule

- How many property owners will be impacted?
  - 1 – More than 10
  - 3 – > 1 to 10
  - 5 – 1 or less (mostly in the right-of-way)

Design Schedule

- Estimated time to complete design
  - 1 – More than 12 months
  - 3 – 6 to 12 months
  - 5 – Less than 6 months

Permitting Schedule

- Estimated time to acquire state and federal permits
  - 1 – More than 6 months
  - 3 – 60 days to 6 months
  - 5 – Less than 60 days

Construction Schedule

- Estimated time to complete construction
  - 1 – Long term – construction > 3 years
  - 3 – Moderate – construction 1-3 years
  - 5 – Short term – construction < 1 year

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Scoring – Economic Criteria

Capital Costs
- What is the estimated cost to construct?
  - 1 – > $20M
  - 2 – $10M to < $20M
  - 3 – $5M to < $10M
  - 4 – $1M to <$5M
  - 5 – < $1M

Annual O&M Costs
- Cost to maintain a project
  - 1 – High O&M (e.g., includes pumps)
  - 3 – Moderate O&M (e.g., includes ponds, filter media, etc.)
  - 5 – Low O&M (e.g., mostly gravity pipes and structures)

Funding Potential
- What portion of the project could be paid for by a grant?
  - 1 – less than 25%
  - 3 – 25% to 50%
  - 5 – greater than 50%

Partnering Opportunities
- What portion could be paid for by partnering opportunities?
  - 1 – less than 25%
  - 3 – 25% to 50%
  - 5 – greater than 50%

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Scoring – Social Criteria

Recreational Potential
- Is there an opportunity to incorporate parks facilities into the projects?
  - 1 – No opportunity
  - 3 – Opportunity for stormwater improvements to also provide a route for a greenway
  - 5 – Opportunity to provide park or green space

Community Disturbance
- How long and to what degree will existing traffic and neighbors be impacted?
  - 1 – High impact
  - 3 – Moderate impact
  - 5 – Low impact

Protection of Critical Services
- Will critical services be protected?
  - 1 – No protection provided
  - 3 – Flooding of non-neighborhood roads would be mitigated
  - 5 – Flooding of critical sites or driveways would be mitigated

Social Vulnerability Index
- Are at-risk populations benefitting from the project?
  - 1 – SVI range 0 to 0.33
  - 3 – SVI range 0.33 to 0.66
  - 5 – SVI range 0.66 to 1

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Scoring – Environmental Criteria

Habitat Impacts
- Will there be impact to aquatic or terrestrial habitats?
  - 1 – Potential negative impacts (construction disturbance)
  - 3 – Neutral
  - 5 – Potential improvements (reduced velocity, reduced erosion, increased pollutant settlement)

Water Quality Impacts
- What are the potential impact on water quality?
  - 1 – Potential negative impact/increased risk on water quality
  - 3 – No impact on water quality
  - 5 – Potential water quality improvements

~~Air Quality Impacts~~
- Does the alternative negatively impact the air quality?
  - 1 – Yes
  - 5 – No

Protection of Cultural Resources
- Does the project negatively impact cultural or historic sites?
  - 1 – Negative impact
  - 3 – No impact
  - 5 – Mitigation of flooding of cultural resources

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Scoring – Flood Reduction Criteria

Public Safety/Risk Reduction
- Is public safety improved?
  - 1 – Reduces nuisance flooding
  - 2 – Reduces flooding from multiple driveways or other minor safety improvements
  - 3 – Reduces flooding from a minor roadway
  - 4 – Reduces flooding from multiple minor roadways or other moderate safety improvement
  - 5 – Reduces flooding from a major roadway or transportation infrastructure or other major safety improvement

Annual Flood Damage Reduction Benefits
- Does the project reduce stormwater surcharges and instances of flooding?
  - 1 – No property or building impacts
  - 2 – Mitigates minor property flooding
  - 3 – Mitigates flooding in a building or addresses a service request
  - 4 – Mitigates flooding of 2-3 buildings or addressed multiple service requests
  - 5 – Mitigates flooding of critical infrastructure or >3 buildings

Disruption of Commerce
- To what degree are business affected?
  - 1 – No business improvements
  - 3 – Mitigates flooding of a business
  - 5 – Mitigates flooding of multiple businesses

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Example Results

Rank	All Criteria
1	Shelby Park A - Area 2 - Alt 1
2	Shelby Park A - Area 3 - Alt - 1
3	East Nashville - Area 9 - Alt 1
4	East Nashville - Area 14 - Alt 1
5	East Nashville - Area 6 - Alt 1
6	Shelby Park A - Area 1 - Alt 1
7	East Nashville - Area 1 - Alt 1
8	East Nashville - Area 8 - Alt 1
9	Shelby Park A - Area 4 - Alt 1
10	East Nashville - Area 5 - Alt 1
11	East Nashville - Area 2 - Alt 1
12	East Nashville - Area 4 - Alt 1
13	East Nashville - Area 3 - Alt - 1
14	East Nashville - Area 12 - Alt 1
15	East Nashville - Area 13 - Alt 1
16	East Nashville - Area 7 - Alt 1
17	East Nashville - Area 15 - Alt 1
18	East Nashville - Area 11 - Alt 1
19	East Nashville - Area 10 - Alt 1

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Secondary Criteria Results

Primary Criteria	Primary Percentage	Subcriteria	Subcriteria Percentage	Final Weight
Flood Reduction Benefits	27.87%	Public Safety/Risk Reduction	64.86%	18.08%
Environmental Impacts	23.86%	Water Quality Impacts	45.43%	10.84%
Economic Considerations	23.68%	Partnering Opportunity	40.31%	9.54%
Environmental Impacts	23.86%	Habitat Impacts	28.64%	6.83%
Social Considerations	13.66%	Protection of Critical Services/Emergency Response	47.17%	6.44%
Economic Considerations	23.68%	Capital Cost	22.63%	5.36%
Economic Considerations	23.68%	Funding Potential	22.29%	5.28%
Flood Reduction Benefits	27.87%	Annual Flood Damage Reduction Benefit	17.92%	4.99%
Schedule	10.93%	Property Acquisition Schedule	44.40%	4.85%
Flood Reduction Benefits	27.87%	Disruption of Commerce	17.22%	4.80%
Economic Considerations	23.68%	Annual O&M Costs	14.78%	3.50%
Environmental Impacts	23.86%	Protection of Cultural Resources	13.43%	3.21%
~~Environmental Impacts~~	~~23.86%~~	~~Air Quality Impacts~~	~~12.50%~~	~~2.98%~~
Schedule	10.93%	Construction Schedule	26.35%	2.88%
Social Considerations	13.66%	Social Vulnerability Index	18.04%	2.46%
Social Considerations	13.66%	Recreational Potential	17.92%	2.45%
Social Considerations	13.66%	Community Disturbance	16.88%	2.31%
Schedule	10.93%	Design Schedule	20.36%	2.22%
Schedule	10.93%	Permitting Schedule	8.89%	0.97%

Proposed Cutoff

20

Example Results

Rank	All Criteria	2.45% Cutoff
1	Shelby Park A - Area 2 - Alt 1	Shelby Park A - Area 2 - Alt 1
2	Shelby Park A - Area 3 - Alt - 1	Shelby Park A - Area 3 - Alt - 1
3	East Nashville - Area 9 - Alt 1	East Nashville - Area 9 - Alt 1
4	East Nashville - Area 14 - Alt 1	East Nashville - Area 14 - Alt 1
5	East Nashville - Area 6 - Alt 1	East Nashville - Area 6 - Alt 1
6	Shelby Park A - Area 1 - Alt 1	East Nashville - Area 1 - Alt 1
7	East Nashville - Area 1 - Alt 1	Shelby Park A - Area 1 - Alt 1
8	East Nashville - Area 8 - Alt 1	East Nashville - Area 8 - Alt 1
9	Shelby Park A - Area 4 - Alt 1	East Nashville - Area 2 - Alt 1
10	East Nashville - Area 5 - Alt 1	East Nashville - Area 5 - Alt 1
11	East Nashville - Area 2 - Alt 1	Shelby Park A - Area 4 - Alt 1
12	East Nashville - Area 4 - Alt 1	East Nashville - Area 4 - Alt 1
13	East Nashville - Area 3 - Alt - 1	East Nashville - Area 3 - Alt - 1
14	East Nashville - Area 12 - Alt 1	East Nashville - Area 12 - Alt 1
15	East Nashville - Area 13 - Alt 1	East Nashville - Area 13 - Alt 1
16	East Nashville - Area 7 - Alt 1	East Nashville - Area 7 - Alt 1
17	East Nashville - Area 15 - Alt 1	East Nashville - Area 15 - Alt 1
18	East Nashville - Area 11 - Alt 1	East Nashville - Area 11 - Alt 1
19	East Nashville - Area 10 - Alt 1	East Nashville - Area 10 - Alt 1

21

Example Results

Tier 1
Weighted Score
>3.5

Tier 2
Weighted Score
>2.5 to 3.5

Tier 3
Weighted Score
2.5 and below

Rank	All Criteria	2.45% Cutoff
1	Shelby Park A - Area 2 - Alt 1	Shelby Park A - Area 2 - Alt 1
2	Shelby Park A - Area 3 - Alt - 1	Shelby Park A - Area 3 - Alt - 1
3	East Nashville - Area 9 - Alt 1	East Nashville - Area 9 - Alt 1
4	East Nashville - Area 14 - Alt 1	East Nashville - Area 14 - Alt 1
5	East Nashville - Area 6 - Alt 1*	East Nashville - Area 6 - Alt 1
6	Shelby Park A - Area 1 - Alt 1	East Nashville - Area 1 - Alt 1
7	East Nashville - Area 1 - Alt 1*	Shelby Park A - Area 1 - Alt 1
8	East Nashville - Area 8 - Alt 1	East Nashville - Area 8 - Alt 1
9	Shelby Park A - Area 4 - Alt 1	East Nashville - Area 2 - Alt 1
10	East Nashville - Area 5 - Alt 1	East Nashville - Area 5 - Alt 1
11	East Nashville - Area 2 - Alt 1	Shelby Park A - Area 4 - Alt 1
12	East Nashville - Area 4 - Alt 1*	East Nashville - Area 4 - Alt 1
13	East Nashville - Area 3 - Alt - 1	East Nashville - Area 3 - Alt - 1
14	East Nashville - Area 12 - Alt 1	East Nashville - Area 12 - Alt 1
15	East Nashville - Area 13 - Alt 1	East Nashville - Area 13 - Alt 1
16	East Nashville - Area 7 - Alt 1	East Nashville - Area 7 - Alt 1
17	East Nashville - Area 15 - Alt 1	East Nashville - Area 15 - Alt 1
18	East Nashville - Area 11 - Alt 1	East Nashville - Area 11 - Alt 1
19	East Nashville - Area 10 - Alt 1	East Nashville - Area 10 - Alt 1

22

Shelby Park A – Area 2

Shelby Park A - Area 2
Alternative #1

Upsize 735 linear feet (LF) of reinforced concrete pipe (RCP) around Nissan Stadium from Shelby Ave (B290083) to Stadium Lot D (B290050). Pipe capacities sized assuming completion of Area 1 improvements.

Details:
- 140 LF 24" RCP
- 30 LF 30" RCP
- 565 LF 42" RCP
- 7 Structures

Benefits:
- Flood Mitigation
- Improved Safety
  - Road Flooding
  - Parking Lot Flooding
- Highly Visible Issue
- Improved Resiliency
  - Reduced Velocities

Planning-level Opinion of Probable Project Cost:

$800,000

Potential Easements: (Council District 6)

0 (Existing R.O.W. / Metro)

BARGE DESIGN SOLUTIONS

23

Shelby Park A – Area 3

Shelby Park A - Area 3
Alternative #1

Upsize 2,915 linear feet (LF) of reinforced concrete pipe (RCP) around the industrial area east of Korean Veterans Blvd from Sylvan St (B290199) and Crutcher St (B290152) to the Cumberland River Outfall.

Details:
- 515 LF 24" RCP
- 1,070 LF 30" RCP
- 340 LF 36" RCP
- 145 LF 42" RCP
- 845 LF 54" RCP
- 17 Structures

Benefits:
- Flood Mitigation
- Improved Safety
  - Road Flooding
- Improved Resiliency
  - Property Flooding
  - Reduced Velocities

Planning-level Opinion of Probable Project Cost:

$3,400,000

Potential Easements: (Council District 6)

1

BARGE DESIGN SOLUTIONS

24

East Nashville – Area 9

East Nashville - Area 9
Alternative #1

Upsize 159 linear feet (LF) of reinforced concrete pipe (RCP). Install 4,309 LF of new RCP.

Details:
- 427 LF 18" RCP
- 1,922 LF 24" RCP
- 910 LF 30" RCP
- 1,309 LF 36" RCP
- 21 Structures

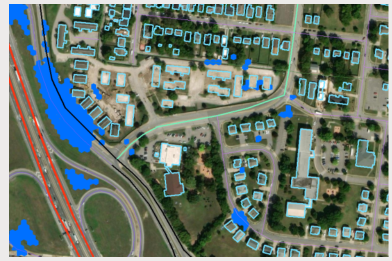
Benefits:
- Flood Mitigation
- Improved Safety
  - Road Flooding
- Highly Visible Issue

Planning-level Opinion of Probable Project Cost:

$2,930,000

Potential Easements: (Council District 5)

4 affected parcels



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Q&A

Questions?

26

Thank you.

METRO WATER SERVICES

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Metro Water Services Stormwater Master Plan

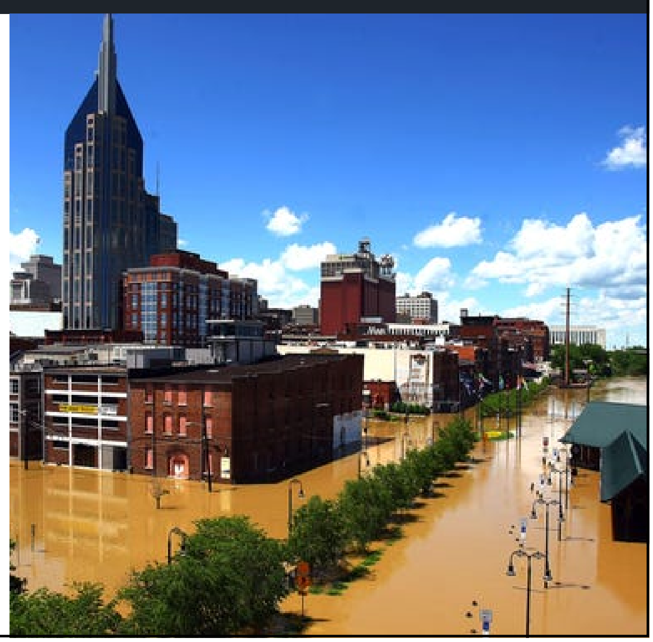
BARGE DESIGN SOLUTIONS

METRO WATER SERVICES

1

Project Objective

The overall objective of the Stormwater Masterplan is to study existing infrastructure and develop alternatives to reduce or abate flooding throughout the Metro service area.



2

Project Overview

Combined Sewer System Modeling Coordination

Watershed Project Approach

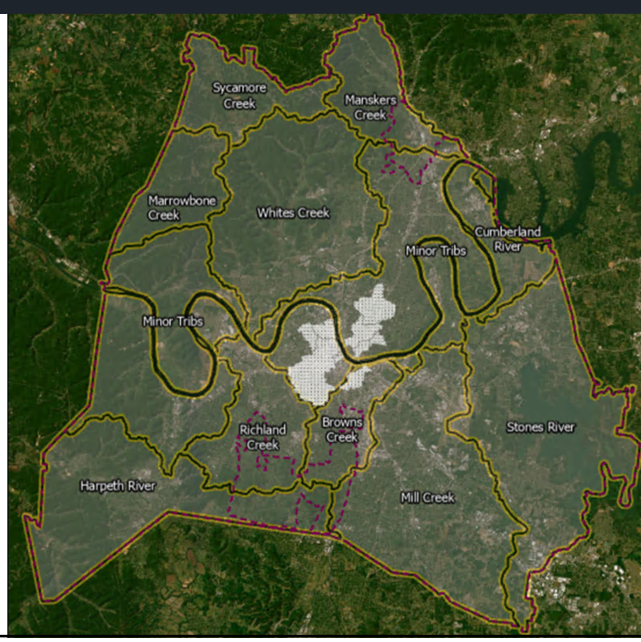
10 YR / 100 YR Alternatives

Project Support

Future Meeting Discussion Topics

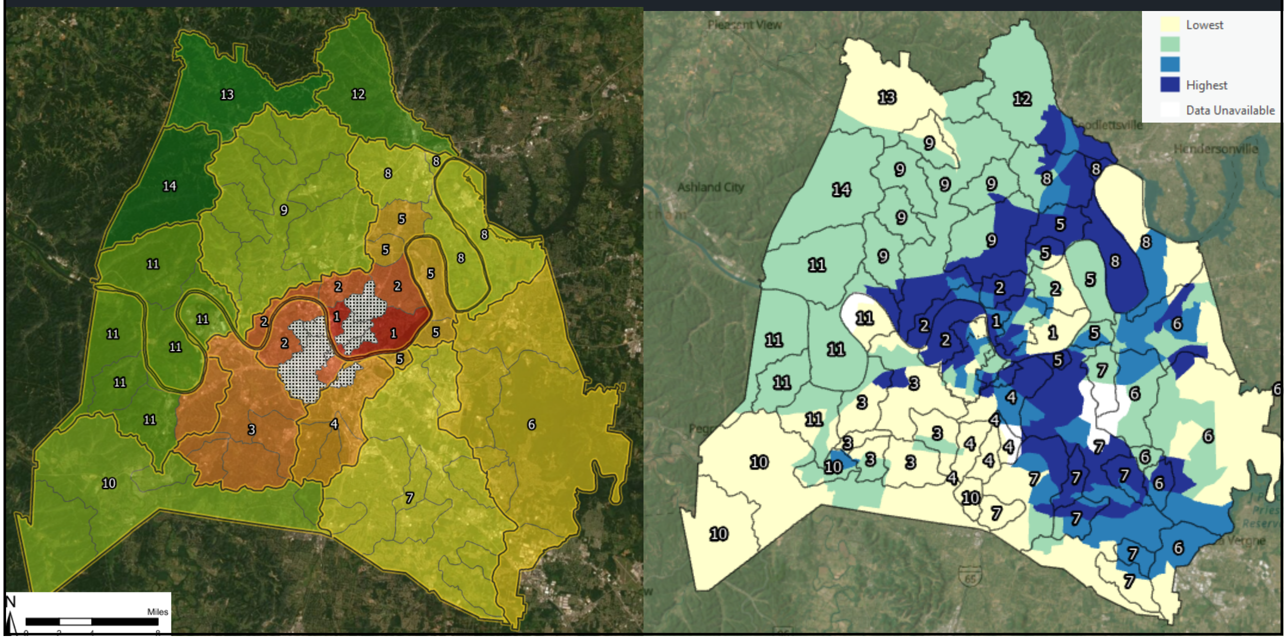
3

USACE Basins



4

Basin Prioritization



5

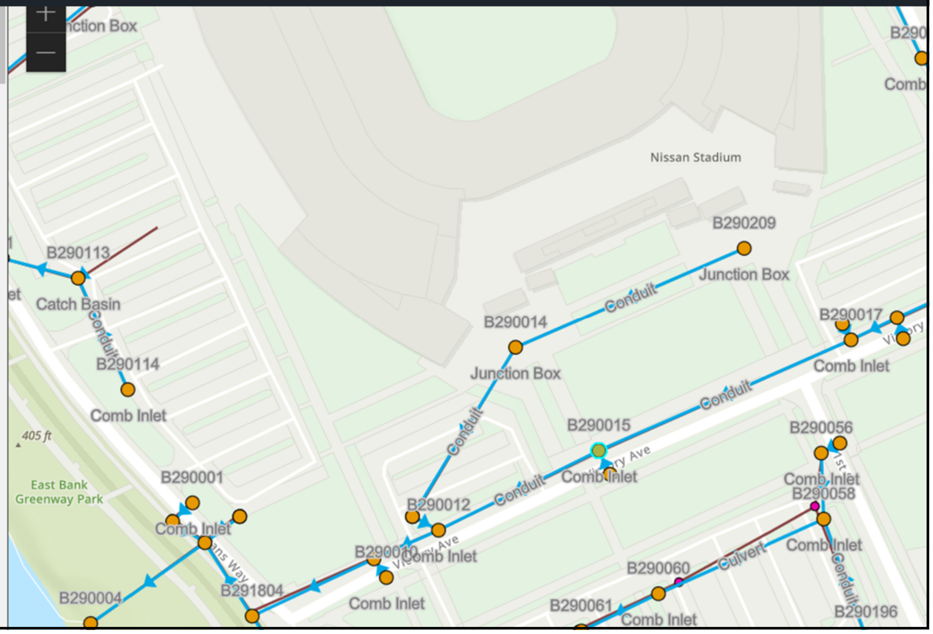
Planning

15” AND GREATER → ~100,000 STRUCTURES

6

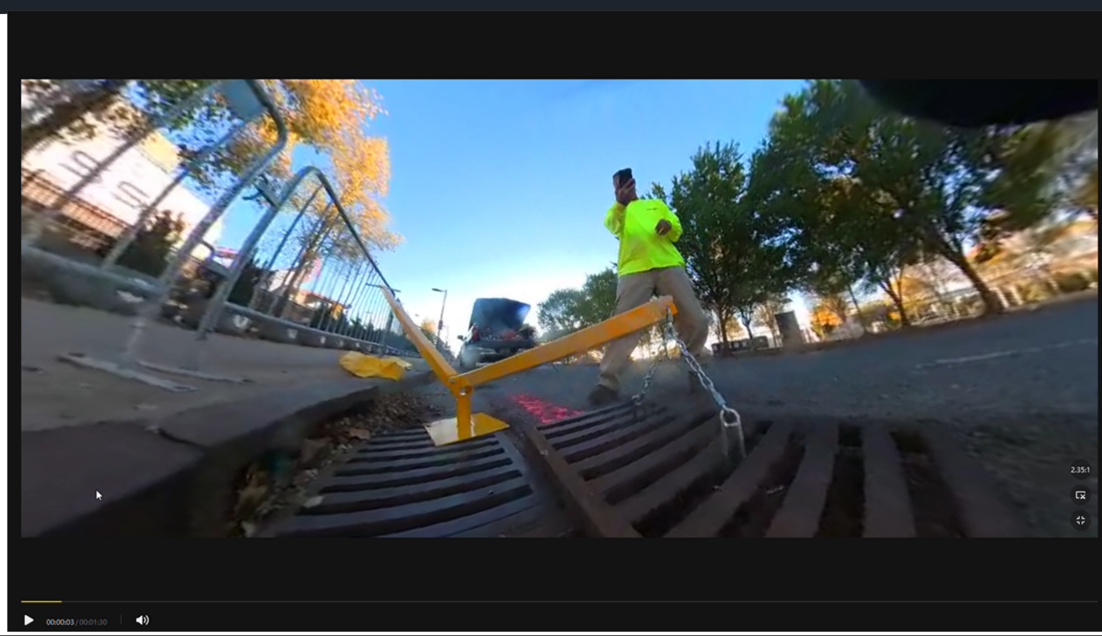
Inventory and Condition Assessment

GlobalID	7dbc308e-794b-4af4-94c1-c95e2b8532b1
Completed By	
Date Collected	9/30/2022, 7:28 AM
Submitted By	Brandy Trotter
Field ID	B290015
Facility ID	
SWGR Project ID	
Mapping Accuracy	Survey-Grade GPS
Point Type	Comb Inlet
Point Material Type	Concrete
Number of Grates	3
Headwall Shape	
Number of Pipes	3
Weir/Orfice 1 Dimension 1	



7

360 DEGREE VIDEO DEMO



8

Immediate Issue Notification

Description
Structural Failure
Safety Issue
Illicit Discharge
Clogged

9

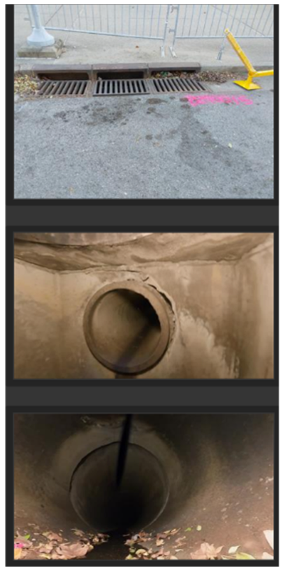
Inventory & Condition Assessment

GRADE	COMMON DEFECTS
Other	Roof drains or underdrains
Incomplete	Pipe unable to be evaluated due to inability to access
0	None
1	Poor grouting in joints, Small cracks
2	Poor grouting in joints, Medium cracks, Joint separation, Infiltration, Cracked coating, Aggregate showing
3	Medium cracks, Joint separation, Infiltration, Damaged coating, Aggregate showing, Roots in pipe, Exposed/rusted reinforcement, Surface rusted, Signs of surcharging, Small holes
4	Joint separation, Infiltration leading to sinkholes, Missing coating, Surface rusted, Settled deposits, Medium holes
5	Collapse

10

Inventory & Condition Assessment

Rim Elevation	416.995
Bottom Elevation	397.595
Notes	
My Source	BargeDesignSolutions
Bike Friendly Grate?	YES
Slot Type	Perpendicular
Grate Level	Flush
Infield Offset	
In Combined Storm Sewer	
Is Outfall?	
Is Outlet?	
Is Inlet?	YES



Length	20.00
Width	32.000
Depth	19.400
Owner	
Condition Assessment	Grade 3 - Fair
Major Issues	None

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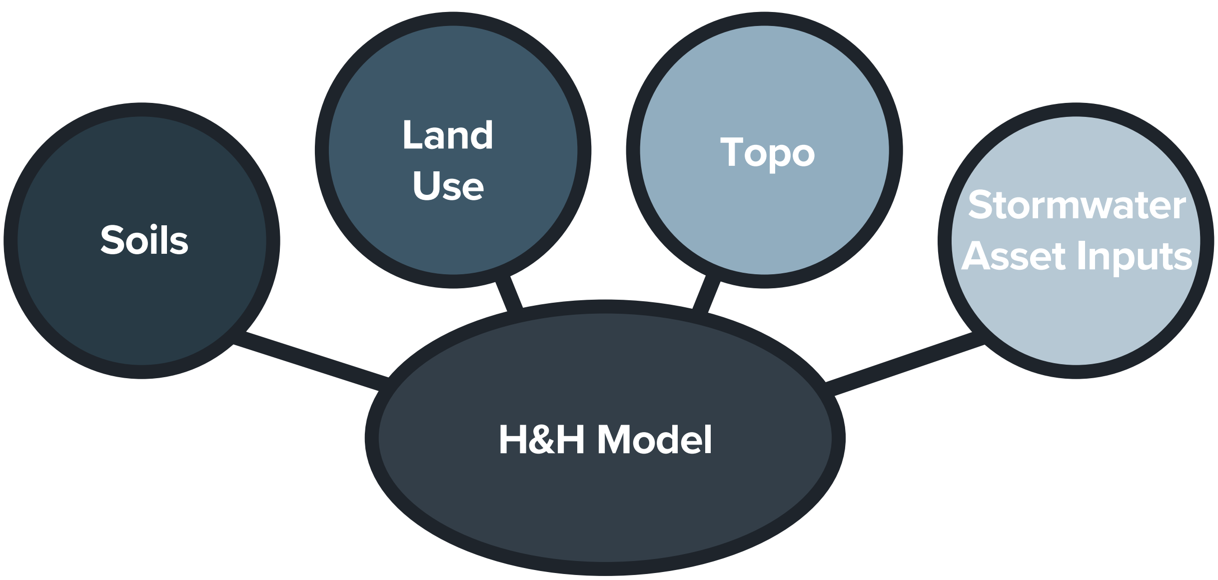
Modeling



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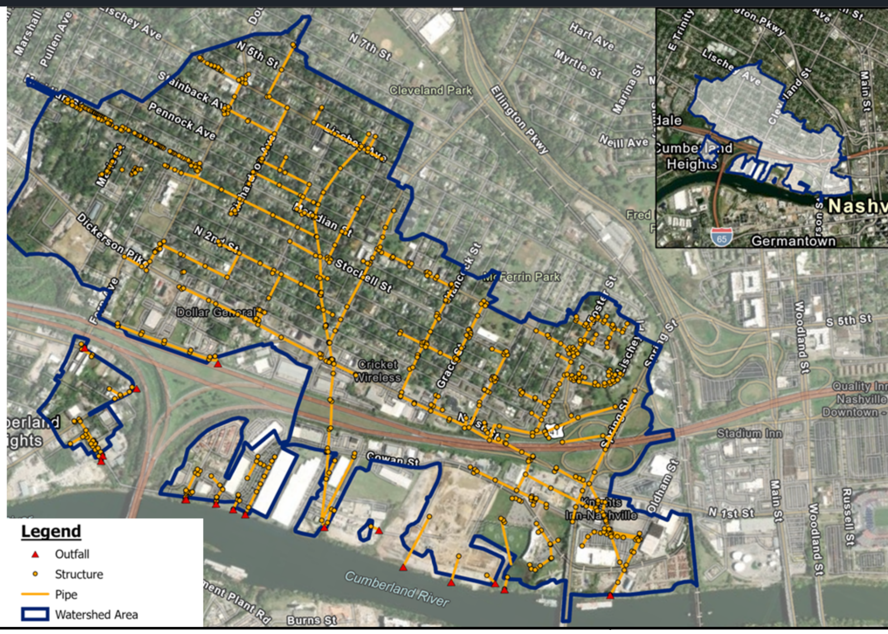
Hydraulic Model Creation



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Analysis

DESIGN STORM EVENT	10-YEAR / 100-YEAR
LEVEL OF SERVICE	WATER ELEVATION BELOW RIM
BUILDING FLOODING	100-YEAR
INUNDATION EXTENT	FLOOD DEPTHS
FUTURE CONDITIONS	NASHVILLE NEXT

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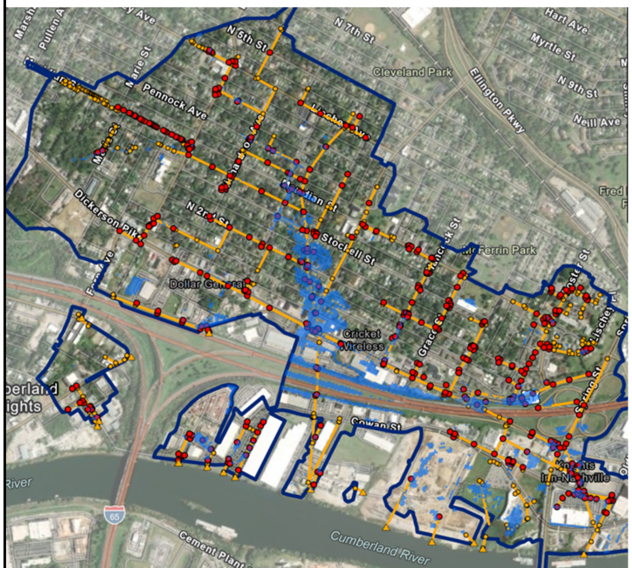
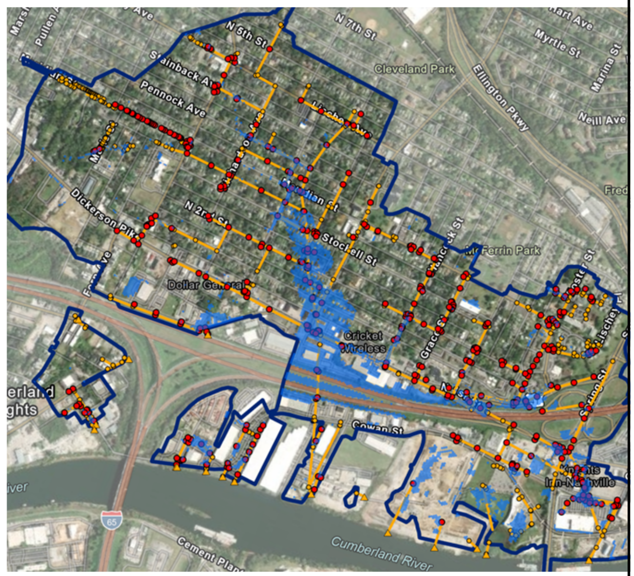
10- YR / 100 YR INNUNDATION Maps





Capital Improvement Plan (CIP)

East Nashville - Area 2
Alternative #1

Upsize 5,075 linear feet (LF) of reinforced concrete pipe (RCP). Install 2,368 LF of new RCP.

Details:
- 559 LF 24" RCP
- 517 LF 30" RCP
- 615 LF 36" RCP
- 1,115 LF 42" RCP
- 2,247 LF 48" RCP
- 416 LF 7x5 RCB
- 1,974 LF 9x6 RCB
- 26 Structures

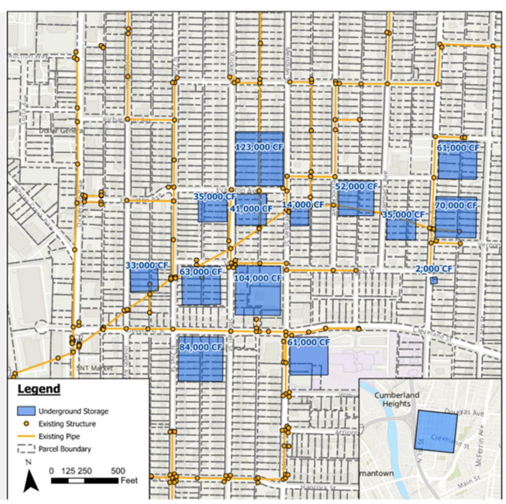
Benefits:
- Flood Mitigation
- Improved Safety
  - Road Flooding
- Highly Visible Issue
- Improved Resiliency
  - Reduced Velocities

Planning-level Opinion of Probable Project Cost:

$22,515,000

Potential Easements: (Council District 5)

5 affected parcels



East Nashville - Area 2
Alternative #2

Provide 778,000 cubic feet (CF) of underground storage around the residential neighborhoods north of Cleveland Street and east of Dickerson Pike.

Details:
- 778,000 CF Storage

Benefits:
- Flood Mitigation
- Improved Safety
  - Road Flooding
  - Residential Lot Flooding
- Highly Visible Issue

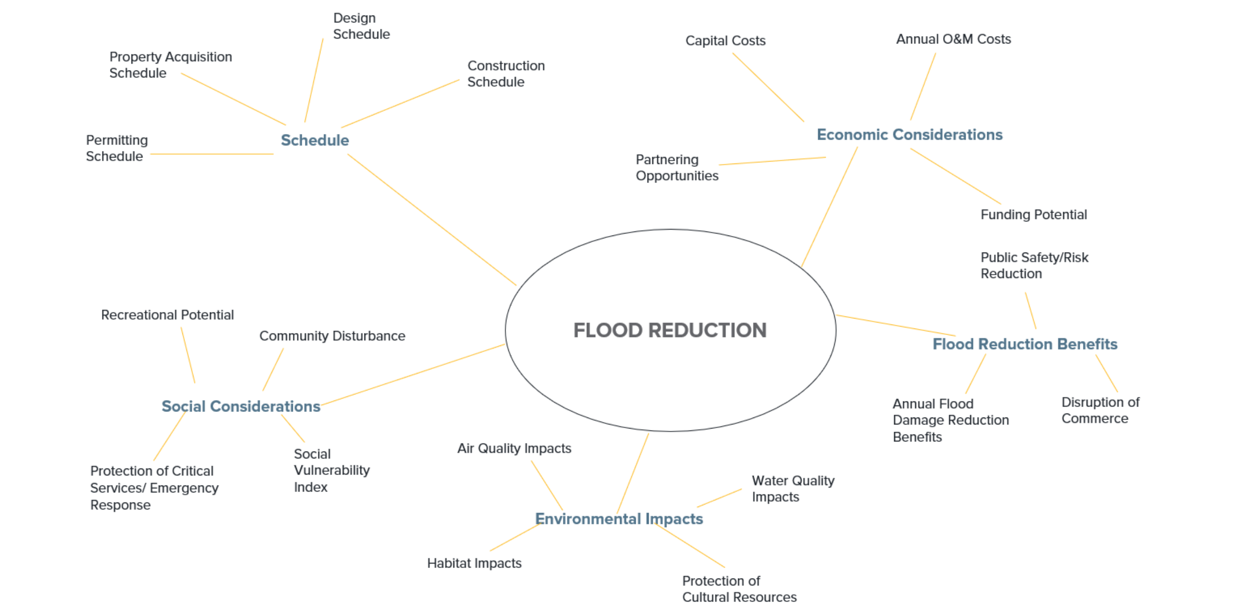
Planning-level Opinion of Probable Project Cost:

$40,720,000

Potential Easements: (Council District 5)

159 affected parcels

Decision Criteria



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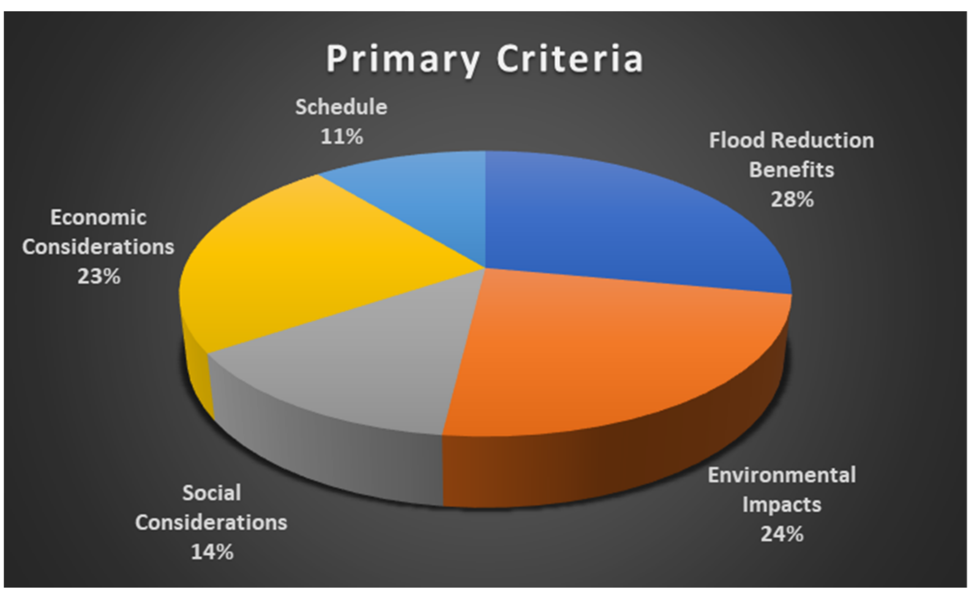
Decision Criteria



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Decision Criteria

Primary Criteria	Primary Percentage	Subcriteria	Subcriteria Percentage	Final Weight
Flood Reduction Benefits	27.87%	Public Safety/Risk Reduction	64.86%	18.08%
Environmental Impacts	23.86%	Water Quality Impacts	45.43%	10.84%
Economic Considerations	23.68%	Partnering Opportunity	40.31%	9.54%
Environmental Impacts	23.86%	Habitat Impacts	28.64%	6.83%
Social Considerations	13.66%	Protection of Critical Services/Emergency Response	47.17%	6.44%
Economic Considerations	23.68%	Capital Cost	22.63%	5.36%
Economic Considerations	23.68%	Funding Potential	22.29%	5.28%
Flood Reduction Benefits	27.87%	Annual Flood Damage Reduction Benefit	17.92%	4.99%
Schedule	10.93%	Property Acquisition Schedule	44.40%	4.85%
Flood Reduction Benefits	27.87%	Disruption of Commerce	17.22%	4.80%
Economic Considerations	23.68%	Annual O&M Costs	14.78%	3.50%
Environmental Impacts	23.86%	Protection of Cultural Resources	13.43%	3.21%
Environmental Impacts	23.86%	Air Quality Impacts	12.50%	2.98%
Schedule	10.93%	Construction Schedule	26.35%	2.88%
Social Considerations	13.66%	Social Vulnerability Index	18.04%	2.46%
Social Considerations	13.66%	Recreational Potential	17.92%	2.45%
Social Considerations	13.66%	Community Disturbance	16.88%	2.31%
Schedule	10.93%	Design Schedule	20.36%	2.22%
Schedule	10.93%	Permitting Schedule	8.89%	0.97%

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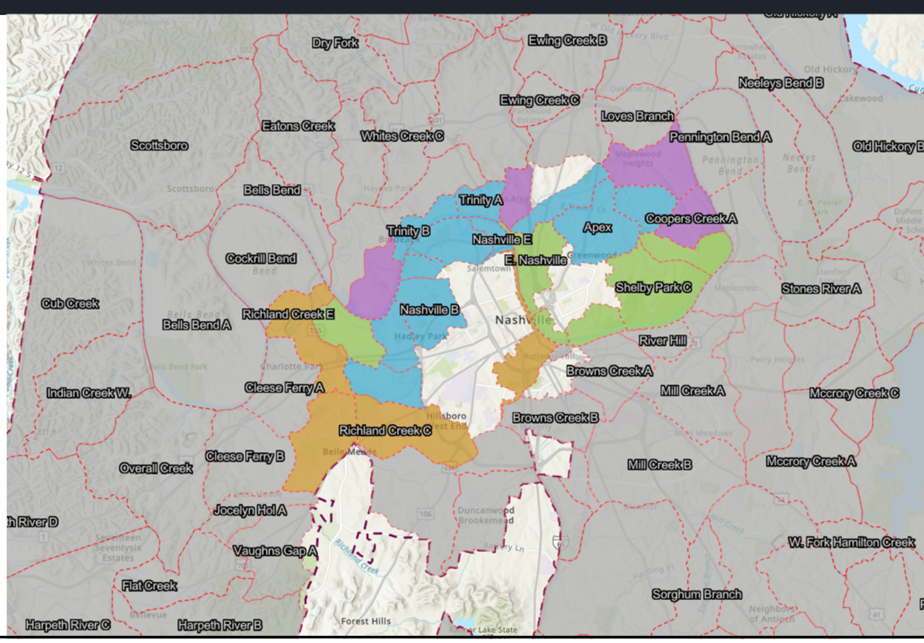
Progress



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Project Overview

Combined Sewer System Modeling Coordination

Watershed Project Approach

10 YR / 100 YR Alternatives

Project Support

Future Meeting Discussion Topics

21

Combined Sewer System Coordination

- Single Rain Gauge at BNA
- Routing Runoff from Impervious Area to Pervious Area
- Type II vs Balanced Hyetograph
- SCS Curve Number vs Modified Green Ampt Infiltration Method

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Project Overview

Combined Sewer System Modeling Coordination

Watershed Project Approach

10 YR / 100 YR Alternatives

Project Support

Future Meeting Discussion Topics

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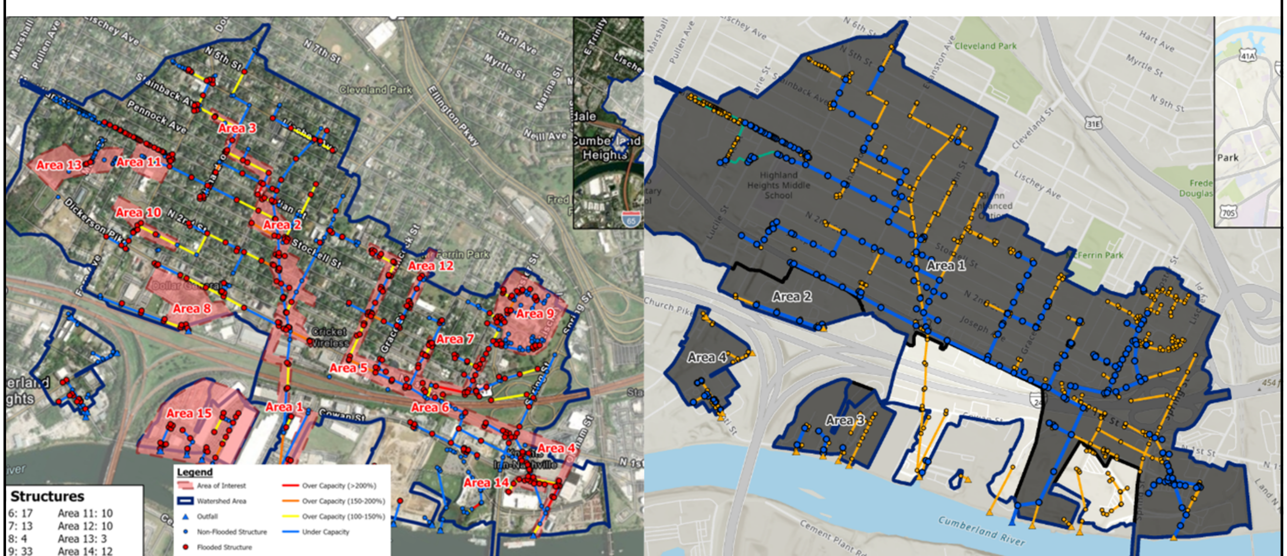
Watershed Project Approach



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- Project Overview
- Combined Sewer System Modeling Coordination
- Watershed Project Approach
- **10 YR / 100 YR Alternatives**
- Project Support
- Future Meeting Discussion Topics

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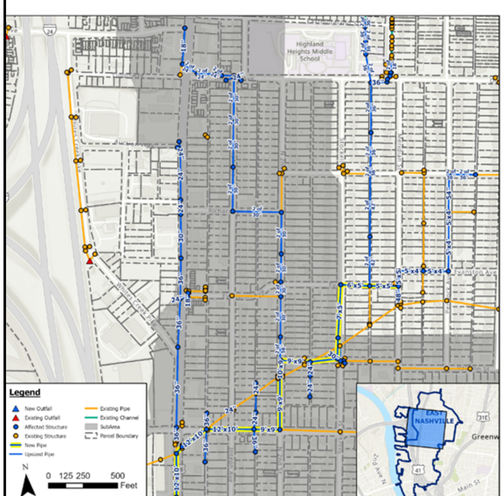
10 YR / 100 YR Project Sheets



East Nashville - Area 1.C
Alternative #1 - 10 yr

Upsize 8,390 linear feet (LF) of reinforced concrete pipe (RCP). Install 2,660 LF of new RCBC (Box culvert). Area 1.C improvements to be constructed after Area 1.A and Area 1.B are completed.

Details:
- 320 LF 18" RCP
- 1,810 LF 24" RCP
- 4,120 LF 30" RCP
- 2,140 LF 36" RCP
- 740 LF 7'x5' RCBC
- 790 LF 9'x9' RCBC
- 120 LF 10'x9' RCBC
- 1,010 LF 12'x10' RCBC
- 55 Structures

Benefits:
- Flood Mitigation
- Improved Safety
  - Road Flooding
  - Residential Lot Flooding
- Highly Visible Issue
  - 3 Service Requests

Planning-level Opinion of Probable Project Cost: $27,600,000

Potential Easements (Council District 5): 2

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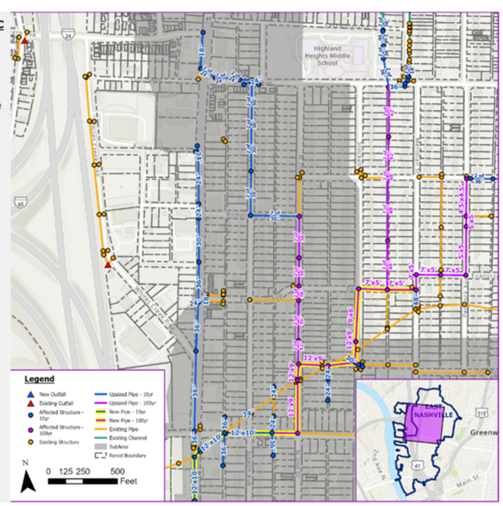

East Nashville - Area 1.C
Alternative #1 - 100 yr

Upsize 9,580 linear feet (LF) of reinforced concrete pipe (RCP). Install 2,660 LF of new RCBC (Box culvert). Area 1.C improvements to be constructed after Area 1.A and Area 1.B are completed.

Details:
- 320 LF 18" RCP
- 1,810 LF 24" RCP
- 3,220 LF 30" RCP
- 3,650 LF 36" RCP
- 580 LF 42" RCP
- 390 LF 9'x6' RCBC
- 1,070 LF 12'x9' RCBC
- 1,200 LF 12'x10' RCBC
- 55 Structures

Benefits:
- Flood Mitigation
- Improved Safety
  - Road Flooding
  - Residential Lot Flooding
- Highly Visible Issue
  - 3 Service Requests

Planning-level Opinion of Probable Project Cost: $30,100,000

Potential Easements (Council District 5): 2

BARGE DESIGN SOLUTIONS

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- Project Overview
- Combined Sewer System Modeling Coordination
- Watershed Project Approach
- 10 YR / 100 YR Alternatives
- **Project Support**
- Future Meeting Discussion Topics

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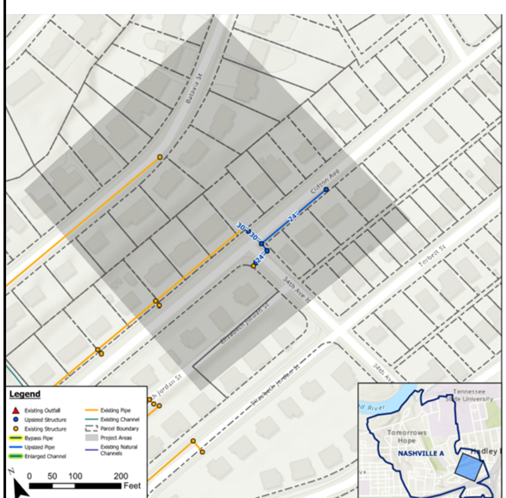
MWS Stormwater CIP Support



Nashville A - Area 3.B
Alternative #1 - 10 yr

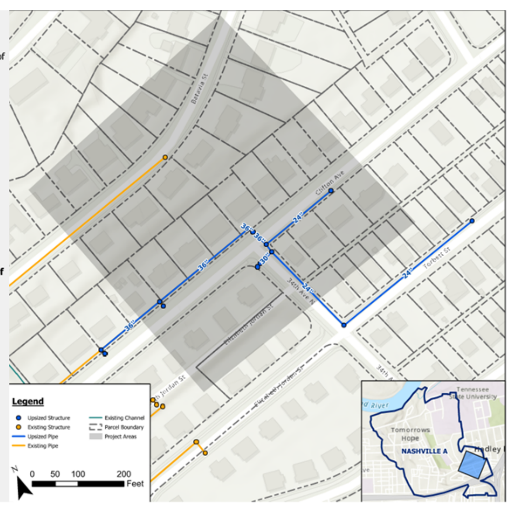
Upsize 300 linear feet (LF) of reinforced concrete pipe (RCP) and RC Box Culvert (RCBC).

Details:
- 220 LF 24" RCP
- 80 LF 30" RCP
- 6 Structures

Benefits:
- Flood Mitigation
- Improved Safety
  - Road Flooding
- Highly Visible Issue
- Improved Resiliency
  - Reduced Velocities

Planning-level Opinion of Probable Project Cost: $X

Potential Easements (Council District 21): X



Nashville A - Area 3.B
Alternative #2 - 10 yr

Upsize 710 linear feet (LF) of reinforced concrete pipe (RCP) and RC Box Culvert (RCBC) and install 590 LF of new RCP.

Details:
- 770 LF 24" RCP
- 40 LF 30" RCP
- 490 LF 36" RCP
- 10 Structures (2 New)

Benefits:
- Flood Mitigation
- Improved Safety
  - Road Flooding
- Highly Visible Issue
- Improved Resiliency
  - Reduced Velocities

Planning-level Opinion of Probable Project Cost: $X

Potential Easements (Council District 21): X

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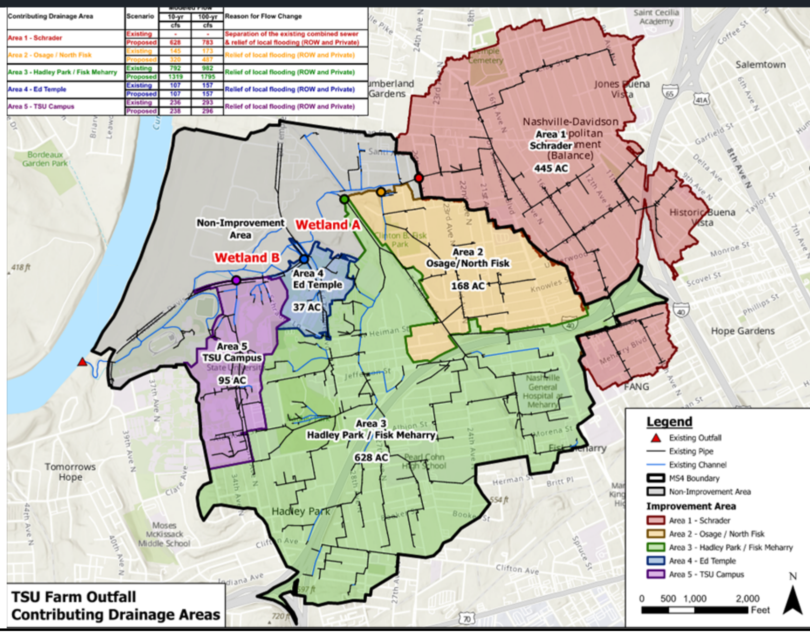
Sewer Separation



Contributing Drainage Area	Scenario	Modeled Flow 10-yr cfs	Modeled Flow 100-yr cfs	Reason for Flow Change
Area 1 - Schrader	Existing	-	-	Separation of the existing combined sewer & relief of local flooding (ROW and Private)
	Proposed	628	783	
Area 2 - Osage / North Fisk	Existing	145	173	Relief of local flooding (ROW and Private)
	Proposed	320	487	
Area 3 - Hadley Park / Fisk Meharry	Existing	792	982	Relief of local flooding (ROW and Private)
	Proposed	1319	1795	
Area 4 - Ed Temple	Existing	107	157	Relief of local flooding (ROW and Private)
	Proposed	107	157	
Area 5 - TSU Campus	Existing	236	293	Relief of local flooding (ROW and Private)
	Proposed	238	296	

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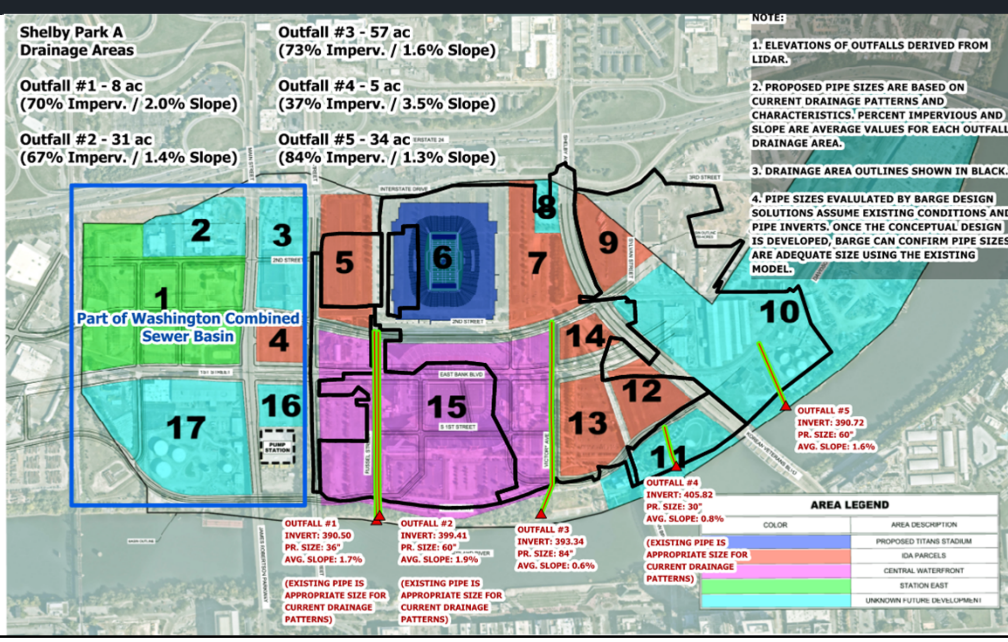
East Bank



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Project Overview

Combined Sewer System Modeling Coordination

Watershed Project Approach

10 YR / 100 YR Alternatives

Project Support

Future Meeting Discussion Topics

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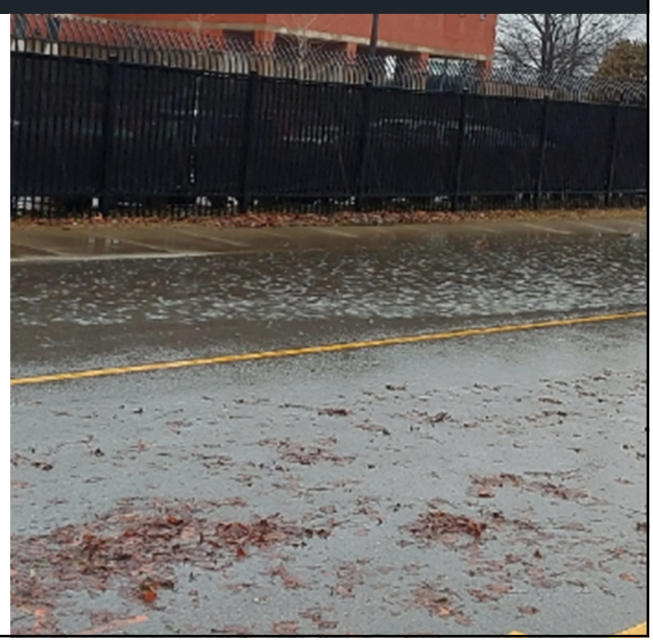
Future Meeting

Capital Improvement Project Results

Climate Analysis Results



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Metro Water Services Stormwater Master Plan

BARGE DESIGN SOLUTIONS

METRO WATER SERVICES

1

Project Objective

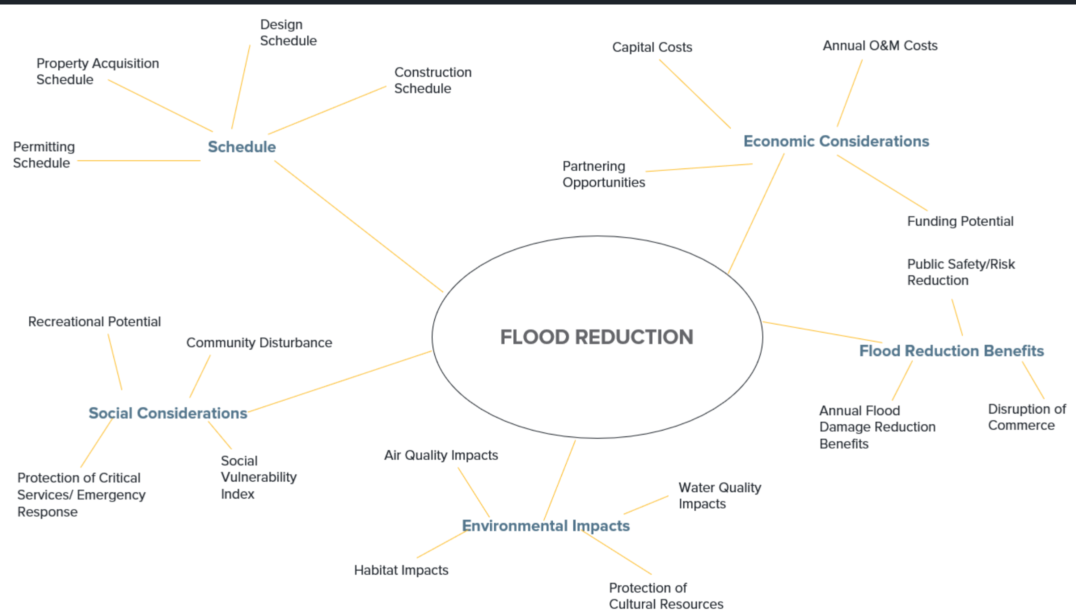
The overall objective of the Stormwater Masterplan is to study existing infrastructure and develop alternatives to reduce or abate flooding throughout the Metro service area.

2

- Criteria Overview
- Overview of Identified Projects
- Results of Ranking
- Early Action Projects
- Future Meeting Discussion Topics

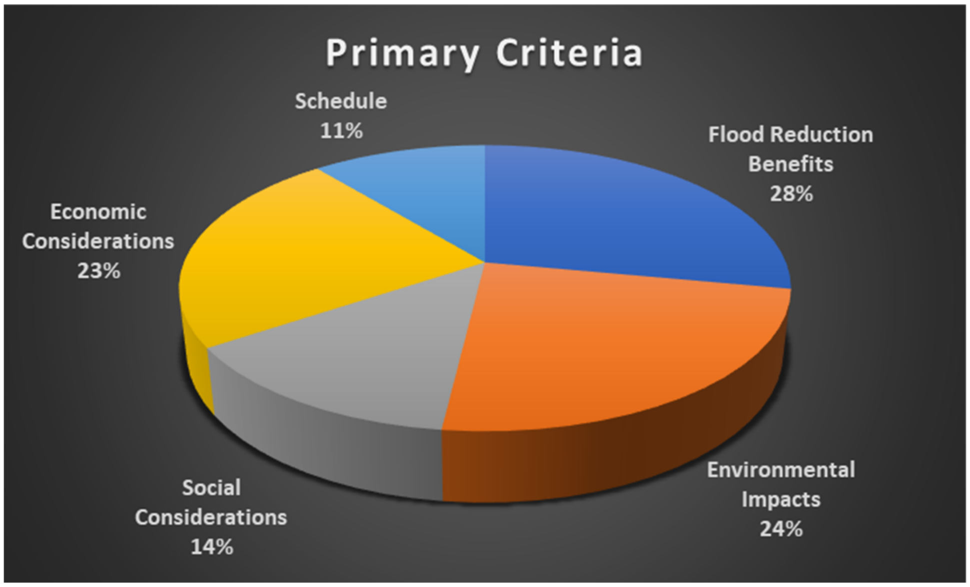
3

Decision Criteria



4

Decision Criteria



5

Decision Criteria

Primary Criteria	Primary Percentage	Subcriteria	Subcriteria Percentage	Final Weight
Flood Reduction Benefits	27.87%	Public Safety/Risk Reduction	64.86%	18.08%
Environmental Impacts	23.86%	Water Quality Impacts	45.43%	10.84%
Economic Considerations	23.68%	Partnering Opportunity	40.31%	9.54%
Environmental Impacts	23.86%	Habitat Impacts	28.64%	6.83%
Social Considerations	13.66%	Protection of Critical Services/Emergency Response	47.17%	6.44%
Economic Considerations	23.68%	Capital Cost	22.63%	5.36%
Economic Considerations	23.68%	Funding Potential	22.29%	5.28%
Flood Reduction Benefits	27.87%	Annual Flood Damage Reduction Benefit	17.92%	4.99%
Schedule	10.93%	Property Acquisition Schedule	44.40%	4.85%
Flood Reduction Benefits	27.87%	Disruption of Commerce	17.22%	4.80%
Economic Considerations	23.68%	Annual O&M Costs	14.78%	3.50%
Environmental Impacts	23.86%	Protection of Cultural Resources	13.43%	3.21%
Environmental Impacts	23.86%	Air Quality Impacts	12.50%	2.98%
Schedule	10.93%	Construction Schedule	26.35%	2.88%
Social Considerations	13.66%	Social Vulnerability Index	18.04%	2.46%
Social Considerations	13.66%	Recreational Potential	17.92%	2.45%
Social Considerations	13.66%	Community Disturbance	16.88%	2.31%
Schedule	10.93%	Design Schedule	20.36%	2.22%
Schedule	10.93%	Permitting Schedule	8.89%	0.97%

6

Criteria Overview

Overview of Identified Projects

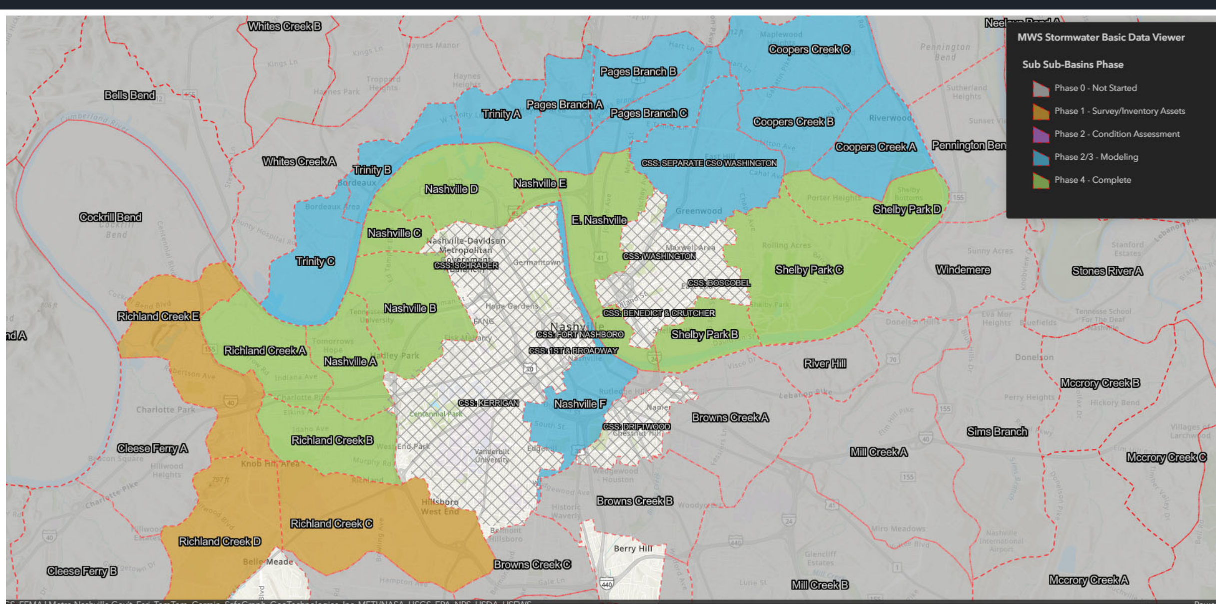
Results of Ranking

Early Action Projects

Future Meeting Discussion Topics

7

Projects Overview



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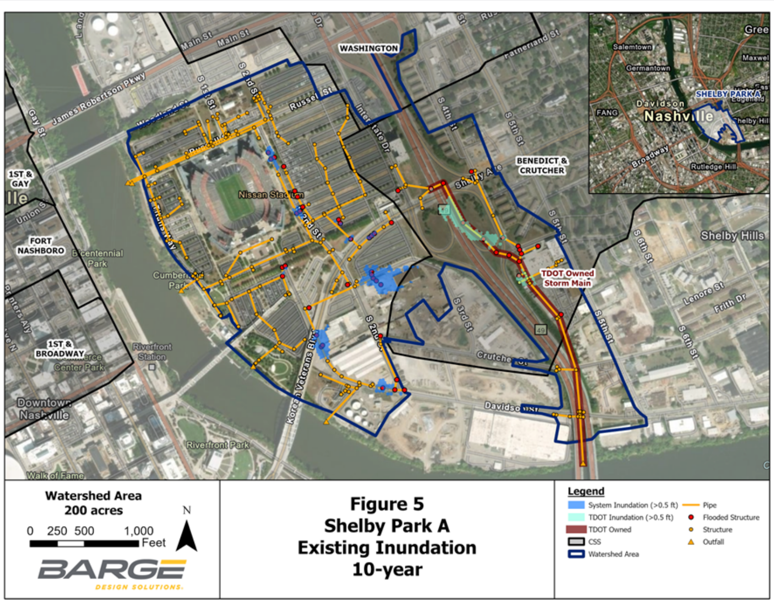
Projects Overview

12 MODELED SUB-BASINS	70 PROBLEM AREAS
RANGE OF ESTIMATED COSTS	$50K TO $104M
TOTAL COST	$683M

9

Projects Overview



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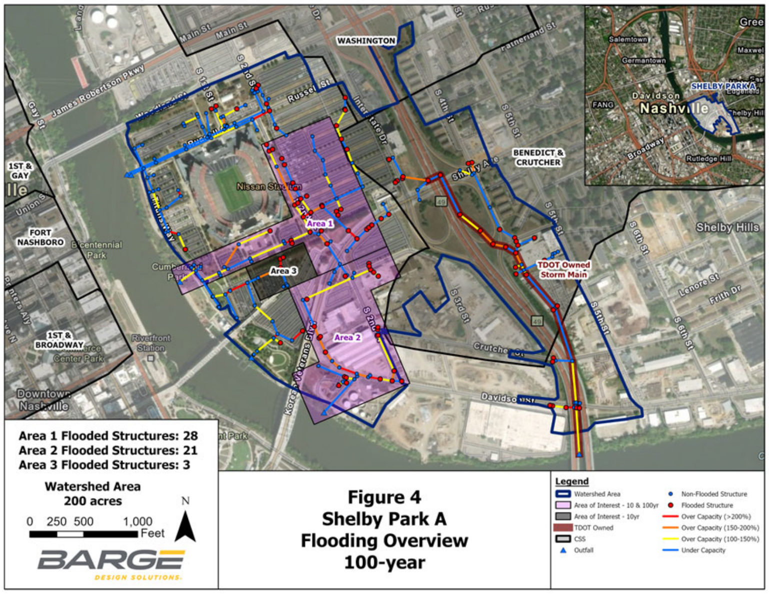
Projects Overview



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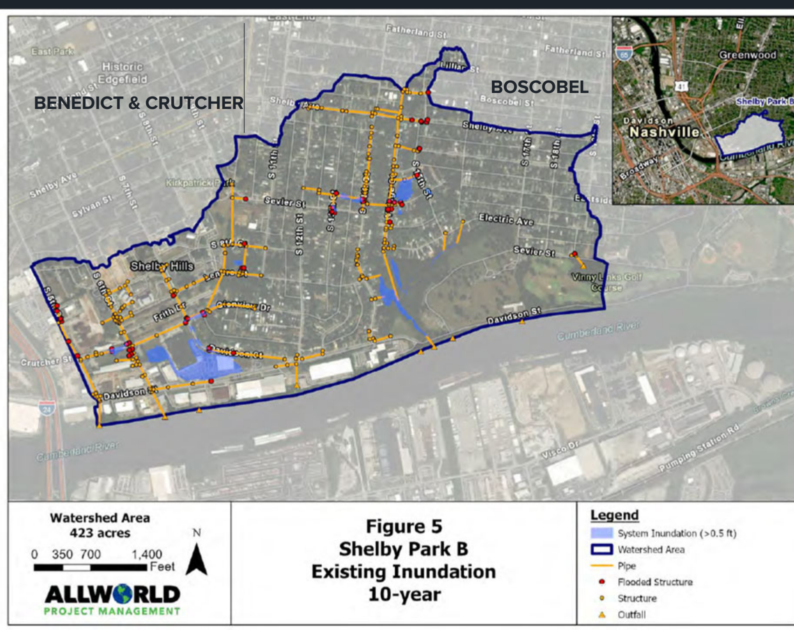
Projects Overview



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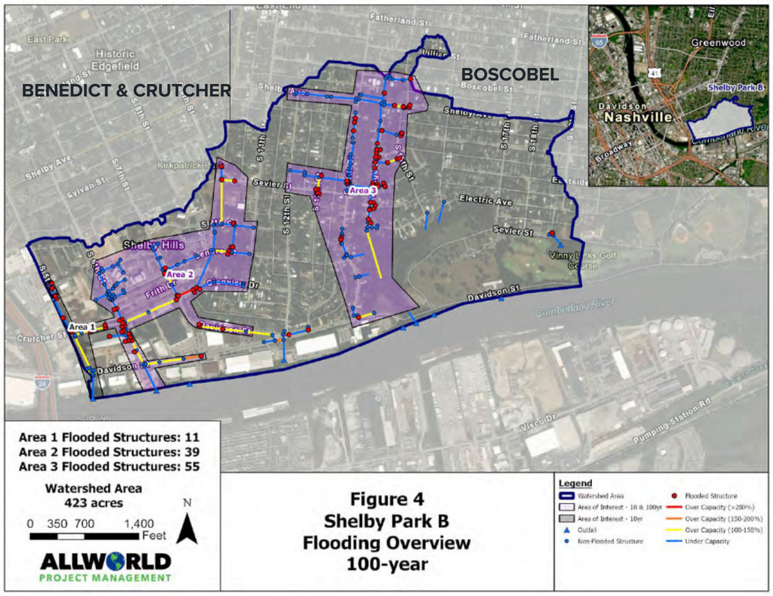
Projects Overview



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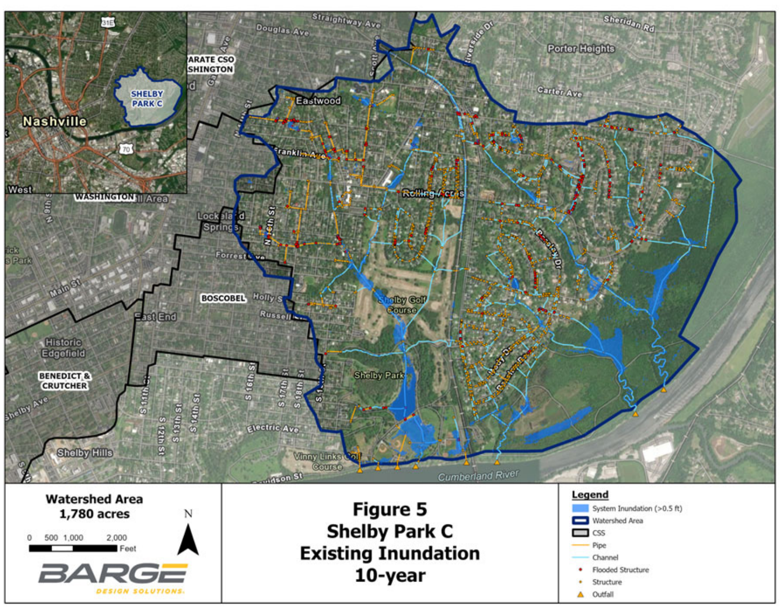
Projects Overview



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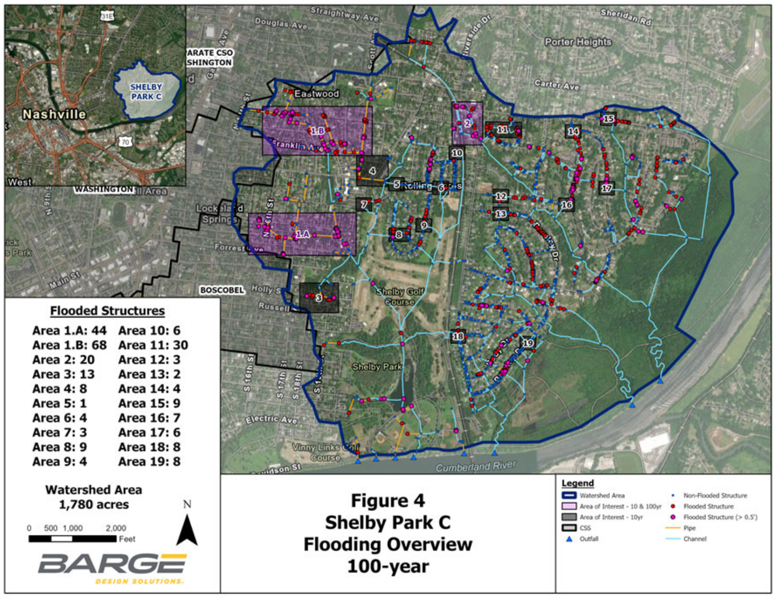
Projects Overview



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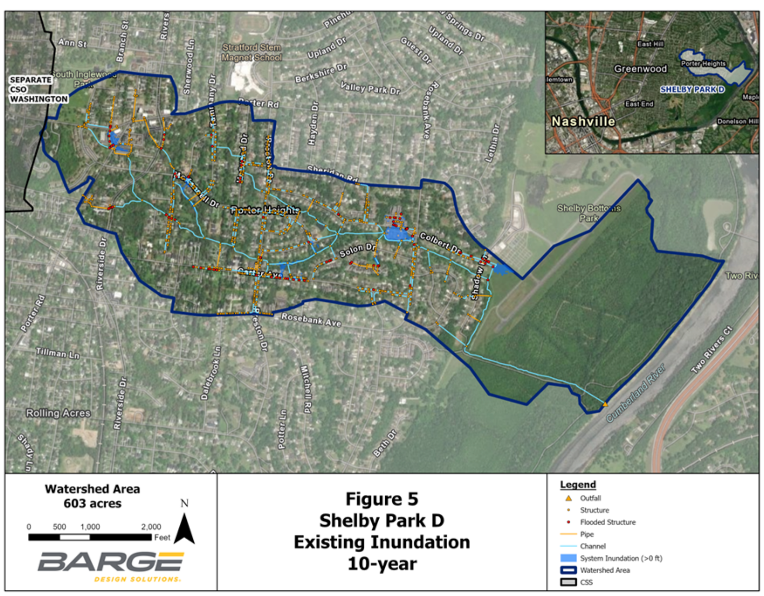
Projects Overview



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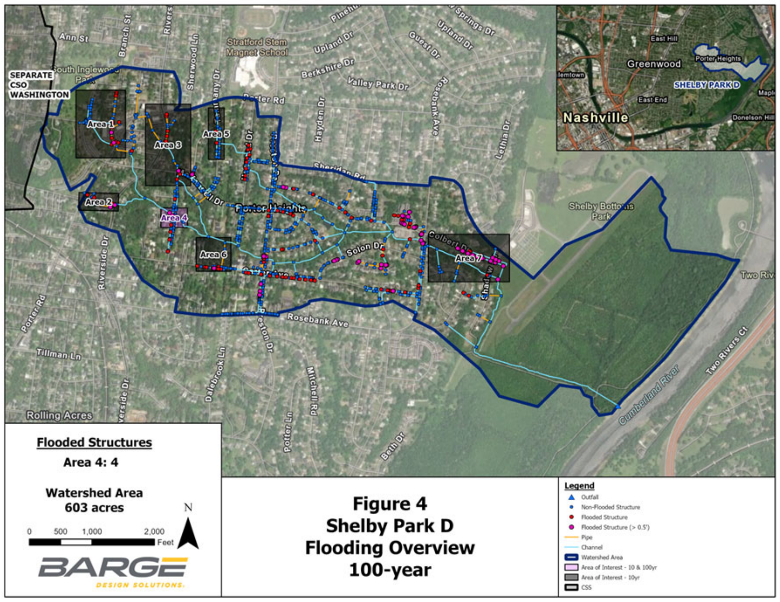
Projects Overview



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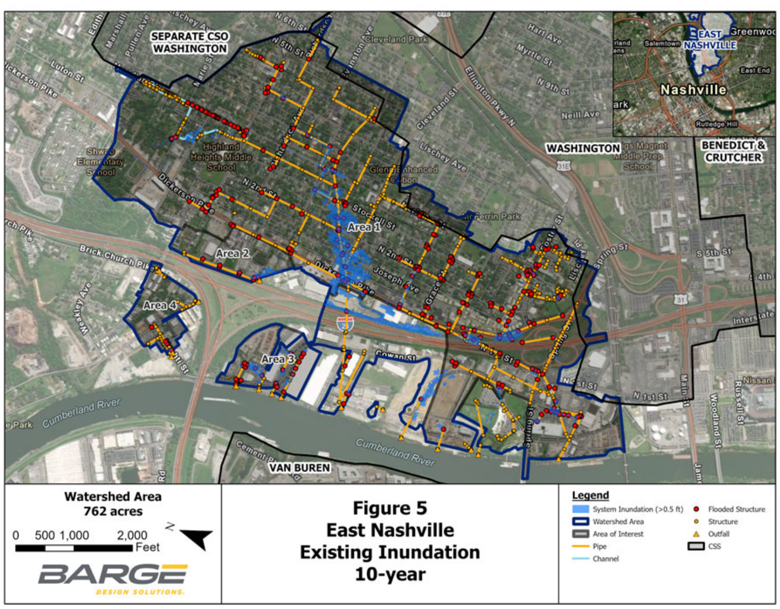
Projects Overview



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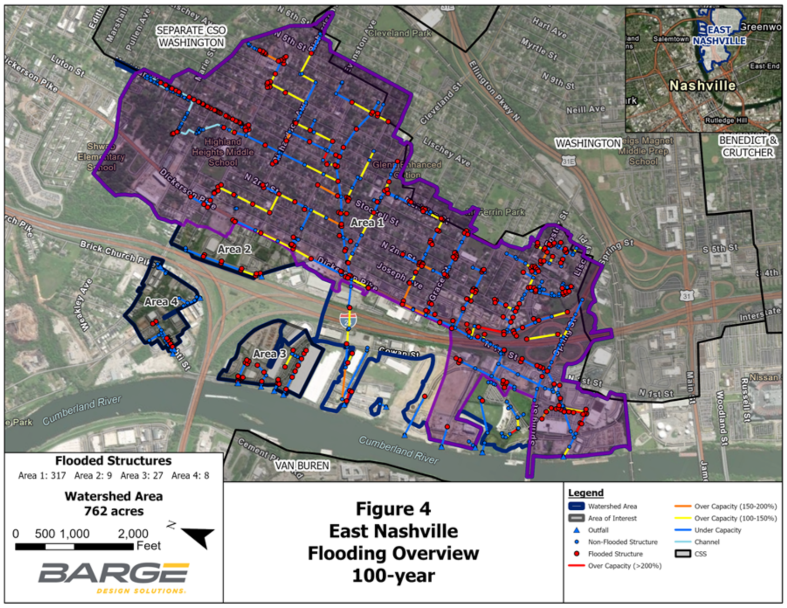
Projects Overview



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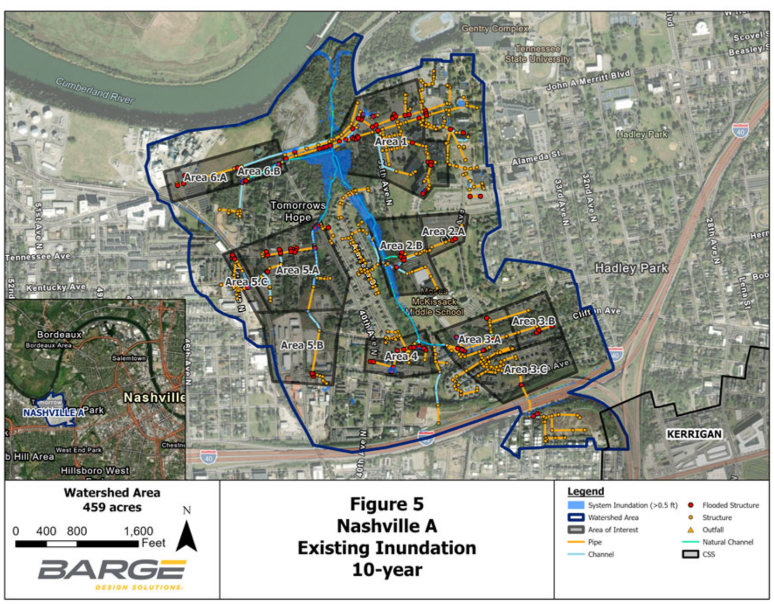
Projects Overview



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Projects Overview

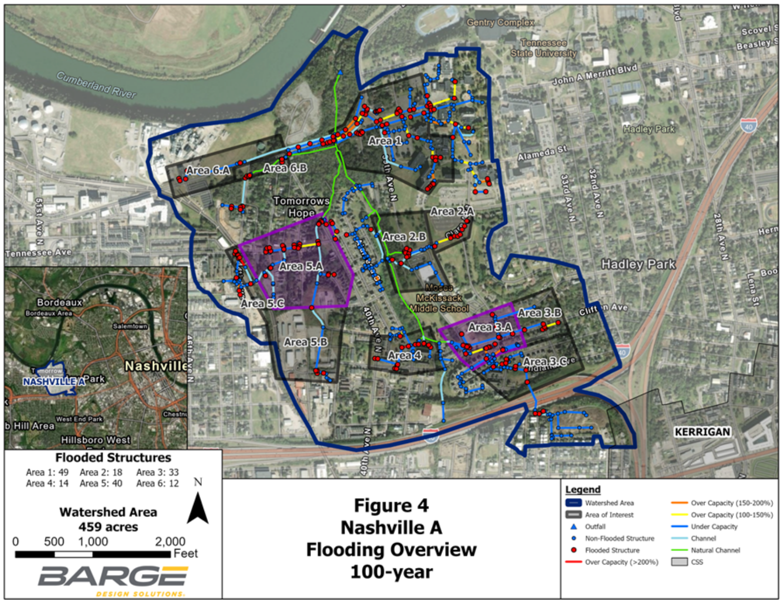


Figure 4
Nashville A
Flooding Overview
100-year

21

Projects Overview

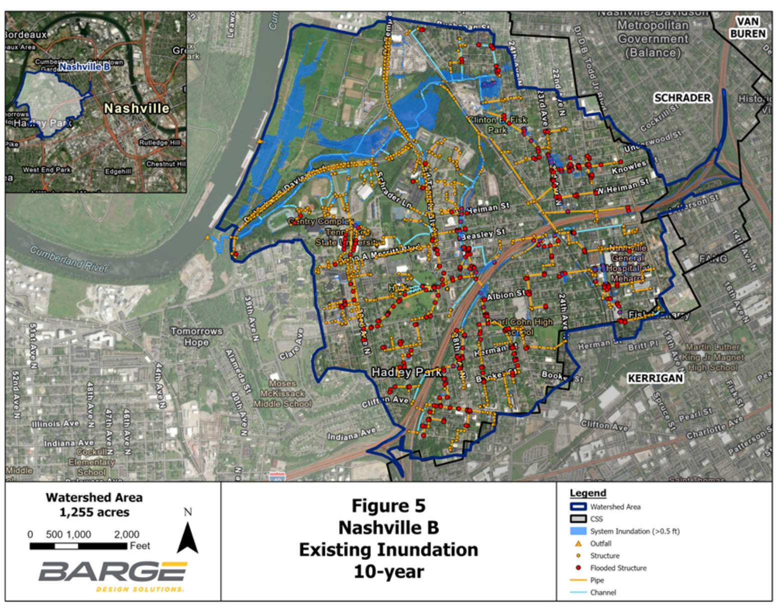
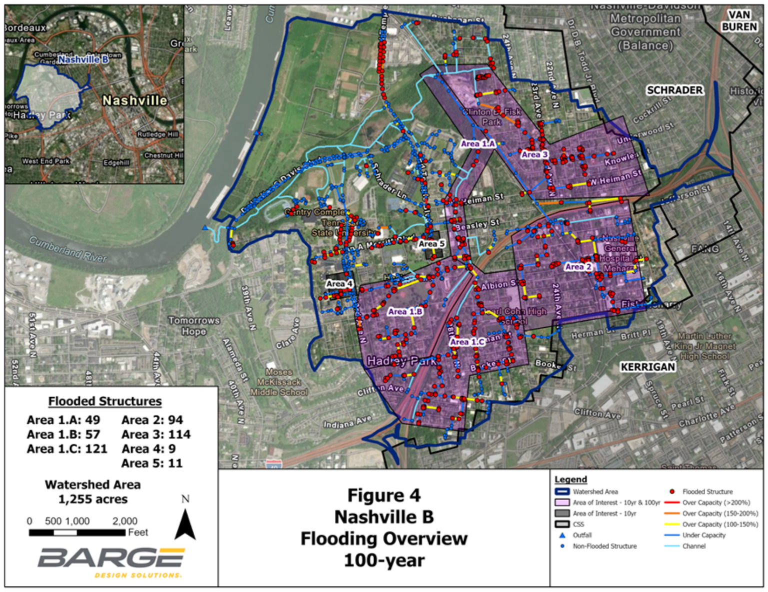


Figure 5
Nashville B
Existing Inundation
10-year

22

Projects Overview



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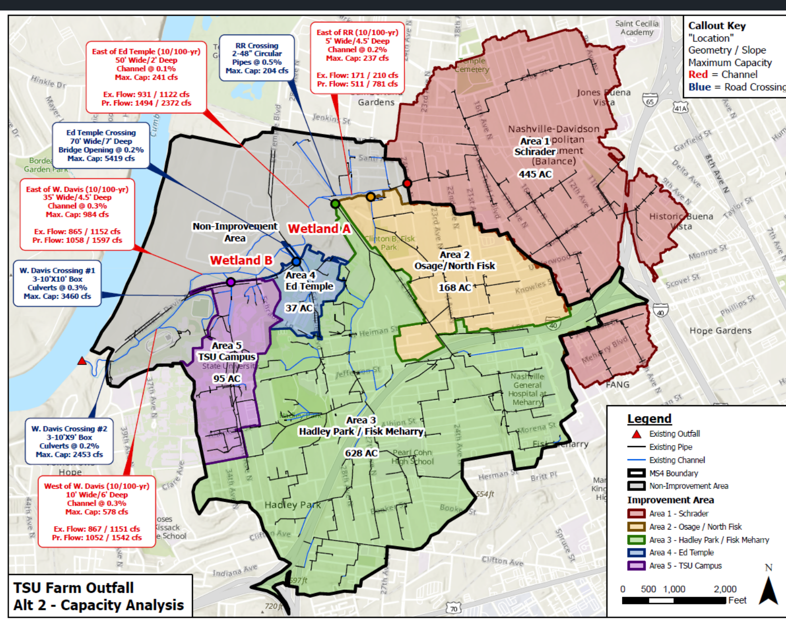
Projects Overview



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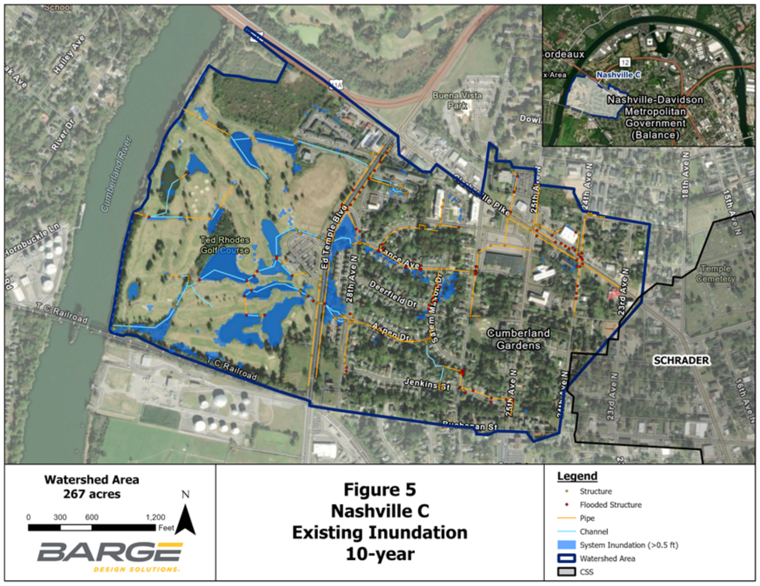
Projects Overview



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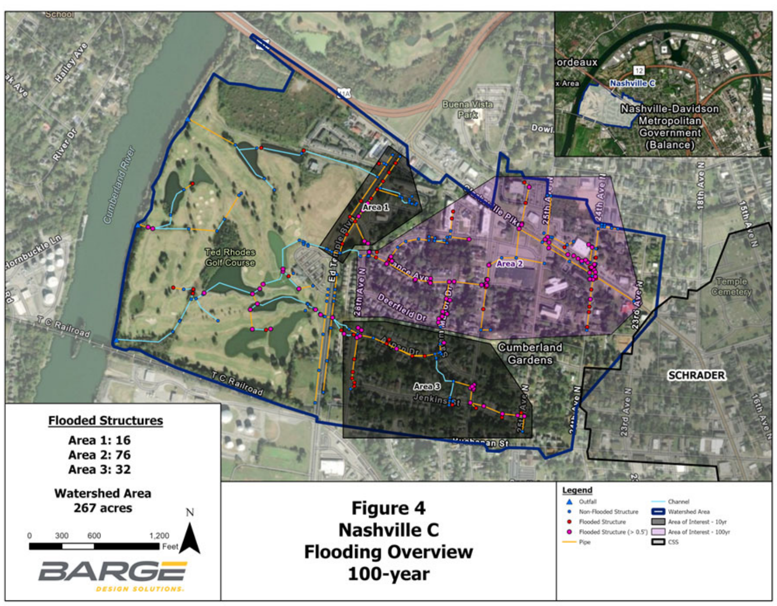
Projects Overview



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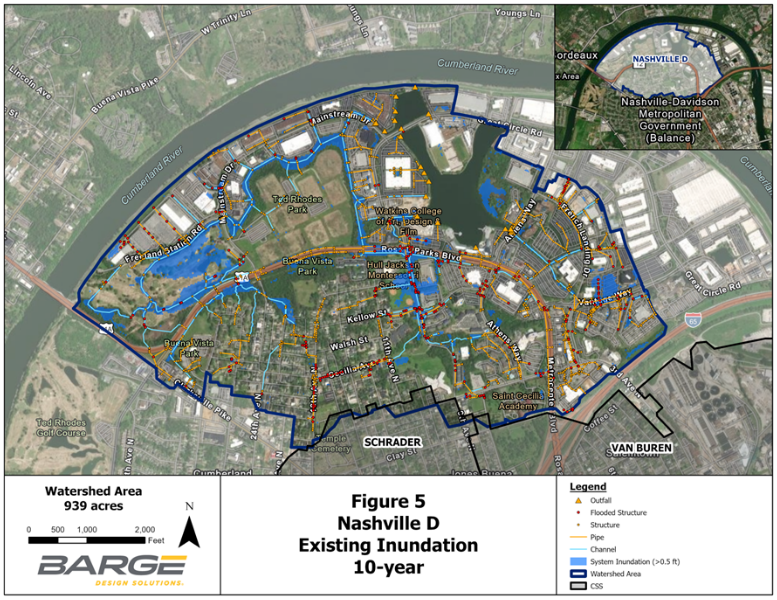
Projects Overview



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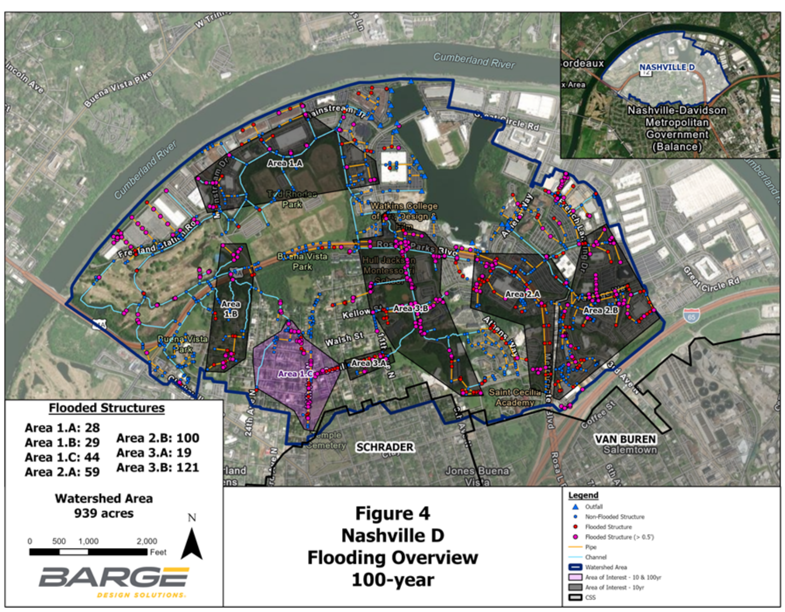
Projects Overview



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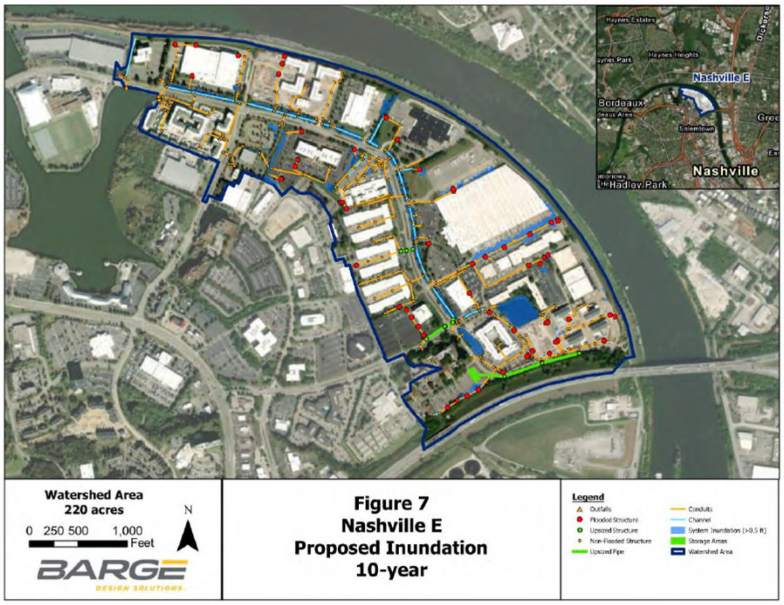
Projects Overview



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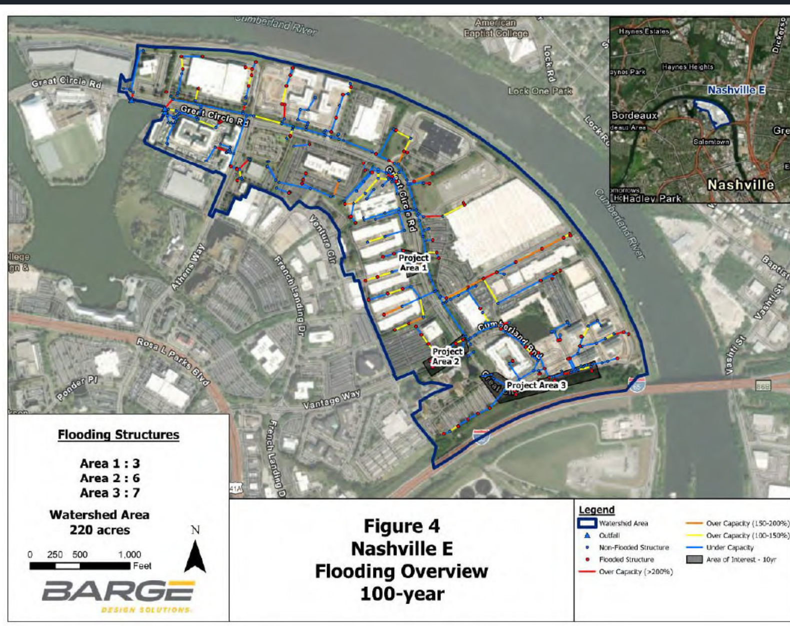
Projects Overview



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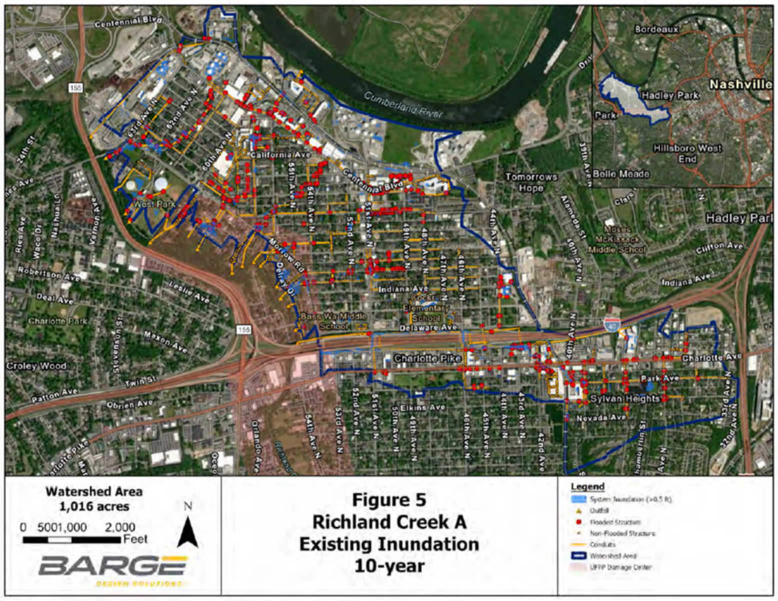
Projects Overview



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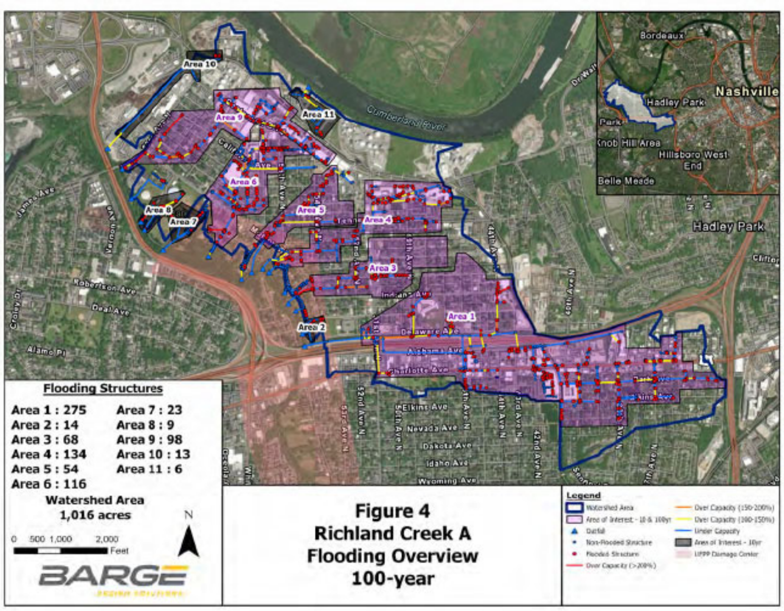
Projects Overview



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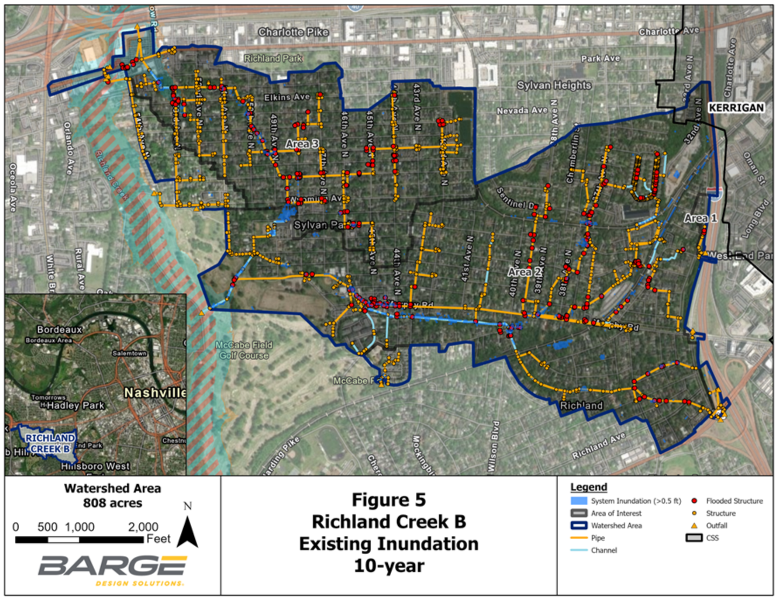
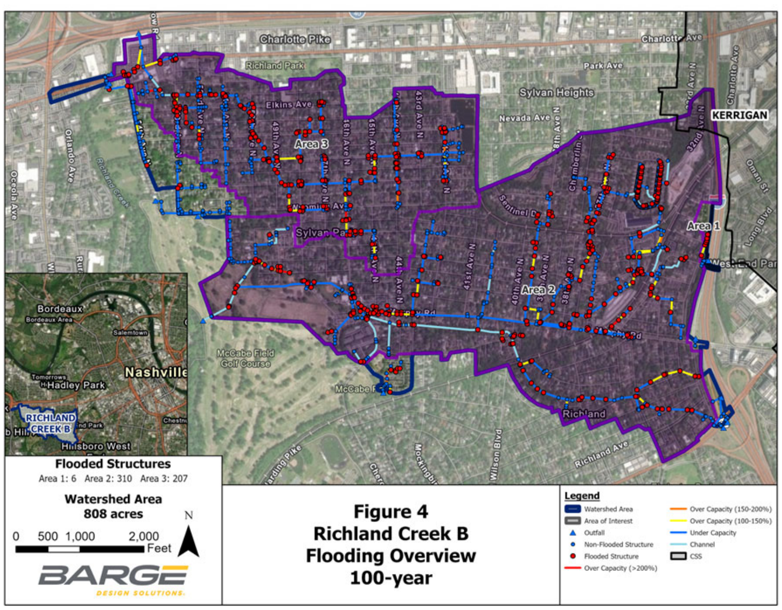
METRO WATER SERVICES

Projects Overview



METRO WATER SERVICES

Projects Overview



Criteria Overview

Overview of Identified Projects

Results of Ranking

Early Action Projects

Future Meeting Discussion Topics

35

Tiered Ranking

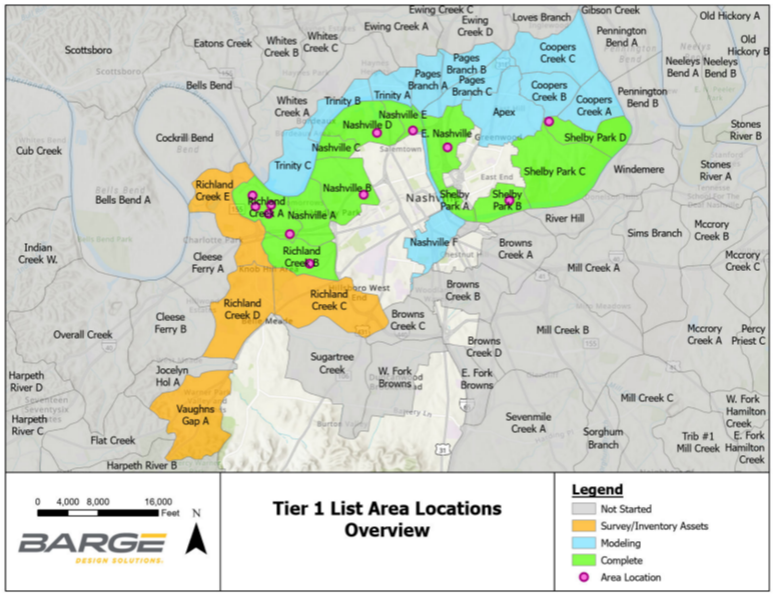
Tier 1	80^{th} Percentile and Above	13 Projects
Tier 2	Between 20^{th} and 80^{th} Percentile	42 Projects
Tier 3	20^{th} Percentile and Below	9 Projects

6 Projects in Shelby Park A, Shelby Park B and East Nashville not included in the ranking because of East Bank, Cayce Homes, and Oracle Development

36

Tiered Ranking

Tier 1 Projects
East Nashville - Area 1
Richland Creek A - Area 3
Richland Creek B - Area 2
Richland Creek A - Area 1
Richland Creek A - Area 9
Nashville D - Area 3
Nashville E - Area 3
Richland Creek A - Area 6
Shelby Park B - Area 3
Richland Creek A - Area 5
Nashville B - Area 2
Shelby Park D - Area 1
Nashville D - Area 2



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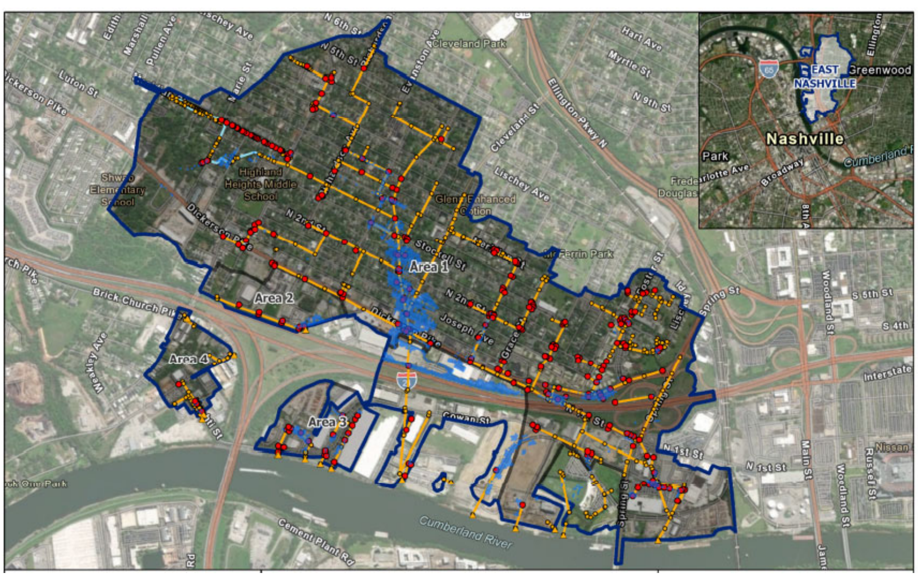
Top Ranked Project



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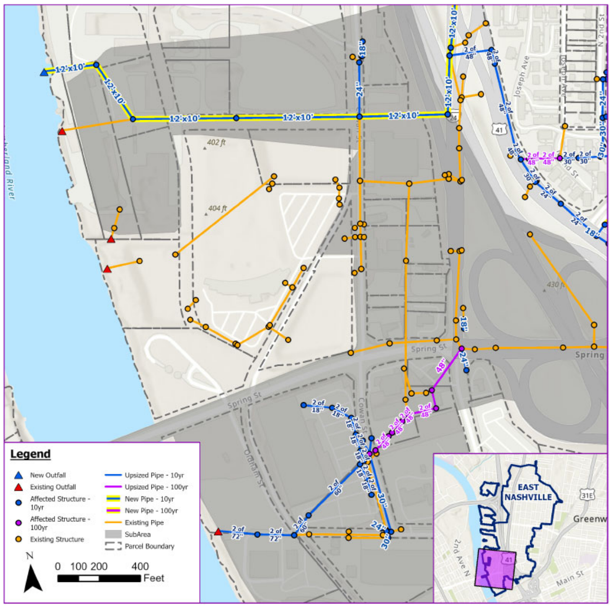
Top Ranked Project



East Nashville - Area 1.A
Alternative #1 - 100 yr

Upsize 4,360 linear feet (LF) of reinforced concrete pipe (RCP). Install 2,390 LF of new RCBC (Box culvert).

Details:
- 1,500 LF 18" RCP
- 460 LF 24" RCP
- 430 LF 30" RCP
- 620 LF 48" RCP
- 610 LF 60" RCP
- 740 LF 72" RCP
- 2,390 LF 12'x10' RCBC
- 40 Structures

Benefits:
- Flood Mitigation
- Improved Safety
  - Road Flooding
  - Parking Lot Flooding
- Highly Visible Issue
  - 1 Service Request
- Improved Resiliency
  - Reduced Velocities

Planning-level Opinion of Probable Project Cost: $30,500,000

Potential Easements (Council District 19): 10

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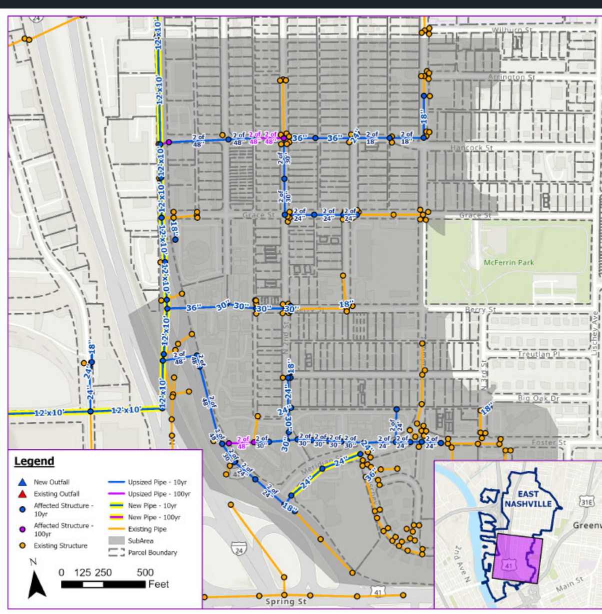
Top Ranked Project



East Nashville - Area 1.B
Alternative #1 - 100 yr

Upsize 10,230 linear feet (LF) of reinforced concrete pipe (RCP). Install 2,440 LF of new RCP and RCBC (Box culvert). Area 1.B improvements to be constructed after Area 1.A are completed.

Details:
- 1,040 LF 18" RCP
- 2,760 LF 24" RCP
- 2,730 LF 30" RCP
- 760 LF 36" RCP
- 3,430 LF 48" RCP
- 1,950 LF 12'x10' RCBC
- 70 Structures

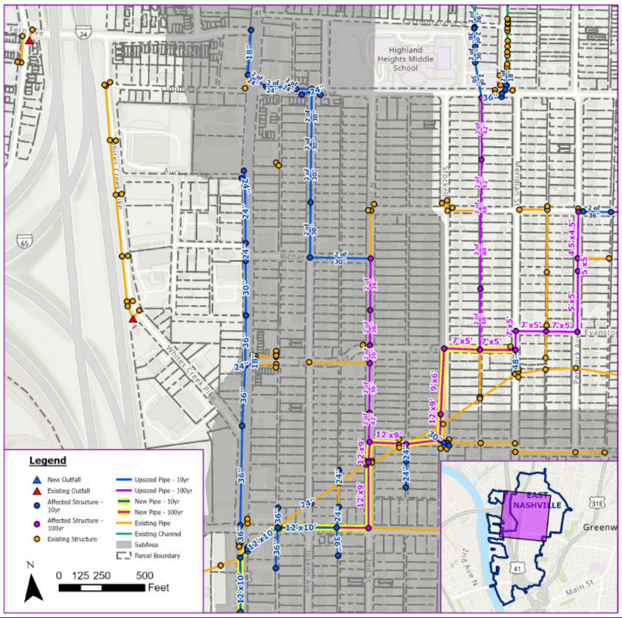
Benefits:
- Flood Mitigation
- Improved Safety
  - Road Flooding
  - Parking Lot Flooding
- Highly Visible Issue
  - 2 Service Requests
- Improved Resiliency
  - Reduced Velocities

Planning-level Opinion of Probable Project Cost: $28,600,000

Potential Easements (Council District 5): 7

40

Top Ranked Project



East Nashville - Area 1.C
Alternative #1 - 100 yr

Upsize 9,580 linear feet (LF) of reinforced concrete pipe (RCP). Install 2,660 LF of new RCBC (Box culvert). Area 1.C improvements to be constructed after Area 1.A and Area 1.B are completed.

Details:
- 320 LF 18" RCP
- 1,810 LF 24" RCP
- 3,220 LF 30" RCP
- 3,650 LF 36" RCP
- 580 LF 42" RCP
- 390 LF 9'x6' RCBC
- 1,070 LF 12'x9' RCBC
- 1,200 LF 12'x10' RCBC
- 55 Structures

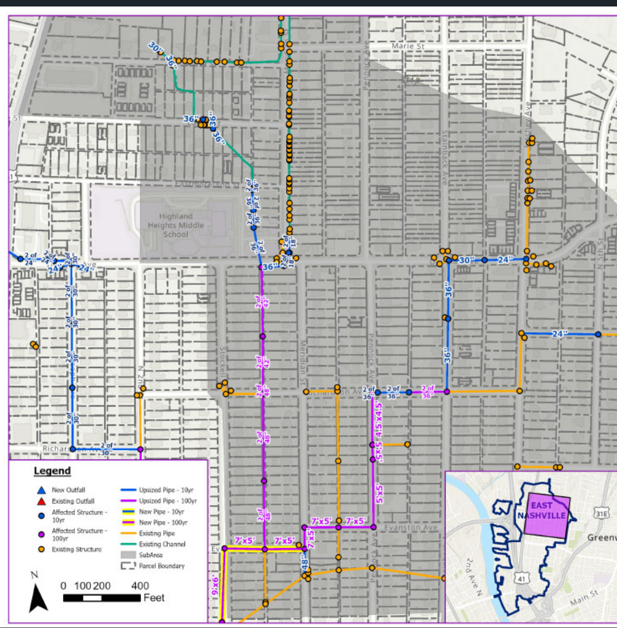
Benefits:
- Flood Mitigation
- Improved Safety
  - Road Flooding
  - Residential Lot Flooding
- Highly Visible Issue
  - 3 Service Requests

Planning-level Opinion of Probable Project Cost:
$30,100,000

Potential Easements (Council District 5): 2

41

Top Ranked Project



East Nashville - Area 1.D
Alternative #1 - 100 yr

Upsize 6,560 linear feet (LF) of reinforced concrete pipe (RCP). Install 420 LF of new RCBC (Box culvert). Area 1.D improvements to be constructed after Area 1.A, Area 1.B, and Area 1.C are completed.

Details:
- 130 LF 18" RCP
- 680 LF 24" RCP
- 320 LF 30" RCP
- 1,800 LF 36" RCP
- 630 LF 42" RCP
- 1,820 LF 48" RCP
- 280 LF 4.5'x4.5' RCBC
- 430 LF 5'x5' RCBC
- 890 LF 7'x5' RCBC
- 37 Structures

Benefits:
- Flood Mitigation
- Improved Safety
  - Road Flooding
  - Residential Lot Flooding
- Highly Visible Issue
  - 2 Service Requests

Planning-level Opinion of Probable Project Cost:
$14,700,000

Potential Easements (Council District 5): 11

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Criteria Overview

Overview of Identified Projects

Results of Ranking

Early Action Projects

Future Meeting Discussion Topics

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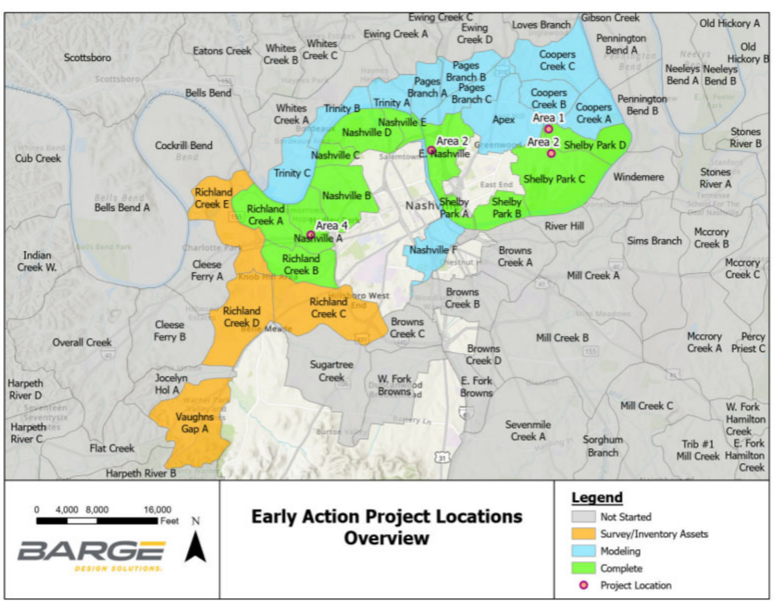
Potential Early Action Project



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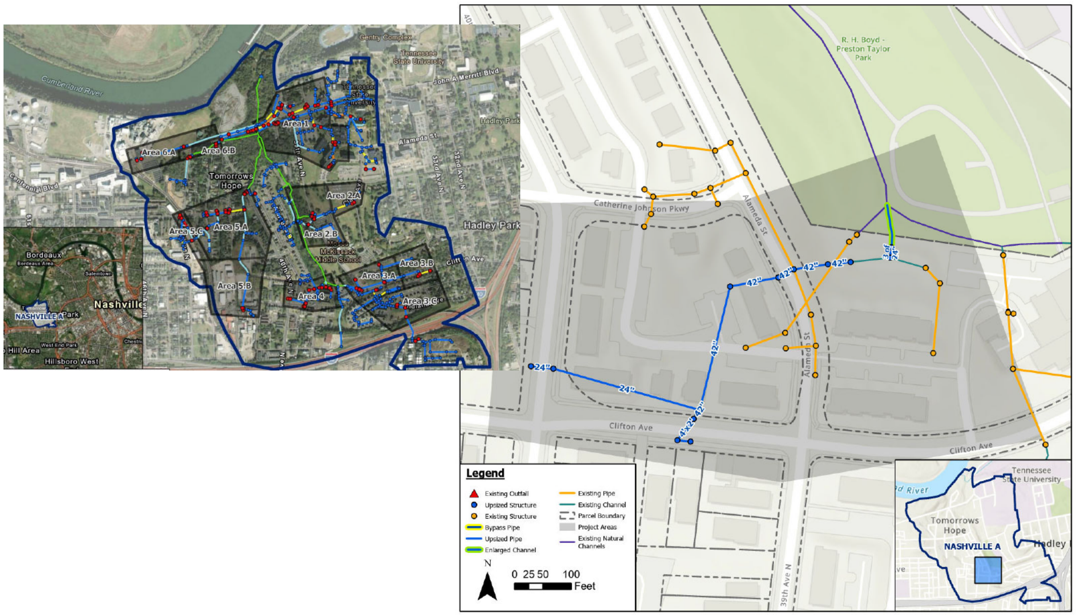
Potential Early Action Project



Nashville A - Area 4
Alternative #1 - 10 yr

Upsize 920 linear feet (LF) of reinforced concrete pipe (RCP) and RC Box Culvert (RCBC).

Details:
- 370 LF 24" RCP
- 470 LF 42" RCP
- 80 LF 4'x2' RCBC
- 75 LF Enlarged Channel
- 13 Structures

Benefits:
- Flood Mitigation
- Improved Safety
  - Road Flooding
- Highly Visible Issue
- Improved Resiliency
  - Reduced Velocities

Planning-level Opinion of Probable Project Cost: $1,400,000

Potential Easements (Council District 21): 0 (MDHA-owned and existing R.O.W.)

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Potential Early Action Project

East Nashville - Area 2
Alternative #1 - 10 yr

Upsize 1,840 linear feet (LF) of reinforced concrete box (RCB).

Details:
- 40 LF 18" RCP
- 1,660 LF 24" RCP
- 160 LF 30" RCP
- 7 Structures

Benefits:
- Flood Mitigation
- Improved Safety
  - Road Flooding
- Highly Visible Issue
  - 2 Service Requests

Planning-level Opinion of Probable Project Cost: $1,100,000

Potential Easements (Council District 5): 0 (Existing R.O.W.)

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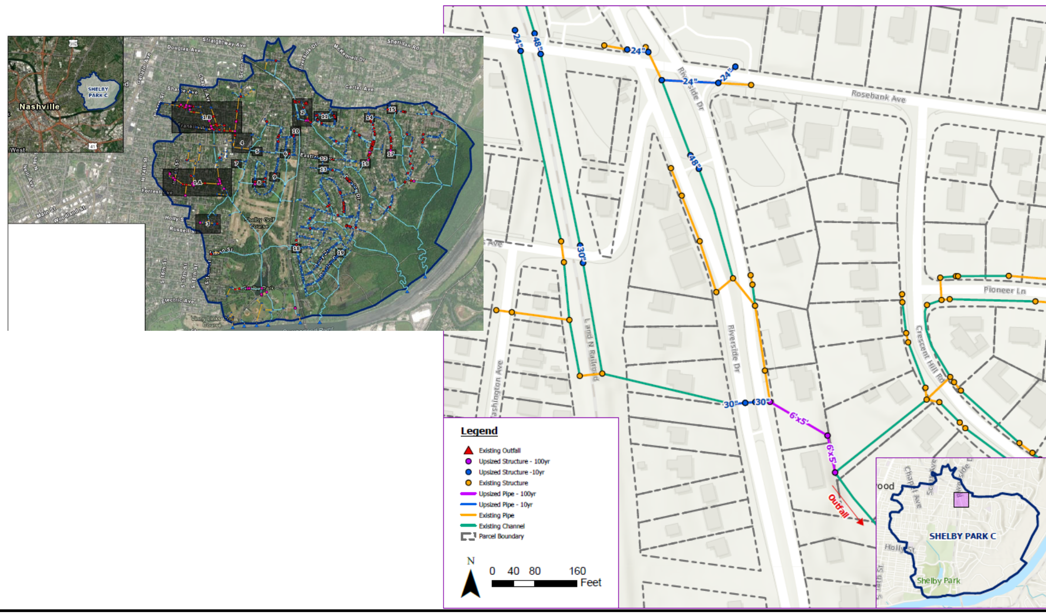
Potential Early Action Project



Shelby Park C - Area 2
Alternative #1 - 100 yr

Upsize 615 linear feet (LF) of reinforced concrete pipe (RCP) from Rosebank Ave (various) to Riverside Dr (B291199).

Details:
- 235 LF 24" RCP
- 105 LF 30" RCP
- 75 LF 48" RCP
- 200 LF 6'X5' RCBC
- 19 Structures

Benefits:
- Flood Mitigation
- Improved Safety
  - Road Flooding
- Improved Resiliency
  - Property Flooding
  - Reduced Velocities

Planning-level Opinion of Probable Project Cost:

$2,000,000

Potential Easements: (Council District 6)

3

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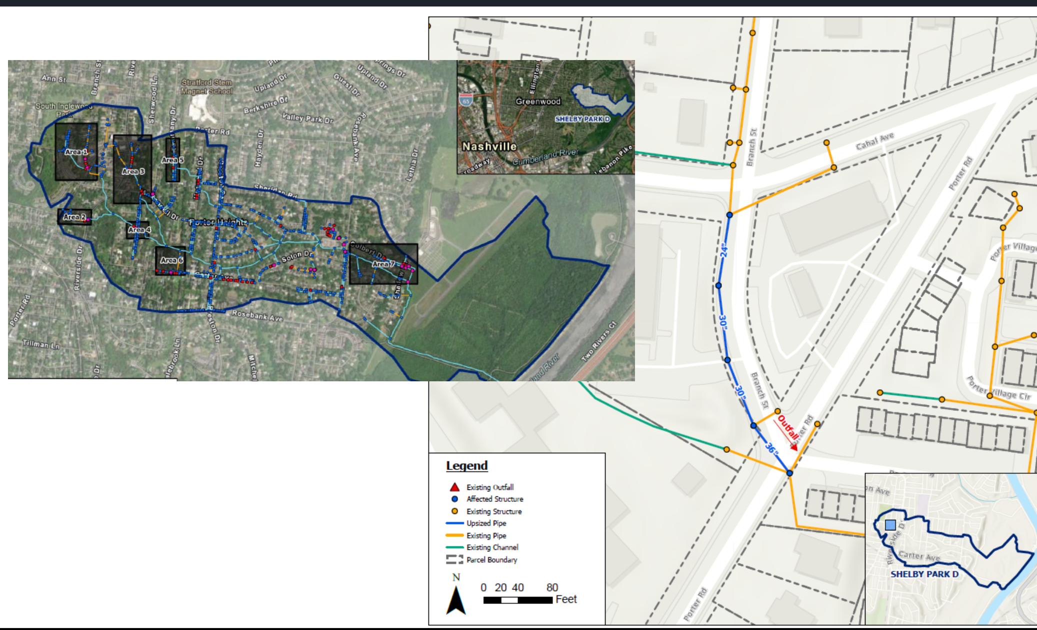
Potential Early Action Project



Shelby Park D - Area 1
Alternative #1 - 10 yr

Upsize 330 linear feet (LF) of reinforced concrete pipe (RCP) from Cahal Ave & Branch St to Branch St & Porter Rd.

Details:

- 85 LF 24" RCP
- 175 LF 30" RCP
- 70 LF 36" RCP
- 5 Structures

Benefits:
- Flood Mitigation
- Improved Safety
  - Road Flooding
- Improved Resiliency
  - Property Flooding
  - Reduced Velocities

Planning-level Opinion of Probable Project Cost:

$500,000

Potential Easements: (Council District 7)

0 (Existing R.O.W.)

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Criteria Overview

Overview of Identified Projects

Results of Ranking

Early Action Projects

Future Meeting Discussion Topics

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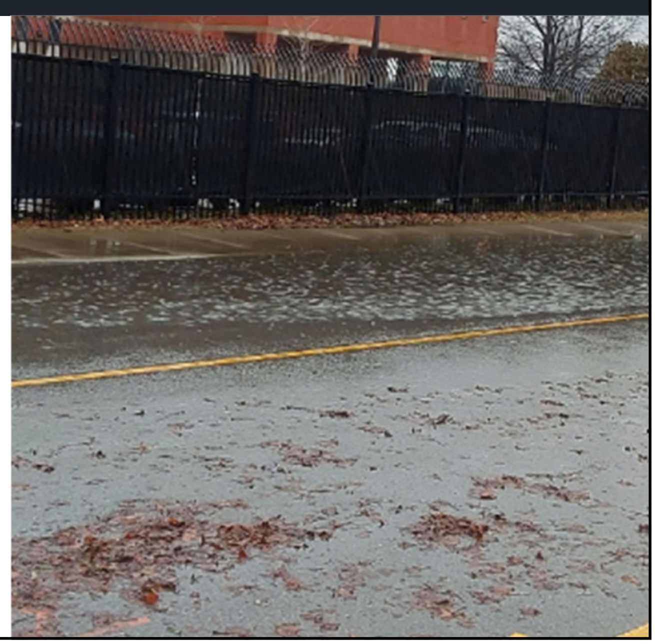
Future Meeting

- Inventory and Modeling Progress
- Projects
- Quarterly Meetings



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APPENDIX C – Memorandums

MEMORANDUM

TO:	**Matt Tays, Metro Water Services**
FROM:	**Clayton Foster, Barge Design Solutions**
DATE:	**November 30, 2022**
Barge PROJECT NO.:	**37875-02**
RE:	**Stormwater Masterplan Advisory Committee, Revision 1**

Purpose

The overall objective of the Stormwater Masterplan is to study and develop alternatives to reduce or eliminate flooding throughout the Metro service area. Such solutions require broad consensus and support from various groups in the community. Therefore, a point of emphasis of this effort is developing consensus among engaged groups regarding decisions made through the master planning process. Some examples of these decisions are determining what level of service should be obtained through the alternatives evaluated and the relative importance of the various criteria used to evaluate the suitability of a specific alternative for a given area. Considering and addressing the perspectives of a wide cross-section of the community including elected officials; regulators; advocacy groups; and business leaders, will allow the Masterplan to represent the community. Plans developed with this type of broad support are generally more successful than plans crafted in isolation. This memorandum describes the role of advisory committee members in more detail, including recommended committee members, the role of committee members, and a plan for advisory committee meetings.

Recommended Advisory Committee Members

Table 1.1 shows organizations that have technical expertise, permitting authority, or special interest in flooding impacts in Metro Nashville and could be engaged as advisory committee members.

While the advisory committee can be made of each of these organizations which will provide the broadest of perspectives and insights into decisions, it may become overly burdensome and slow down the master planning process to try and achieve consensus on this type of advisory committee scale. We would recommend selecting a group made of Metro staff, a business community leader, a local official, and a representative from at least one government entity, critical service provider, and environmental group so that the group is of a manageable size but different groups have a representative for their interests and considerations.

Table 1.1: Potential Advisory Committee Groups

Federal Emergency Management Agency (FEMA)	Cumberland River Compact
Metro Codes Administration	Richland Creek Watershed Association
Metro Office of Emergency Management	Urban Land Institute (URI)
Metro Parks and Recreation	NAIOP- Nashville Chapter (Commercial Real Estate Development Association)
Metro Planning Commission	Tennessee Emergency Management Agency (TEMA)
Nashville Department of Transportation and Multimodal Infrastructure	Tennessee Department of Transportation (TDOT)
Metro Water Services	Nashville Area Chamber of Commerce
Downtown Partnership	Metro City Council (Public Works Committee)
United States Army Corps of Engineers	

Role of the Advisory Committee

An important role of the advisory committee will be to help Metro make key decisions during the master planning process. The advisory committee will participate in discussions, complete survey forms, and provide feedback on different aspects of the project which will ultimately lead to recommendations to the Project Management Team. The Project Management Team is comprised of Metro Water Services (MWS) employees who will ultimately make the decisions regarding the project direction.

While there will be other decisions that need to be made at some point in the future, Metro needs agreement on two issues in the near term.

1. Agreement is needed of an appropriate level of service to be obtained through the Stormwater Masterplan improvements. Level of service includes the design storm to be modeled and designed for as well as performance of infrastructure. Examples of performance of infrastructure could be whether some level of ponding is acceptable in a roadway or no ponding is acceptable, or pipes are allowed to surcharge during design storm events or no surcharge is allowed.

2. Input is required regarding the criteria developed to identify and determine the watershed priority areas. Criteria presented may include the rate of development in an area, density of development, community complaints, or data quality. The advisory committee members should provide feedback regarding the criteria presented and recommend other criteria that should be considered.

Additionally, the advisory committee will be engaged to provide input on future issues such as the appropriateness of future flood mitigation solutions. These alternatives will have different advantages and disadvantages in terms of cost, schedule, environmental impacts, and social considerations. The committee will help to decide the importance of each of these criteria in a way that reflects the community's values. The committee members should provide feedback regarding the different impacts and recommend other criteria that should be considered during discussions.

To facilitate agreement with the level of service decisions, as well as to provide overall input into the master planning process, the advisory committee is anticipated to be engaged throughout the five-year program to provide input and feedback on major decisions which will ultimately drive project scope.

Advisory Committee Meetings

Throughout the master planning development process, the advisory committee will convene and be updated on the program status and given an opportunity to critique and offer recommendations to the plan. Below is an outline of the suggested process.

First three meetings: The first advisory committee meeting will include an overview of the program objectives, potential topics, and general schedule to be expected. At the first meeting we will also introduce the topic of stormwater level of service and the criteria used to rank the basins to be studied and facilitate a discussion to solicit input. Two additional meetings will provide follow up with committee members and additional discussion in order to achieve consensus on the level of service and final basin rankings.

Fourth meeting: Once level of service and basin ranking are agreed to by the advisory committee and the project management team, Barge will solicit feedback on how improvement alternatives are developed. Barge will provide questionnaires via email to the committee and then lead a meeting to determine the level of importance of each criterion used to evaluate potential alternatives. The questionnaire results in conjunction with discussions with the advisory committee will be aggregated to form a final ranking of each criterion. The final rankings will be used during the alternatives analysis to determine which alternative should be used for master planning.

Additional meetings will be used to engage the advisory committee with additional topics that the Project Management Team and Barge desire input on during the planning process such as further alternatives analysis or emergent stormwater concerns.

DATA REVIEW AND WATERSHED PRIORITIZATION

Prepared For: Metro Water Services

37875-01
August 2022

CONTENTS

BARGE DESIGN SOLUTIONS

FIGURES

TABLES

1.0 INTRODUCTION

Metro Water Services (MWS) requested Barge Design Solutions (Barge) perform a review of existing stormwater infrastructure data provided by MWS and other agencies to assess its adequacy and usefulness in the development of an updated stormwater masterplan. Barge will use the available information to provide MWS with a watershed prioritization list which will be used as a guide to determine which watersheds should be inventoried and master planned first. Barge's analysis, recommendations, and watershed prioritization are summarized below.

2.0 DATA REVIEW

2.1 MWS Stormwater Geodatabases

MWS provided a stormwater infrastructure geodatabase that included the following:

1. Pipes
2. Culverts
3. Inlets
4. Manholes
5. Headwalls
6. Best Management Practices (BMP)
7. Stream centerlines
8. MWS watersheds
9. Other utilities
10. Critical facilities
11. Other miscellaneous data

2.2 Metro Planning Department Shapefiles

The Metro Planning department provided a series of shapefiles that contained the following:

1. Building locations
2. Locations of active development projects
3. Parcels
4. Parking lot locations
5. Pavement/sidewalk shapefiles
6. Various zoning overlays

2.3 USACE Shapefiles

The U.S. Army Corps of Engineers (USACE) provided a shapefile that included the following:

1. Floodplains
2. Cross-sections with base flood elevations
3. Floodways and buffers
4. Stream centerlines
5. USACE watersheds
6. Source of hydrology models available to the USACE

2.4 Data Analysis

The data was reviewed, and discussions occurred with MWS staff regarding the data. The following was observed:

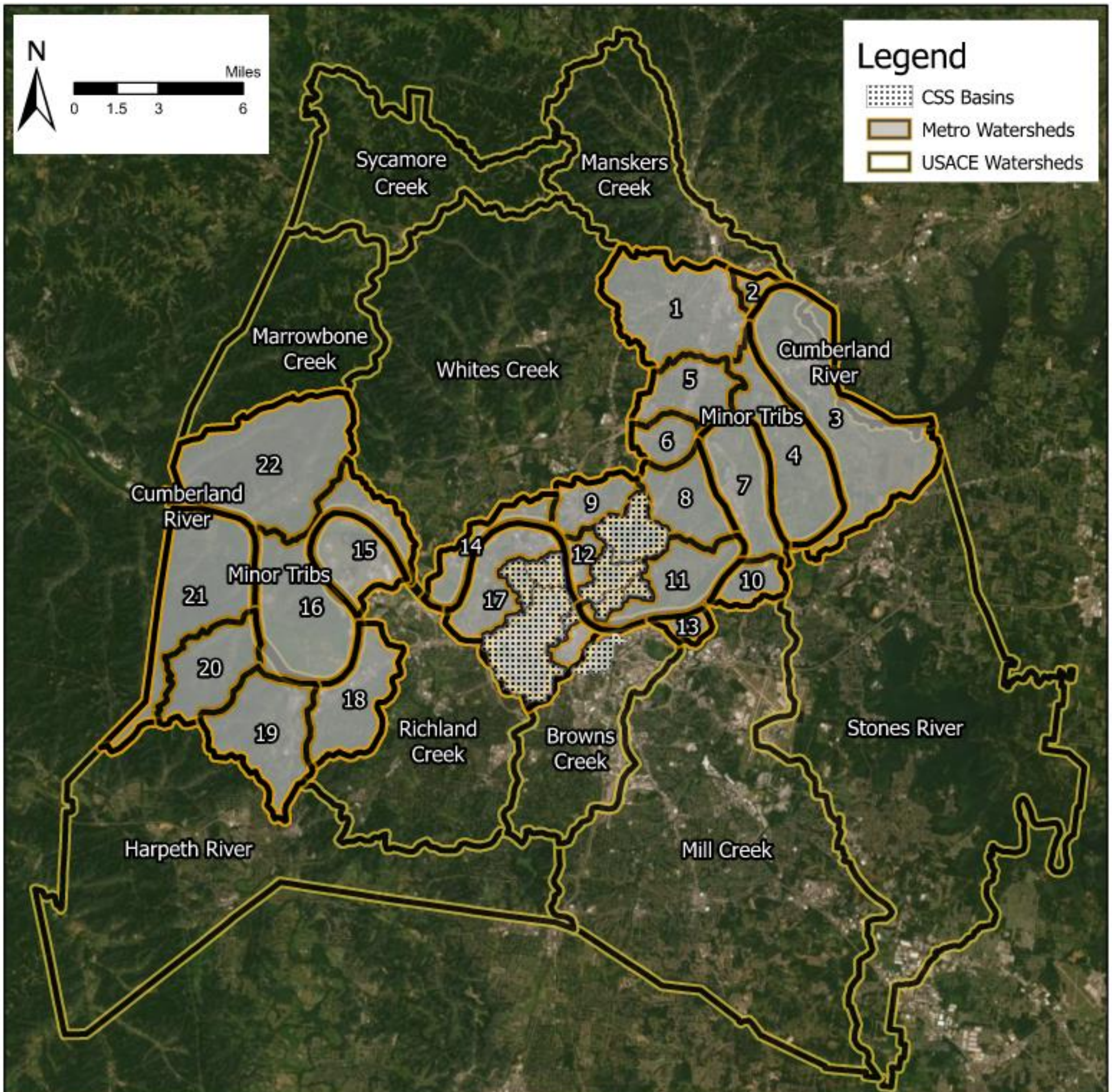
1. The MWS stormwater infrastructure geodatabase contained inexact XY coordinates of the structures but rarely contained elevations associated with a top of casting (TC) or invert elevation (IE). Currently, 78 percent of elements classified as conduits do not have elevation data and 95 percent of culverts do not have elevation data.
2. The current geodatabase was initially developed in the early 2000s and does not contain any current condition assessments. Additionally, the current schema is dated.
3. The USACE watersheds have been subdivided to create the MWS watersheds. There are currently 10 USACE watersheds that have been subdivided into 63 MWS watersheds. USACE watershed size varies between 16 and 151 square miles.
4. The USACE stream centerline shapefile contains attributes that document the hydrology used to develop current hydraulic models. While some models are old, developed between 1988 and 1999, most were developed after 2012.
5. Locations of Routine and Remedial services requests are stored as GIS features. Those features have been exported by MWS and provided to Barge to evaluate the number of reported deficiencies in a specific watershed.

2.5 Data Analysis Recommendations

Based on the data review, Barge recommends using the existing stormwater infrastructure geodatabase to locate existing features (manholes, inlets, catch basins, etc.) and collect accurate XYZ coordinates for the structure. Simultaneously, photos will be taken, and a condition assessment will be performed using a modified National Association of Sewer Service Companies (NASSCO) rating scale of 1 to 5.

Barge recommends using the current hydrology information from the USACE to build the hydrology and hydraulics models for the system analysis. The masterplan hydrology will require a finer resolution than the current USACE hydrology since the basins will be delineated to an individual inlet or catch basin scale, but the current inputs will provide the basis for the smaller drainage area delineations. As some of these hydrology models are dated, Barge will review current shapefiles provided by Metro Planning containing new building footprints and paved areas to confirm that runoff coefficients have not increased substantially. If so, they will be adjusted.

Barge recommends that MWS use the USACE's watersheds as the study boundary sequence with the exception of USACE's "minor tributary" watershed. The minor tributary watershed is a series of smaller sub-basins that are adjacent to the Cumberland River. Figure 2.1 shows the proposed study boundaries using the USACE watersheds and MWS sub-basins for the minor tributaries. The minor tributaries sub-basins will be grouped where appropriate to form larger basin areas to be inventoried and studied based on their location or based on criteria outlined below.



No.	1	2	3	4	5	6	7	8	9	10	11
Metro Watershed	Dry Creek	Unnamed Basin (north of Old Hickory Basin)	Old Hickory	Neeley's Bend	Gibson Creek	Loves Branch	Pennington Bend	Coopers Creek	Pages Branch	Windemere	Shelby Park
No.	12	13	14	15	16	17	18	19	20	21	22
Metro Watershed	East Nashville	River Hill	Unnamed Basin (north of Nashville Basin)	Cockrell Bend	Bells Bend	Nashville	Cleese Ferry	Overall Creek	Indian Creek W.	Cub Creek	Scottosboro

Figure 2.1: Location Map for USACE Watersheds and MWS Sub-Basins of Minor Tributaries

3.0 WATERSHED PRIORITIZATION MATRIX

Based on the information available, Barge developed a Watershed Prioritization Matrix to assist the stormwater master planning process by comparing the different stormwater basins and providing a ranking. The general approach using the Prioritization Matrix includes:

- Determining important metrics and criteria
- Establishing a weighted factor for each criterion
- Determining the individual score for each criterion for each watershed
- Calculating the weighted score for each criterion
- Totalizing the weighted scores for each watershed
- Ranking watersheds according to weighted scores

The Prioritization Matrix is not intended to be the only means to set priorities but instead to be a tool used as a guide for decision making. Engineering judgement and experience will be major factors in determining prioritization.

Table 3.1 provides Barge's recommendation for prioritization criteria, the method of defining the criteria, and the weighted factor for combining each criterion into an overall score. Additionally, a fifth criterion will be basins neighboring combined sewer systems (CSSs) that are being studied will be given preference.

Table 3.1: Prioritization Criteria and Weighted Factor

	Criteria	Criteria Definition	Weighted Factor
1	Development Density	Number of Parcels	0.2
2	Experiencing Growth	Number of Active Development Permits	0.3
3	Existing Issues	Number of Service Requests	0.3
4	Data Quality	Age and Source of Data	0.2

Development density, experiencing growth, and existing issues were determined to be critical factors for prioritizing the watershed basins. These factors highlight areas where the stormwater masterplan will impact the most people, will allow for improvements to be installed with development, and will address existing issues with the stormwater system.

Additionally, a goal of the masterplan project is to improve the overall quality of stormwater geographic information systems (GIS) data across Nashville. Since improving data quality is a goal, Barge considered the current quality of GIS data as a factor to guide the prioritization. To identify watersheds that contained data that is considered less reliable, Barge assigned a data quality score to each GIS feature for outfalls, inlets, catch basins, best management practices (BMPs), culverts, and conduits. The same calculation was applied to each asset type. The calculation used data age and source of data as the factors. For age, Barge used the Data Created field and considered older data less reliable than data created more recently. To score the data based on source, Barge used the Mapping Accuracy field. Barge considered data created from record drawings to be less reliable than data created from global positioning system (GPS) survey or traditional survey. The two scores, age and source, were then combined equally to assign the data quality score to each GIS feature. From there, Barge used GIS to assign an average data quality score for every GIS feature in each watershed.

Table 3.2 shows the weighted scoring for development density, Table 3.3 shows the weighted scoring for active development permits, Table 3.4 shows the weighted scoring for the number of service requests, and Table 3.5 shows the average score that represents the quality of GIS data for each basin.

Table 3.6 provides a summary of the each of the weighted scores, combines the weighted scores into a single score per basin, and provides the recommended prioritization list based on the scoring. Figure 3.1 is visual representation of the prioritization list.

Table 3.2: Weighted Score for Development Density Per Basin

	Watershed	Area (Sq. Mi.)	No. of Parcels	Parcels / Sq. Mile	Parcels / Sq. Mile (%)	Weighted Score for Development Density
MINOR TRIBS	Shelby Park	6	5,834	1004	5.72	1.14
	East Nashville	2	2,092	1300	7.41	1.48
	Nashville	7	9,298	1340	7.64	1.53
	Unnamed Basin (north of Nashville Basin)	3	2,376	706	4.02	0.80
	Pages Branch	3	2,841	930	5.30	1.06
	Dry Creek	10	5,417	533	3.04	0.61
	Old Hickory	16	8,295	524	2.99	0.60
	Cleese Ferry	6	4,639	737	4.20	0.84
	Gibson Creek	4	4,668	1068	6.09	1.22
	Coopers Creek	5	6,875	1434	8.17	1.63
	Overall Creek	8	1,985	253	1.44	0.29
	Windemere	2	1,548	738	4.20	0.84
	Neely's Bend	9	3,816	438	2.49	0.50
	River Hill	1	399	410	2.34	0.47
	Unnamed Basin (north of Old Hickory Basin)	1	517	569	3.24	0.65
	Cockrill Bend	5	78	17	0.10	0.02
	Pennington Bend	6	2,573	427	2.43	0.49
	Loves Branch	2	1,764	791	4.51	0.90
	Bells Bend	13	233	18	0.10	0.02
	Indian Creek W.	6	173	30	0.17	0.03
	Cub Creek	11	328	31	0.17	0.03
	Scottsboro	15	594	41	0.23	0.05
	Mill Creek	71	55,809	783	4.46	0.89
	Stones River	78	39,570	509	2.90	0.58
	Whites Creek	63	16,897	269	1.53	0.31
	Browns Creek	16	15,608	947	5.40	1.08
	Richland Creek	28	29,702	1055	6.01	1.20
	Harpeth River	56	17,735	316	1.80	0.36
	Sycamore Creek	21	1,869	87	0.50	0.10
	Mansker Creek	21	3,851	181	1.03	0.21
	Marrowbone Creek	19	1,176	62	0.35	0.07
	TOTAL	**514**	**248,560**		**100**	**20**

Table 3.3: Weighted Score for Active Development Permits Per Basin

	Watershed	Area (Sq. Mi.)	Active Development Permits	Development Permits / Sq. Mile	Development Permits / Sq. Mile (%)	Weighted Score for Active Development
MINOR TRIBS	Shelby Park	6	9	1.5	2.66	0.80
	East Nashville	2	18	11.2	19.20	5.76
	Nashville	7	51	7.4	12.62	3.78
	Unnamed Basin (north of Nashville Basin)	3	16	4.8	8.16	2.45
	Pages Branch	3	16	5.2	8.99	2.70
	Dry Creek	10	16	1.6	2.70	0.81
	Old Hickory	16	16	1.0	1.74	0.52
	Cleese Ferry	6	7	1.1	1.91	0.57
	Gibson Creek	4	7	1.6	2.75	0.82
	Coopers Creek	5	9	1.9	3.22	0.97
	Overall Creek	8	7	0.9	1.53	0.46
	Windemere	2	3	1.4	2.45	0.74
	Neely's Bend	9	4	0.5	0.79	0.24
	River Hill	1	5	5.1	8.82	2.65
	Unnamed Basin (north of Old Hickory Basin)	1	3	3.3	5.66	1.70
	Cockrill Bend	5	1	0.2	0.37	0.11
	Pennington Bend	6	1	0.2	0.28	0.09
	Loves Branch	2	2	0.9	1.54	0.46
	Bells Bend	13	3	0.2	0.39	0.12
	Indian Creek W.	6	0	0.0	0.00	0.00
	Cub Creek	11	1	0.1	0.16	0.05
	Scottsboro	15	1	0.1	0.12	0.04
	Mill Creek	71	95	1.3	2.29	0.69
	Stones River	78	87	1.1	1.92	0.58
	Whites Creek	63	52	0.8	1.42	0.43
	Browns Creek	16	44	2.7	4.58	1.38
	Richland Creek	28	40	1.4	2.44	0.73
	Harpeth River	56	16	0.3	0.49	0.15
	Sycamore Creek	21	7	0.3	0.56	0.17
	Mansker Creek	21	3	0.1	0.24	0.07
	Marrowbone Creek	19	0	0.0	0.00	0.00
	TOTAL	**514**	**540**		**100**	**30**

Table 3.4: Weighted Score for Service Requests Per Basin

	Watershed	Area (Sq. Mi.)	Service Requests	Service Requests / Sq. Mile	Service Requests / Sq. Mile (%)	Weighted Score for Service Requests
MINOR TRIBS	Shelby Park	6	30	5.16	6.10	1.83
	East Nashville	2	10	6.21	7.34	2.20
	Nashville	7	26	3.75	4.43	1.33
	Unnamed Basin (north of Nashville Basin)	3	12	3.57	4.21	1.26
	Pages Branch	3	15	4.91	5.80	1.74
	Dry Creek	10	18	1.77	2.09	0.63
	Old Hickory	16	44	2.78	3.29	0.99
	Cleese Ferry	6	16	2.54	3.00	0.90
	Gibson Creek	4	24	5.49	6.49	1.95
	Coopers Creek	5	75	15.65	18.48	5.54
	Overall Creek	8	0	0.00	0.00	0.00
	Windemere	2	14	6.67	7.88	2.36
	Neely's Bend	9	25	2.87	3.39	1.02
	River Hill	1	2	2.06	2.43	0.73
	Unnamed Basin (north of Old Hickory Basin)	1	1	1.10	1.30	0.39
	Cockrill Bend	5	0	0.00	0.00	0.00
	Pennington Bend	6	5	0.83	0.98	0.29
	Loves Branch	2	14	6.28	7.42	2.23
	Bells Bend	13	0	0.00	0.00	0.00
	Indian Creek W.	6	0	0.00	0.00	0.00
	Cub Creek	11	2	0.19	0.22	0.07
	Scottsboro	15	4	0.27	0.32	0.10
	Mill Creek	71	99	1.39	1.64	0.49
	Stones River	78	103	1.32	1.56	0.47
	Whites Creek	63	54	0.86	1.01	0.30
	Browns Creek	16	11	0.67	0.79	0.24
	Richland Creek	28	205	7.28	8.60	2.58
	Harpeth River	56	53	0.94	1.12	0.33
	Sycamore Creek	21	0	0.00	0.00	0.00
	Mansker Creek	21	2	0.09	0.11	0.03
	Marrowbone Creek	19	0	0.00	0.00	0.00
	TOTAL	**514**	**864**		**100**	**30**

Table 3.5: Weighted Score for Quality of Data Per Basin

	Watershed	No. of Assets	Average Data Age Score	Average Data Source Score	Weighted Score for Data Quality	Data Quality Percentage (%)	Weighted Data Quality Score
MINOR TRIBS	**Shelby Park**	**4,121**	**5.96**	**7.86**	**6.91**	**3.06**	**0.61**
	East Nashville	1,997	6.10	8.55	7.33	3.24	0.65
	Nashville	10,732	5.33	7.99	6.66	2.95	0.59
	Unnamed Basin (north of Nashville Basin)	1,452	7.34	7.30	7.32	3.24	0.65
	Pages Branch	3,146	5.69	8.61	7.15	3.16	0.63
	Dry Creek	3,933	7.13	7.36	7.25	3.21	0.64
	Old Hickory	5,965	7.15	7.22	7.19	3.18	0.64
	Cleese Ferry	5,579	7.16	7.43	7.29	3.23	0.65
	Gibson Creek	3,952	7.80	7.15	7.47	3.31	0.66
	Coopers Creek	3,911	7.11	7.70	7.40	3.28	0.66
	Overall Creek	3,396	6.76	7.66	7.21	3.19	0.64
	Windemere	1,479	7.77	7.03	7.40	3.27	0.65
	Neely's Bend	3,276	7.45	7.38	7.42	3.28	0.66
	River Hill	525	7.73	7.11	7.42	3.28	0.66
	Unnamed Basin (north of Old Hickory Basin)	720	6.53	8.06	7.29	3.23	0.65
	Cockrill Bend	944	5.38	8.47	6.93	3.07	0.61
	Pennington Bend	2,872	7.46	7.51	7.49	3.32	0.66
	Loves Branch	1,609	8.23	6.98	7.60	3.37	0.67
	Bells Bend	1,067	7.86	6.94	7.40	3.28	0.66
	Indian Creek W.	318	7.83	6.73	7.28	3.22	0.64
	Cub Creek	807	7.94	6.84	7.39	3.27	0.65
	Scottsboro	1,491	8.25	6.74	7.49	3.32	0.66
	Mill Creek	55,631	6.69	7.96	7.33	3.24	0.65
	Stones River	37,756	6.34	7.99	7.16	3.17	0.63
	Whites Creek	19,891	7.25	7.46	7.35	3.26	0.65
	Browns Creek	11,903	6.23	7.74	6.99	3.09	0.62
	Richland Creek	22,194	6.94	7.53	7.24	3.20	0.64
	Harpeth River	19,095	7.11	7.39	7.25	3.21	0.64
	Sycamore Creek	2,806	7.89	6.92	7.41	3.28	0.66
	Mansker Creek	3,230	7.41	7.32	7.37	3.26	0.65
	Marrowbone Creek	1,596	8.22	6.75	7.49	3.31	0.66
	TOTAL	**237,394**				**100**	**20**

Table 3.6: Summary of the Weighted Scores and Prioritization Ranking

Priority		Watershed	Area (Sq. Mi.)	Weighted Score for Dvlpmnt Density	Weighted Score for Active Dvlpmnt	Weighted Score for Service Requests	Weighted Score for Data Quality	Total Weighted Score
1	Minor Tribs	East Nashville	6	1.14	0.80	1.83	0.61	8.94
		Shelby Park	2	1.48	5.76	2.20	0.65	4.09
2	Minor Tribs	Nashville	7	1.53	3.78	1.33	0.59	6.92
		Unnamed Basin (north of Nashville Basin)	3	0.80	2.45	1.26	0.65	4.94
		Pages Branch	3	1.06	2.70	1.74	0.63	5.86
		Coopers Creek	10	0.61	0.81	0.63	0.64	8.19
3		Richland Creek	16	0.60	0.52	0.99	0.64	6.07
	MT	Cleese Ferry	6	0.84	0.57	0.90	0.65	2.82
4		Browns Creek	4	1.22	0.82	1.95	0.66	4.83
5	Minor Tribs	Gibson Creek	5	1.63	0.97	5.54	0.66	4.38
		Windemere	8	0.29	0.46	0.00	0.64	4.32
		River Hill	2	0.84	0.74	2.36	0.65	4.33
		Pennington Bend	9	0.50	0.24	1.02	0.66	1.48
		Loves Branch	1	0.47	2.65	0.73	0.66	4.00
6		Stones River	1	0.65	1.70	0.39	0.65	3.64
7		Mill Creek	5	0.02	0.11	0.00	0.61	2.99
8	Minor Tribs	Dry Creek	6	0.49	0.09	0.29	0.66	2.57
		Old Hickory	2	0.90	0.46	2.23	0.67	2.60
		Neely's Bend	13	0.02	0.12	0.00	0.66	2.28
		Unnamed Basin (north of Old Hickory Basin)	6	0.03	0.00	0.00	0.64	3.26
9		Whites Creek	11	0.03	0.05	0.07	0.65	2.04
10		Harpeth River	15	0.05	0.04	0.10	0.66	1.43
11	Minor Tribs	Overall Creek	71	0.89	0.69	0.49	0.65	1.36
		Cockrill Bend	78	0.58	0.58	0.47	0.63	0.74
		Bells Bend	63	0.31	0.43	0.30	0.65	0.79
		Indian Creek W.	16	1.08	1.38	0.24	0.62	0.68
		Cub Creek	28	1.20	0.73	2.58	0.64	0.80
		Scottsboro	56	0.36	0.15	0.33	0.64	0.83
12		Mansker Creek	21	0.10	0.17	0.00	0.66	1.11
13		Sycamore Creek	21	0.21	0.07	0.03	0.65	0.96
14		Marrowbone Creek	19	0.07	0.00	0.00	0.66	0.76
		TOTAL	**514**	**20.00**	**30.00**	**30.00**	**20.00**	**100.00**

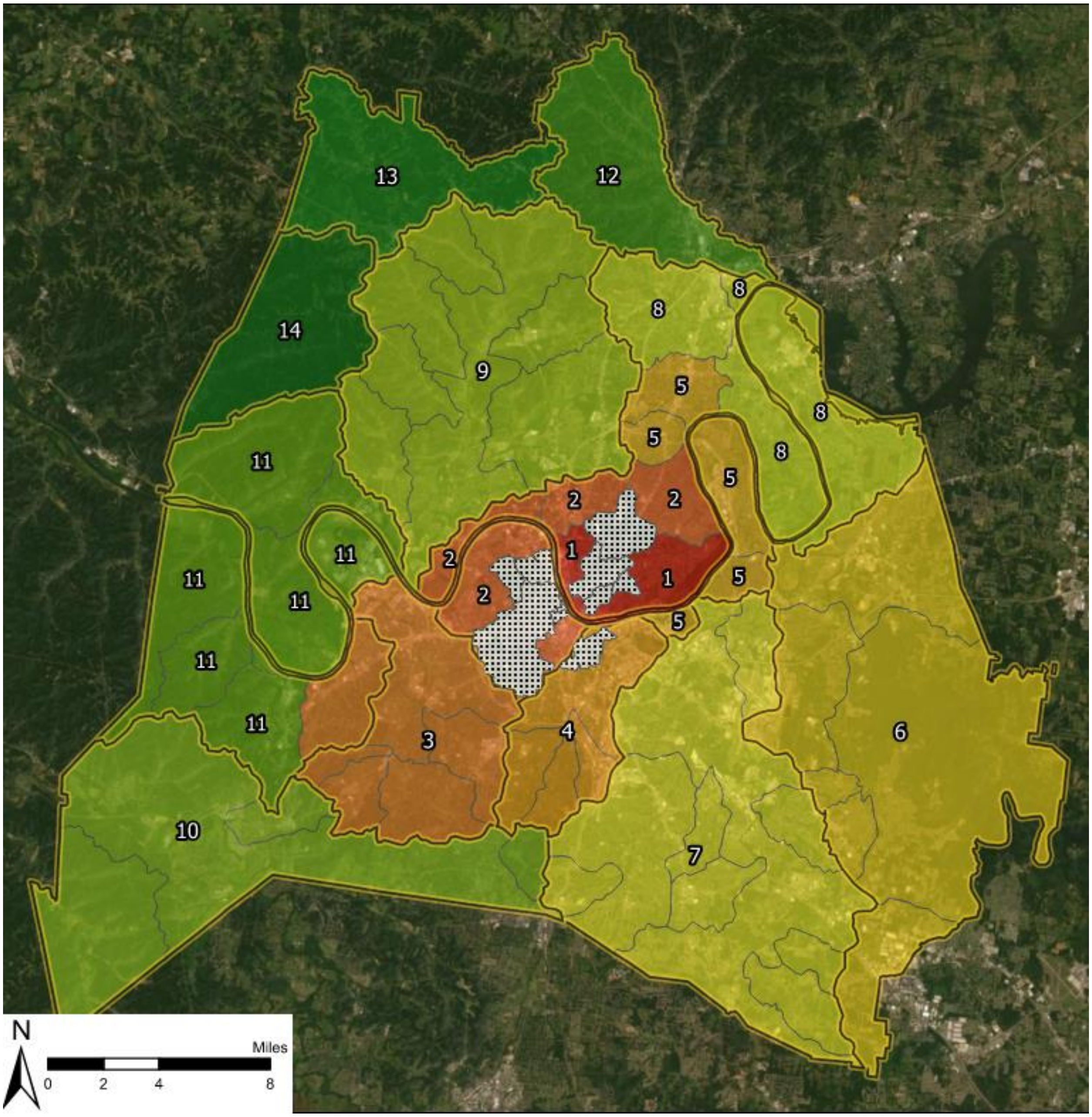


Figure 3.1: Location Map for Prioritization Ranking

4.0 FIRST BASIN RECOMMENDATION

When beginning a masterplan project, it is recommended that a smaller sample watershed be selected to validate the data collection process so the client can approve the process and level of detail. Barge recommends beginning with Metro's Shelby Park and East Nashville watersheds. Reasons for this recommendation include:

1. They ranked high on the watershed Prioritization Matrix.

2. Future development is planned for both areas. By understanding issues now, MWS will be able to plan for any needed stormwater improvements and have them implemented as a part of the developments.
3. They are each a manageable size between two and six square miles.
4. Both are in older areas of the Metro area. It is assumed that the infrastructure is in a poorer condition than in newer areas.

Once these areas have been inventoried and the process is producing the results that both MWS and the Barge team agree to, then other field crews will be trained and deployed to additional watersheds.

BARGE DESIGN SOLUTIONS

MEMORANDUM

TO:	**Matt Tays, Metro Water Services**
FROM:	**Barge Design Solutions**
DATE:	**9/26/2022**
Barge PROJECT NO.:	**37875-04**
RE:	**Standardized Condition Assessment Rating System**

As a part of the inventorying process, Barge Design Solutions (Barge) will provide a condition assessment of each structure (outlet control structures, junction boxes, inlets) to Metro Water Services (MWS). A condition assessment will not be completed for pipes, culverts, and conduits. There are a variety of rating systems which can be used for condition assessment; however, the two most common rating systems are a 1 to 3 scale (good, fair, poor) and a 0 to 5 scale (excellent, good, moderate, fair, poor, failed).

The 1 to 3 scale allows for quicker assessment with more uniform results between assessment crews. However, it has limited ability for future planning for asset replacement and prioritizing future maintenance activities. The 0 to 5 scale has the potential for increased assessment variability between crews, but it provides a more descriptive assessment of the asset's condition. This will allow for greater forecasting for replacement and maintenance. The two rating systems were discussed with MWS on September 15, 2022, and it was determined that for the pilot study the 0 to 5 rating system would be used. The results and effectiveness of this rating system will be reviewed at the conclusion of the pilot study.

For the condition assessment, the assessor will provide a structure rating based on the following definitions:

- Grade 0 (Figure 1): The asset is in excellent condition and has no documented defects. It is similar to that of new construction with no installation defects. This asset is at or near the beginning of its design life.
- Grade 1(Figure 2): The asset is in good condition with only minor installation defects or defects which are minor in nature as a result of its service life so far. This asset is expected to have 20 or more years of remaining service life.
- Grade 2 (Figure 3): The asset is in moderate condition with several minor defects. These minor defects, although not currently affecting its intended use, will likely impact the overall length of the asset's service life. This asset is expected to have 10-20 years of remaining service life.
- Grade 3 (Figure 4): The asset is in fair condition and has one or more moderate defects, but such defect(s) do not appear to be ones that would be considered of imminent risk of failure. This asset is less than 10 years from the end of its useful or design life.
- Grade 4 (Figure 5): Although the asset is partially or fully serving its intended purpose, the asset is in poor condition and has significant defects which are of imminent risk of failure. Failure may

occur at any time, resulting in this asset being upgraded to a Grade 5. This asset is at the end of its useful or design life.

- Grade 5 (Figure 6): The asset has already failed and is no longer serving its intended purpose. This asset has already surpassed its useful or design life.

Figure 1: Grade 0

Figure 2: Grade 1

Figure 3: Grade 2

Figure 4: Grade 3

Figure 5: Grade 4

Figure 6: Grade 5

MEMORANDUM

TO: MWS Stormwater Master Plan Advisory Committee

FROM: MWS / Barge Stormwater Master Plan Team

DATE: January 16, 2024

Barge PROJECT NO.: 3787505

RE: MWS Stormwater Master Plan Update

This memo provides an update on the work that has been ongoing in support of the MWS Stormwater Master Plan since the last meeting with the Advisory Committee, August 31, 2023.

Inventory and condition assessment work is ongoing. A total of 21,500 structures have been surveyed and 20,500 have been assessed for condition in 23 sub-basins. Inventory of priority 1 and priority 2 basins are scheduled to be complete by the end of 2023 with work beginning in priority 3 basin, Richland Creek, in 2024, Figure 1.

We have coordinated with CDM Smith, the team performing the combined sewer separation modeling and masterplan to discuss modeling conventions and assumptions in order to ensure consistency across Metro's stormwater related projects. Since there are some inherent differences in stormwater versus combined sewer modeling, we discussed the differences in the models and where it was appropriate to make changes for consistency. The following changes were agreed upon and are being incorporated into the stormwater models:

- Rainfall totals will be from a single gage, the Nashville airport gage, to eliminate any spatial interpolation between gages.
- The sub-catchment routing method was updated from outlet routing to pervious routing including a percent pervious according to land use.

These changes resulted in slightly reduced peak flows and reduced alternative sizing.

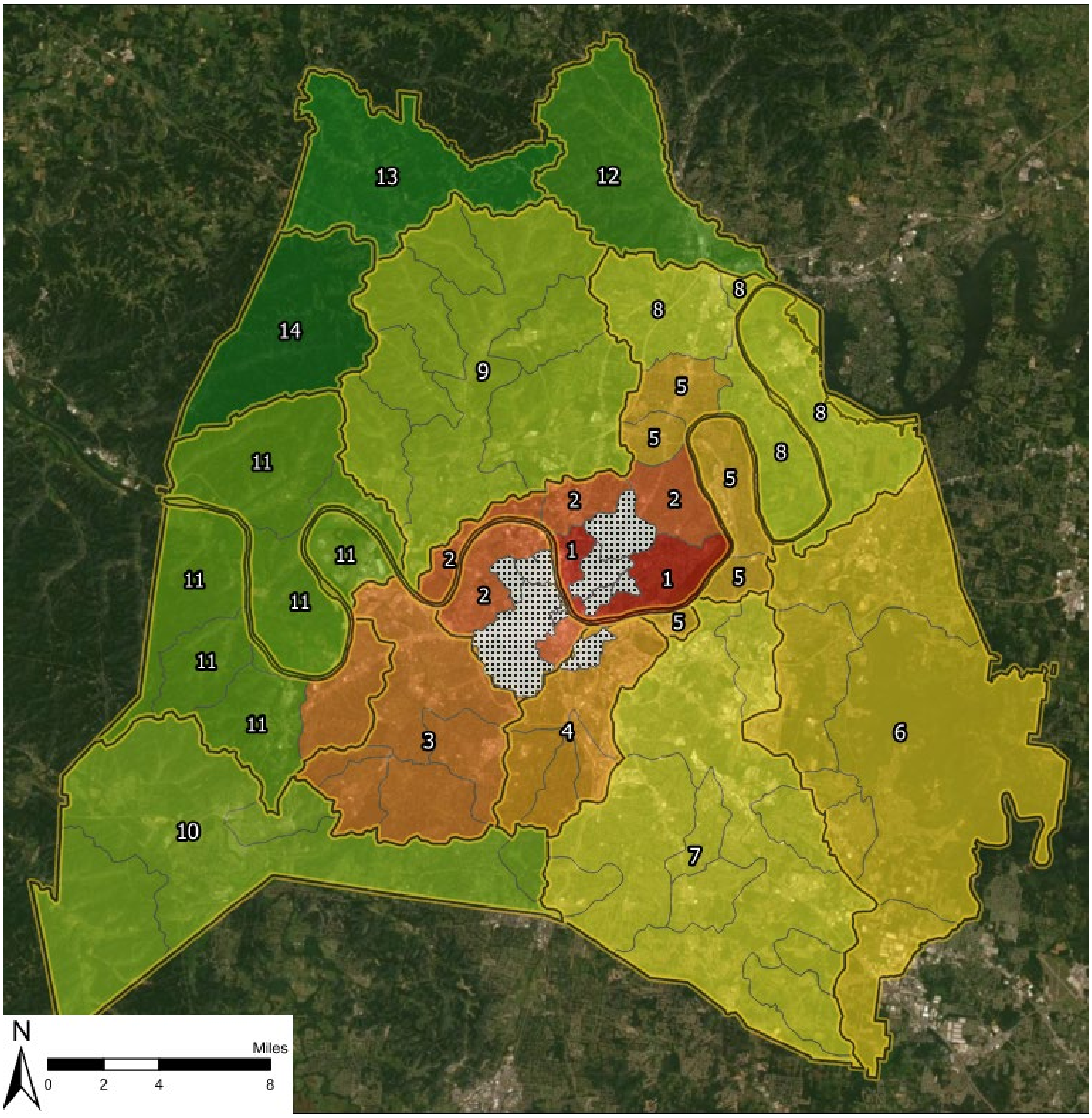


Figure 1: Location Map for Prioritization Ranking

Based on the discussion at our last Advisory Committee meeting, we have revised the proposed alternatives to outfall-based alternatives rather than smaller alternatives that may rely on downstream improvements. This approach results in fewer but larger alternative projects. It is assumed that if portions of an outfall-based alternative are implemented, they will occur from the most downstream point and progress upstream.

Models and draft masterplans have been created for all five sub-basins within priority 1 basins and four more models are currently being developed in priority 2 basins. Models and masterplans in priority 1 basins are being updated based on the coordination between Barge and CDM Smith project teams and the new outfall-based approach to alternatives. Barge is currently performing a climate change analysis to determine the potential effect that climate change may have on future rain events in middle Tennessee.

The results of the analysis will be summarized in the report and presented to the advisory committee for discussion.

The next Advisory Committee meeting will be scheduled in February. We will present results of the modeling for the additional sub-basins, discuss alternatives that have been developed or revised, and review the results of the climate change analysis, if complete. We will also present any changes in decision criteria and scoring that have been discussed during previous Advisory Committee meetings.

APPENDIX D – GIS Inventory Schema

MEMORANDUM

TO: MWS

FROM: Barge

RE: GIS Data Processing

With over 40 years of GIS experience, Barge brings a unique blend of technical expertise and hands-on field data collection knowledge to every project. This dual capability enables us to fully harness the power of the ESRI ecosystem - from data capture in the field to automated processing and final data delivery - ensuring we meet the operational and analytical needs of our clients with precision and efficiency.

Our deep-rooted experience in GIS spans decades of evolving technology and industry practices, which allows us to design and implement modern, schema-driven data collection workflows for ArcGIS Field Maps. Field Maps, paired with High-Accuracy GNSS hardware, empowers field personnel to collect accurate, structured data in real time. To ensure accuracy from the onset, Barge embeds best practices into the experience - enforcing domains, leveraging subtypes, and using smart forms to calculate field values on the fly.

Once data is collected, Barge disseminates the data across internal and client stakeholders through the Esri platform and integrations. Utilizing real-time dashboards and web maps stakeholders at all levels can visualize operational data through intuitive interfaces, enabling rapid decision-making. These dashboards display key performance indicators, map-based visualizations, and historical trends, offering a common operating picture for all project stakeholders. In support of decision-making and system improvement Barge implemented business logic during data collection to send stakeholder's emails outlining major issues such as structural damage and illegal connections – providing site description and pictures of the assets current state.

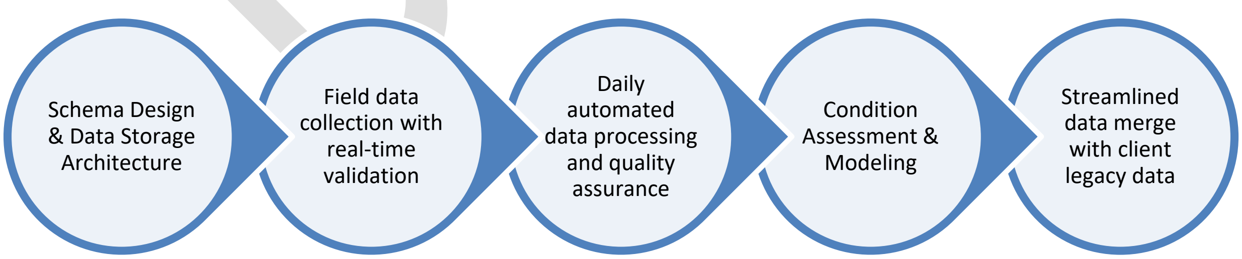


Figure 1. Process Visualization

By leveraging ESRI's modern GIS capabilities—combined with our decades of hands-on experience in GIS data management and automation—organizations can achieve a higher standard of data quality, situational awareness, and cross-functional collaboration. This unified approach fosters more informed decision-making, promotes accountability, and enhances the overall efficiency and effectiveness of operations.

APPENDIX E – Project Prioritization

DRAFT
SWMP PROJECT PRIORITIZATION

Prepared For: Metro Water Services

3787505
June 2025

CONTENTS

FIGURES

1.0 PROJECT SCORING

1.1 Asset Management Plan Scoring (AMPS) Tool

A fundamental goal of the MWS Stormwater Masterplan is to develop and evaluate alternatives for the long-term management of stormwater generated from the City of Nashville's drainage areas. The analysis of each developed alternative included schedule, economic, social, environmental, and flood reduction considerations to allow for a thorough vetting of each solution and, ultimately, the selection of a solution to meet the needs of MWS. Therefore, before a decision on an alternative can be made, the various factors, or criteria that influence a decision, must be identified and weighted in a way that reflects the stakeholders' values. The decision making and weighting process is described in Reference 5 with the highest ranked criteria being:

- Public Safety / Risk Reduction
- Water Quality Impacts
- Partnering Opportunities
- Habitat Impacts
- Protection of Critical Services / Emergency Response
- Capital Costs

In order to automate the weighting and prioritization computations, Barge Design Solutions, Inc (Barge) developed a GIS-based user interface named the AMPS Tool to be used to score each identified stormwater improvement project and produce a weighted, tiered list of priority projects. Figure 1 depicts the user-interface in which projects are scored.

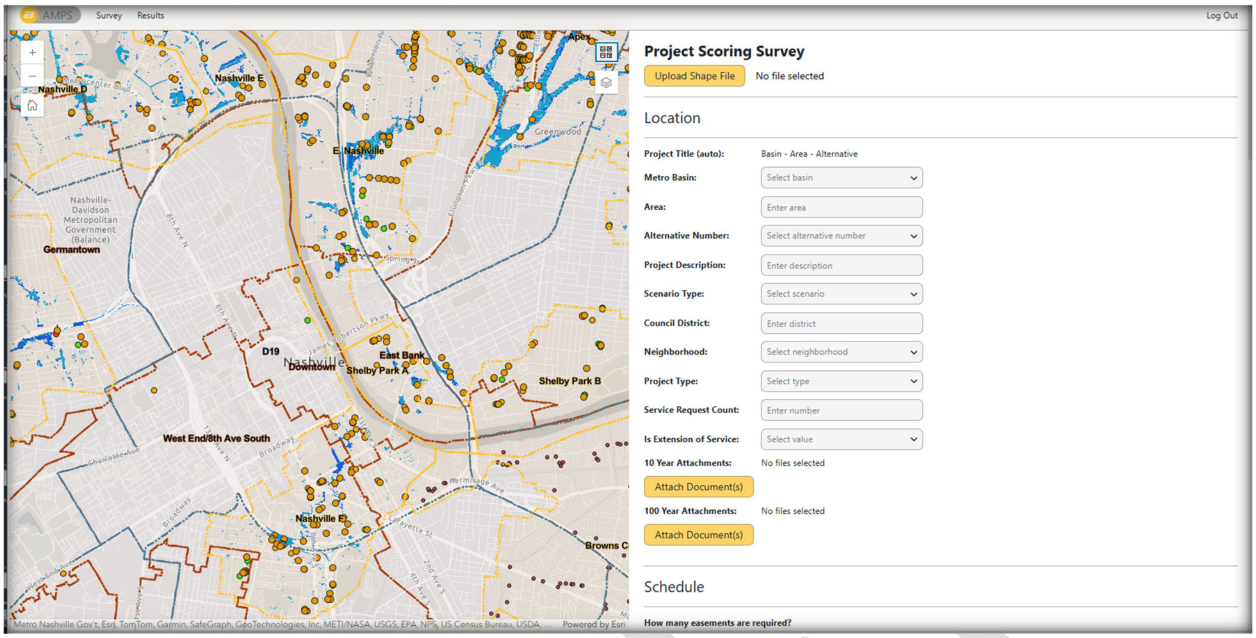


Figure 1. AMPS Project Scoring User-Interface

2.0 PROJECT PRIORITIZATION

2.1 Project Prioritization Results

Once each project has been scored, the weights, determined by the Advisory Committee, are applied and the projects are ranked according to their final weights. Projects whose score ranks in the top 80th percentile are considered Tier 1, or priority projects. Projects between the 20th and 80th percentile are in Tier 2 and those in the bottom 20th percentile in Tier 3. Of the top ranked projects to date, three are located in downtown, six in East Nashville, two in Inglewood, four in North Nashville and six in West Nashville, as shown in Figure 2. As additional projects are developed and scored, the AMPS tool re-calculates and updates the ranking and tiers, expanding the list of priority projects.

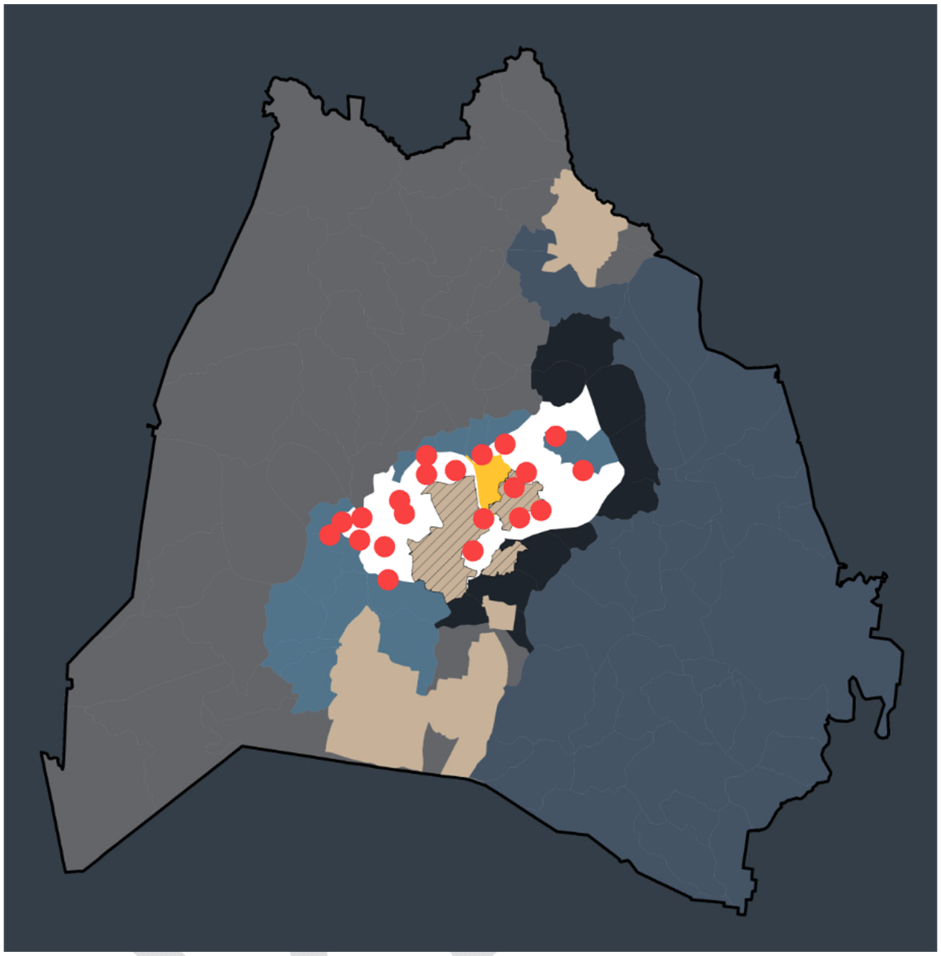


Figure 2 – Location of Top Ranked Projects (as of June 2025)

The Results page of the AMPS tool allows MWS to sort and filter the weighted projects for their use and analysis according to a variety of criteria including watershed, neighborhood, project type and rank. Figure 3 depicts the results page of the AMPS tool.

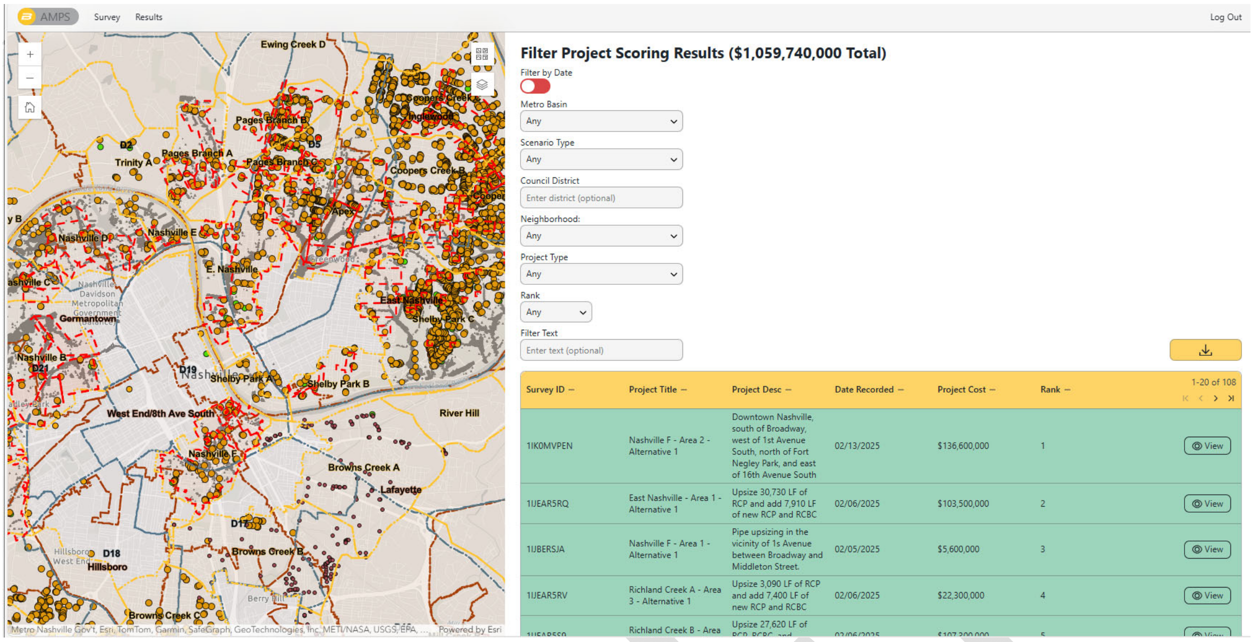


Figure 3 –AMPS Project Scoring Results User-Interface

APPENDIX F – Climate Resiliency Analysis

To:	Metro Water Services
Cc:	Barge Design Solutions
From:	Paradigm Environmental
Date:	6/13/2024
Re:	Climate Resiliency Analysis to Support Stormwater Master Planning in Metro Nashville – Future Design Storms

Changing climate is forecasted to significantly impact rainfall patterns around the world. To support water resources planning, Earth system models (ESMs) have been widely used to predict future climate variability (Arias et al., 2021; Barsugli et al., 2009; Eyring et al., 2016). These projections typically forecast higher peak rainfall events that can potentially put strain on stormwater conveyance systems and flood control facilities. Given the lifespan of flood control infrastructure, it is essential to account for future conditions to ensure effective and efficient design of these systems This technical memorandum summarizes the results of a climate change analysis using current and projected future design storms for downtown Nashville. The analysis uses an ensemble of spatially and temporally downscaled ESMs to develop projected future design storm depths. These future depths and percentage changes from current values can be applied to any appropriate 24-hr precipitation distribution as necessitated by infrastructure-specific planning and design requirements.

1 DESIGN STORMS – CURRENT CONDITIONS

Design storms are regularly used for flood control planning and stormwater design and are based on analyses of historical rainfall that varies spatially and temporally throughout the region. Three design storms were evaluated in this analysis representing a range of return intervals (10-yr, 25-yr, and 100-yr). The precipitation totals for these design storms with a 24-hour duration were provided by Barge Design Solutions and correspond to 4.76 in, 5.60 in, and 6.98 in, respectively.

2 ANALYSIS OF FUTURE METEOROLOGICAL CONDITIONS

The Intergovernmental Panel on Climate Change (IPCC) Coupled Model Inter-comparison Project Phase 6 (CMIP6) ensembles of ESMs were used to evaluate the potential impact of future climate projections (Eyring et al. 2016). This collection of ESMs includes models that can evaluate future climate across the globe using five Shared Socio-economic Pathways (SSPs). Each SSP is associated with at least one representative concentration pathway (RCP) based on greenhouse gas-induced increases in radiative forcing and temperature. SSPs represent a range of development scenarios based on factors influencing global temperature change such as energy use, land use, and emissions trajectories (Riahi et al., 2017). The radiative forcing and global surface temperature change trajectories used in CMIP6 are shown in Figure 2-1; narrative descriptions of the SSPs are given in Table 2-1.

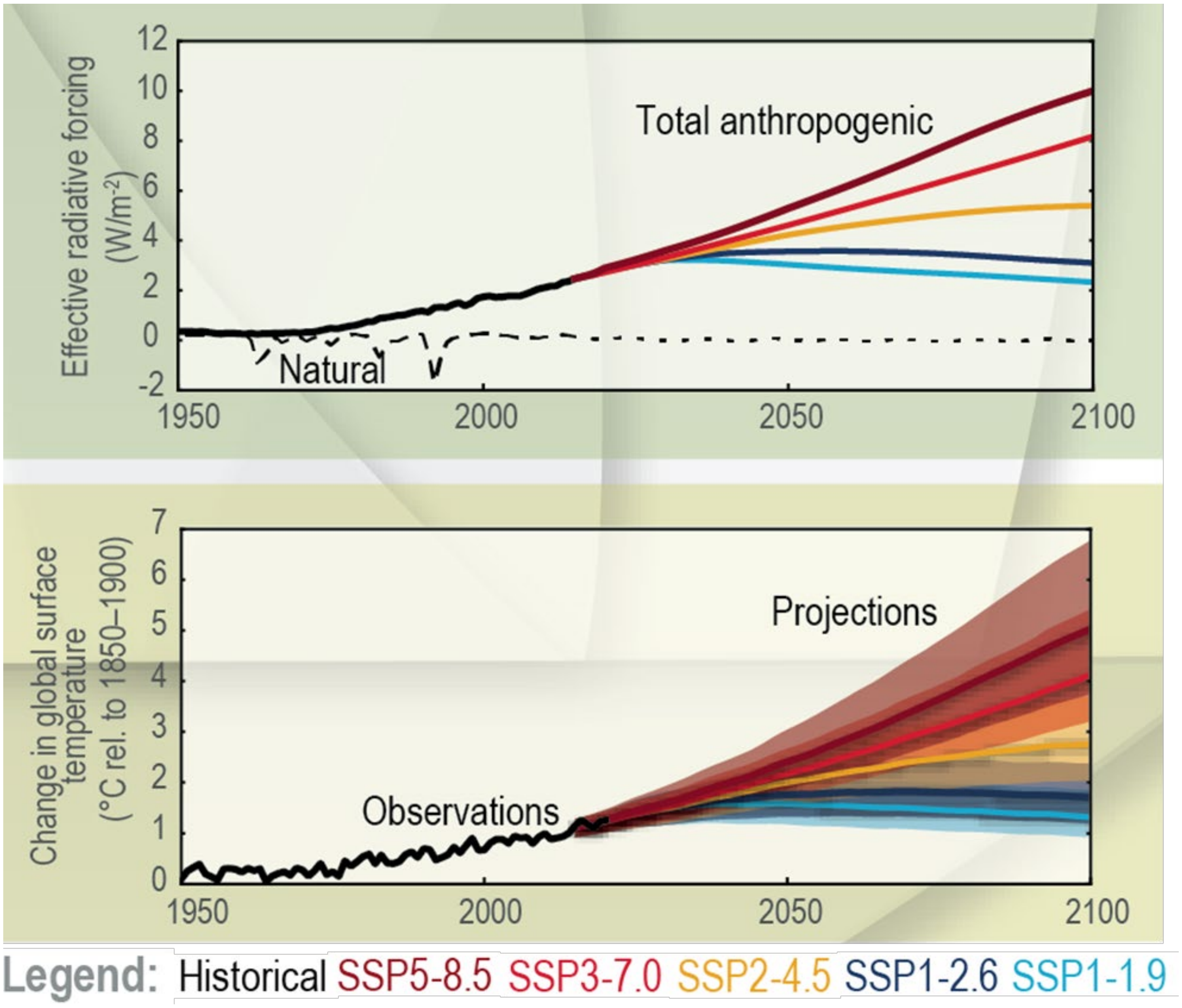


Figure 2-1. Projections of radiative forcing and global surface temperature change used in CMIP6 by SSP (adapted from Figure TS.4 of Arias et al. [2021]).

Table 2-1. SSPs used in CMIP6 and their associated RCP and description (adapted from Riahi et al. [2017])

SSP	RCP(s)	Description
1	1.9	**Sustainability**: The world shifts gradually, but pervasively, toward a more sustainable path, emphasizing more inclusive development that respects perceived environmental boundaries.
	2.6	
2	4.5	**Middle of the road**: The world follows a path in which social, economic, and technological trends do not shift markedly from historical patterns.
3	7.0	**Regional rivalry**: A resurgent nationalism, concerns about competitiveness and security, and regional conflicts push countries to increasingly focus on domestic or, at most, regional issues.
4	3.4	**Inequality**: Highly unequal investments in human capital, combined with increasing disparities in economic opportunity and political power, lead to increasing inequalities and stratification both across and within countries.
5	8.5	**Fossil-fueled development**: This world places increasing faith in competitive markets, innovation and participatory societies to produce rapid technological progress and development of human capital as the path to sustainable development. Global markets are increasingly integrated.

Most ESMs operate at coarse temporal and spatial resolutions (monthly timesteps, and grid cells of 1 degree). However, most hydrological models require finer spatial and temporal resolutions. Statistical downscaling allows modelers to derive fine-resolution datasets from coarse-resolution datasets by using statistical relationships between the coarse and fine resolution data. Raw ESM data have been downscaled to a locally appropriate spatial resolution (approximately 3.7 mi^2) with daily temporal resolution by researchers at the Scripps Institution of Oceanography. These data were downscaled using the Localized Constructed Analogues (LOCA) technique and are one of the datasets being used to inform the Fifth National Climate Assessment (NCA5); additional details are described in Pierce et al. (2014 and 2023). Data from the Scripps LOCA repository (https://cirrus.ucsd.edu/~pierce/LOCA2/) were downloaded for 21 ESMs (Table 2-2), each with 1 historical simulation and 3 of the 5 SSPs (SSP2-4.5, SSP3-7.0, and SSP5-8.5). Modeled historical simulations cover 1950-2014 and future simulations cover 2015-2100. These 84 scenarios were extracted into daily time series for the LOCA grid cell covering downtown Nashville (Figure 2-2).

Table 2-2. Twenty-one selected ESMs used in this analysis

ESM	ACCESS-CM2	ACCESS-ESM1-5	AWI-CM-1-1-MR	BCC-CSM2-MR	CanESM5
	CNRM-CM6-1*	CNRM-ESM2-1*	EC-Earth3-Veg	EC-Earth3	FGOALS-g3
	GFDL-ESM4	INM-CM4-8	INM-CM5-0	IPSL-CM6A-LR	KACE-1-0-G
	MIROC6	MPI-ESM1-2-HR	MPI-ESM1-2-LR	MRI-ESM2-0	NorESM2-LM
	NorESM2-MM	* denotes ESM with forcing input 1 unavailable; ESM uses forcing input 2			

Before future design storms were created, several key metrics of the precipitation and temperature time series were evaluated to understand the trends across ESMs and SSPs. Examining the daily precipitation depths for days with rainfall $\geq$ 0.1 in shows that values at or below the median (50^{th} percentile) are stable between the modeled historical and future SSPs (Table 2-3). At the 75^{th} percentile and above, future depths increase with SSP and time period (mid-century, end of century) compared to the modeled historical. For example, across ESMs, the mean depth of the top 10% of wet days from 2015-2100 increases from the modeled historical by 7%, 9%, and 10% for SSPs 2-4.5, 3-7.0, and 5-8.5, respectively. Annual total rainfall shows similar trends in increasing precipitation with median end of century increases ranging from 7% to 9% (Table 2-4). While precipitation depths show increasing values, the annual average number of consecutive dry days between wet days also shows only slight increases, indicating that storm events may be more intense with longer periods between them (Table 2-5).

Daily minimum and maximum temperature, while not necessary for the development of future design storms, were also evaluated for trends in future conditions by month. As expected, all statistics for maximum (Table 2-6) and minimum temperature (Table 2-7) show increases compared to the modeled historical values. The winter months show the greatest percentage increase in temperature, which could lead to more intense winter storms consistent with the findings of Almazroui et al. (2021), Pierce et al. (2023), and Zhao et al. (2023).

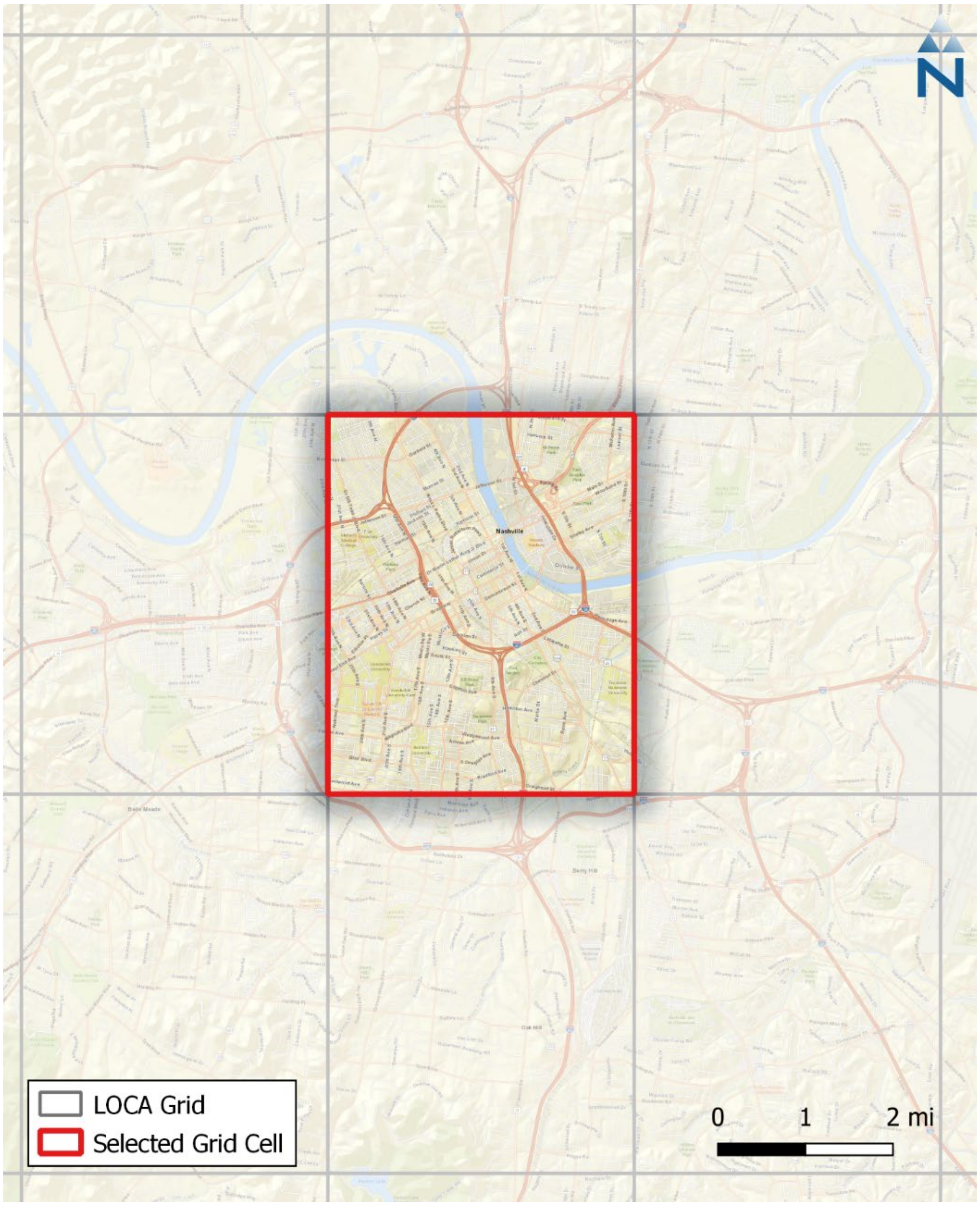


Figure 2-2. LOCA downscaled future climate grid cells and selected cell for downtown Nashville.

Table 2-3. Wet day (rainfall ≥ 0.1in) percentile statistics across modeled historical and future scenarios

Percentile	Historical Precip. (in)	2015 - 2100 Precip. (in)			2040 - 2060 Precip. (in)			2080 - 2100 Precip. (in)		
		SSP2-4.5	SSP3-7.0	SSP5-8.5	SSP2-4.5	SSP3-7.0	SSP5-8.5	SSP2-4.5	SSP3-7.0	SSP5-8.5
5th	0.11	0.11	0.11	0.11	0.11	0.12	0.11	0.11	0.11	0.12
25th	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
50th	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.34
Mean	0.48	0.49	0.50	0.50	0.49	0.49	0.49	0.49	0.51	0.52
75th	0.60	0.61	0.62	0.62	0.61	0.62	0.62	0.62	0.63	0.64
95th	1.26	1.31	1.34	1.34	1.30	1.32	1.32	1.33	1.38	1.41
Mean Top 10%	1.49	1.59	1.62	1.64	1.56	1.57	1.57	1.61	1.69	1.72

Table 2-4. Summary changes in annual total precipitation depth for modeled historical and future scenarios

Statistic	SSP	Annual Total Rainfall (in)			Percentage Change	
		Historical	2040-2060	2080-2100	2040-2060	2080-2100
25^{th} Percentile	2-4.5	44.80	46.22	46.98	3%	5%
	3-7.0	44.80	46.17	47.74	3%	7%
	5-8.5	44.80	46.26	48.44	3%	8%
Mean	2-4.5	50.22	51.72	52.76	3%	5%
	3-7.0	50.22	51.78	53.48	3%	6%
	5-8.5	50.22	52.33	54.64	4%	9%
50th Percentile	2-4.5	49.65	51.08	53.36	3%	7%
	3-7.0	49.65	51.39	52.98	3%	7%
	5-8.5	49.65	52.67	54.34	6%	9%
75th Percentile	2-4.5	55.22	56.85	57.82	3%	5%
	3-7.0	55.22	56.95	59.32	3%	7%
	5-8.5	55.22	57.75	60.62	5%	10%

Color gradient legends:

Low	Median	High

Low	Median	High

Table 2-5. Summary changes in the average number of consecutive dry days for modeled historical and future scenarios

Statistic	SSP	Average Consecutive Dry Days per Year			Percentage Change	
		Historical	2040-2060	2080-2100	2040-2060	2080-2100
25th Percentile	2-4.5	4.4	4.4	4.4	0%	1%
	3-7.0	4.4	4.5	4.5	3%	1%
	5-8.5	4.4	4.4	4.6	0%	4%
Mean	2-4.5	5.1	5.2	5.2	2%	2%
	3-7.0	5.1	5.3	5.4	4%	6%
	5-8.5	5.1	5.3	5.3	3%	5%
50th Percentile	2-4.5	4.9	4.9	5.0	-1%	2%
	3-7.0	4.9	5.1	5.1	2%	3%
	5-8.5	4.9	5.1	5.1	2%	2%
75th Percentile	2-4.5	5.6	5.7	5.7	1%	3%
	3-7.0	5.6	5.8	5.9	3%	6%
	5-8.5	5.6	5.8	5.8	3%	4%

Color gradient legends:

Low	Median	High

Low	Median	High

Table 2-6. Percentage change in monthly average daily maximum temperature from modeled historical median to modeled future conditions

SSP	Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2-4.5	25th Percentile	4%	2%	1%	2%	3%	3%	3%	3%	3%	3%	3%	3%
3-7.0		3%	2%	1%	2%	3%	3%	3%	4%	4%	4%	3%	4%
5-8.5		4%	4%	2%	3%	4%	4%	4%	4%	5%	5%	5%	5%
2-4.5	Mean	11%	9%	6%	5%	6%	5%	5%	6%	6%	7%	8%	9%
3-7.0		12%	10%	7%	6%	7%	7%	6%	7%	7%	8%	9%	10%
5-8.5		13%	11%	8%	7%	8%	8%	7%	8%	8%	10%	10%	12%
2-4.5	50th Percentile	11%	8%	6%	5%	6%	5%	5%	6%	6%	7%	8%	9%
3-7.0		11%	10%	7%	6%	7%	6%	6%	6%	7%	8%	8%	10%
5-8.5		13%	11%	8%	7%	7%	7%	7%	7%	8%	9%	10%	12%
2-4.5	75th Percentile	18%	15%	11%	9%	9%	8%	7%	8%	9%	11%	13%	15%
3-7.0		19%	16%	12%	10%	10%	9%	9%	10%	10%	13%	14%	16%
5-8.5		21%	18%	14%	12%	12%	11%	10%	11%	12%	14%	16%	18%

Color gradient legend:

Lowest	Low	Median	High	Highest

Table 2-7. Percentage change in monthly average daily minimum temperature from modeled historical median to modeled future conditions

SSP	Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2-4.5	25th Percentile	6%	3%	1%	2%	4%	4%	4%	5%	5%	4%	3%	4%
3-7.0		6%	5%	3%	4%	5%	5%	5%	5%	6%	5%	4%	6%
5-8.5		9%	7%	4%	5%	5%	6%	5%	6%	7%	7%	6%	9%
2-4.5	Mean	19%	14%	9%	8%	7%	7%	6%	7%	8%	10%	10%	14%
3-7.0		20%	17%	11%	9%	9%	8%	8%	9%	10%	12%	12%	16%
5-8.5		22%	19%	13%	11%	10%	10%	9%	10%	12%	14%	15%	19%
2-4.5	50th Percentile	18%	13%	9%	8%	7%	7%	6%	7%	9%	9%	11%	14%
3-7.0		19%	16%	11%	9%	9%	8%	8%	8%	10%	12%	12%	15%
5-8.5		22%	19%	13%	11%	10%	9%	8%	10%	12%	14%	15%	18%
2-4.5	75th Percentile	30%	24%	17%	13%	11%	9%	8%	10%	12%	15%	18%	23%
3-7.0		31%	27%	20%	15%	13%	12%	11%	12%	15%	18%	20%	24%
5-8.5		35%	30%	22%	17%	15%	14%	12%	14%	17%	21%	24%	28%

Color gradient legend:

Lowest	Low	Median	High	Highest

3 DESIGN STORMS – FUTURE CONDITIONS

Future design storm rainfall depths were generated using the existing hyetographs described in Section 1 (used for defining current conditions), and LOCA daily downscaled precipitation data for each climate scenario. For each return frequency storm (10-yr, 25-yr, and 100-yr), 24-hour rainfall depths were extracted from the LOCA modeled historical and future datasets for each ESM and SSP. The median values across all ESMs for each SSP were calculated, and then the percentage change between modeled historical and future was calculated. These percentage changes were then applied to the current condition rainfall depths to create future projections for each design storm. Figure 3-1 provides an illustration of this process.

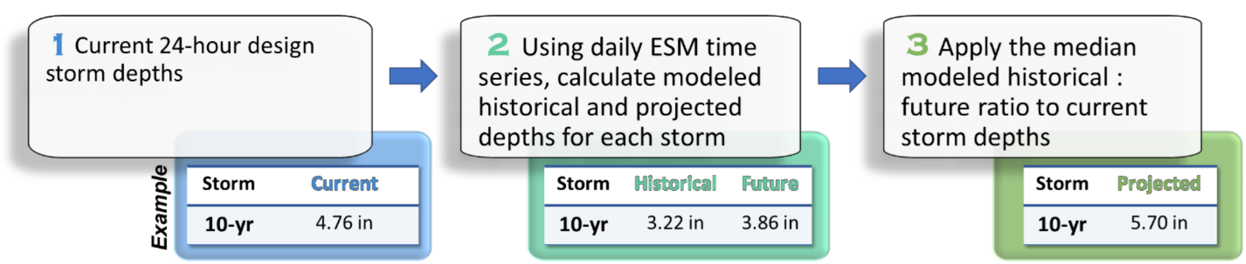


Figure 3-1. Workflow summary for developing future design storm magnitudes (with 10-yr storm example).

Table 3-1 and Table 3-2 provide summaries of the rainfall depth and percentage change in future rainfall depth relative to the modeled historical design storm magnitudes for each return period. These tables include color shading to highlight the relative differences in rainfall depth projections for each storm and SSP. For a given statistic (e.g., median, mean), differences between SSPs in terms of depth for a given return period are relatively small. For example, the mean 10-yr, 24-hr depths are 3.91 in, 3.91 in, and 3.96 in for SSPs 2-4.5, 3-7.0, and 5-8.5, respectively, which corresponds to an 18%-20%

increase compared to the historical value (3.22in). This increasing trend in precipitation intensity can also be seen by comparing the historical median 100-yr value (4.77 in) to the median 25-yr values for all three SSPs (4.71in – 4.91in). This is supported by the findings of Pierce et al. (2023), who report similar increases in the frequency of large events.

Table 3-1. Precipitation depth statistics for modeled historical and future design storms for each SSP across the ensemble of ESMs

SSP	Percentile	Rainfall Depth (in)		
		10yr	25yr	100yr
Historical	25th	3.16	3.55	4.14
	50th	3.22	3.80	4.77
	75th	3.57	4.21	5.30
	Mean	3.31	3.86	4.76
2-4.5	25th	3.65	4.41	5.67
3-7.0		3.74	4.44	5.54
5-8.5		3.68	4.31	5.53
2-4.5	Mean	3.91	4.84	6.57
3-7.0		3.91	4.77	6.30
5-8.5		3.96	4.85	6.46
2-4.5	50th	4.01	4.91	6.47
3-7.0		3.86	4.71	6.10
5-8.5		3.93	4.83	6.35
2-4.5	75th	4.06	5.15	7.04
3-7.0		4.02	5.10	6.81
5-8.5		4.28	5.29	7.25

Color gradient legend:

Lowest	Low	Median	High	Highest

Table 3-2. Percent change from modeled historical to 2100 for design storms for each SSP across the ensemble of ESMs. Bold values were used to create future design storms

SSP	Percentile	Percentage Change in Rainfall Depth from Modeled Historical Median to Modeled Future Conditions		
		10yr	25yr	100yr
2-4.5	25th	13%	16%	19%
3-7.0		16%	17%	16%
5-8.5		14%	13%	16%
2-4.5	Mean	18%	25%	38%
3-7.0		18%	23%	32%
5-8.5		20%	26%	36%
2-4.5	50th	**24%**	**29%**	**36%**
3-7.0		**20%**	**24%**	**28%**
5-8.5		**22%**	**27%**	**33%**
2-4.5	75th	26%	36%	48%
3-7.0		25%	34%	43%
5-8.5		33%	39%	52%

Color gradient legend:

Lowest	Low	Median	High	Highest

While not critical to the development of future design storms, it is interesting to note that SSP2-4.5 (which represents the lowest RCP) has the greatest future depth for all design storms. However, the differences among SSPs for each design storm are slight and may be due to noise in the future climate time series given that the mean values between SSP design storm depths don't vary significantly over time. A paired t-Test was conducted to evaluate the significance of differences between SSP design storm depths. As shown in Table 3-3, all t-Test results have p-values lower than 0.0001, suggesting that any perceived differences in mean values are not statistically significant. Additionally, given Nashville's location, recent literature indicates little difference between SSPs for several measures of extreme precipitation (Zhao et al., 2023).

Table 3-3. t-Test p-values comparing SSP vs. historical design storm depths from 21 ESMs

SSP	p-value for Paired t-Test of the Mean for 21 GCMs by SSP vs. Historical		
	10-yr	25-yr	100-yr
2-4.5	0.000003	0.000006	0.000017
3-7.0	0.000002	0.000007	0.000042
5-8.5	0.000003	0.000013	0.000071

Color gradient legend:

Lowest	Low	Median	High	Highest

After the analyses presented above, the projected future design storm depths were calculated by applying the median percentage increases for the 10-yr, 25-yr, and 100-yr storms by SSP to the current design storm as shown in Table 3-4. These total depths and percentage changes can be applied to any appropriate 24-hr design storm distribution as necessitated by infrastructure planning and design requirements.

Table 3-4. Final total rainfall depths and percentage increases compared to current values by return period and SSP

Return Period (yr)	Total 24-hr Design Storm Depth (in)				Change from Current Value (%)		
	Current	SSP2-4.5	SSP3-7.0	SSP5-8.5	SSP2-4.5	SSP3-7.0	SSP5-8.5
10	4.76	5.93	5.70	5.81	24%	20%	22%
25	5.60	7.24	6.94	7.11	29%	24%	27%
100	6.98	9.47	8.92	9.29	36%	28%	33%

4 CONCLUSIONS

This technical memorandum presented analyses of projected future precipitation from an ensemble of Earth system models and Shared Socioeconomic Pathways. After evaluating and understanding relevant changes to future precipitation across the ensembles, future 24-hr storm depths were calculated for each ensemble member and 10-yr, 25-yr, and 100-yr return periods. Future design storms increased in depth for all three storms compared to the current values; increases ranged from 20% - 24% for the future 10-yr storm, 24% - 29% for the future 25-yr storm, and 28% - 36% for the future 100-yr storm. The maximum future 100-yr design storm, for example, has a depth of 9.5-in, which equates to a 2.5-in increase compared to the current value of 7-in. The design storm depths based on SSP 2-4.5 are recommended for use in cases where a single design storm needs to be chosen for planning purposes; SSP 2-4.5 represents a middle of the road future scenario based on past trends and, in this case, also have the largest percentage increases, making them a conservative choice. The future design storm depths developed under this task can be applied to any appropriate 24-hr precipitation distribution and used as inputs for stormwater master plan modeling under a range of future conditions, which will allow MWS to make informed planning decisions considering margins of safety for climate resiliency.

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