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Project name:
Evaluations and Recommendations for Central Park Project Area

Project ref:
60607729

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From:
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Date:
August 7, 2020

Technical Memorandum

Subject: Evaluations and Recommendations for Central Park Project Area

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1. INTRODUCTION

The City of Charleston (City) retained AECOM to evaluate the Central Park watershed, assess the existing infrastructure and recommend measures to improve surface water management. Stormwater drainage is a major challenge in the City. The existing stormwater system is either inadequate or in need of maintenance in a large portion of the City. Numerous incidents of surface flooding during periods of moderate to heavy rainfall have occurred and have been exacerbated by high tide water levels and storm surge. The severity of flooding varies by location based on the intensity and duration of the rain. The City prepared a Master Drainage and Floodplain Management Plan in 1984 (1984 Master Plan) to outline a comprehensive program to identify and correct deficiencies in the existing systems and accommodate a practical Level of Service (LOS) with the available resources.

The 1984 Master Plan recommended improvements for all areas within the City boundaries. The 1984 Master Plan included portions of the Central Park watershed but not in its entirety. The recommended improvements consisted of increasing the culverts/pipes in their existing alignment and installing pipes/culverts either adjacent to or following the same route as the existing pipes/culverts or along an alternate route. Subsequent to the 1984 Master Plan, the City has experienced significant population growth and development, resulting in changes to topography, drainage patterns, and impervious areas. The City identified a need to evaluate the Central Park watershed given the changes in the topology and the frequency of flooding in the watershed.

2. PROJECT OBJECTIVES

The purpose of this study is to identify and map the existing stormwater collection, detention, and conveyance structures; evaluate their capacity within the watershed for different storm events; and recommend improvements. With ongoing and future redevelopment within the watershed, the City requested that redevelopment plans for the area be considered integrated into stormwater management improvement recommendations. As part of the study, AECOM identified flood-prone areas and recommends conceptual improvements to reduce roadway flooding to acceptable levels.

This study includes identifying the status of capital improvement projects recommended in the 1984 Master Plan. The Technical Memorandum includes the following components to meet the desired objectives:

- Data Collection and Review
- Watershed Modeling
- Level of Service
- Recommended Improvements and Prioritization

3. STUDY AREA

The Central Park watershed is located on James Island enclosed by Maybank Highway in the North, Folly Road in the East, Central Park Rd in the South, and Riverland Drive and Woodland Shores Road in the West. The study area is shown in **Figure 1**. The project encompasses a total area of approximately 500 acres and is made up primarily of residential developments with some small commercial developments and open spaces. The primary drainage feature for this watershed is a large drainage channel conveying runoff from the northern sections of the watershed to James Island Creek which is tidally impacted. The Central Park watershed drains through a network of small roadside drainage ditches and culverts. The watershed is generally flat without much topographic relief. Ponding and backwater influence are prevalent during storm events concurrent with high tides.

Figure 1 – Central Park Watershed Study Area Map

3.1 Topography

The Central Park watershed LiDAR terrain imagery shows that the watershed is generally flat with elevations ranging from 19 feet NAVD88 at the most upstream end of the watershed to -1.0 feet NAVD88 at the downstream end near the James Island Creek. The watershed slope is approximately 0.2 – 0.3 percent. Severe flooding occurs when storm events coincide with high tide in the James Island Creek, resulting in ponding and backwater effects. **Figure 2.** shows the topography of the study area used for the model.

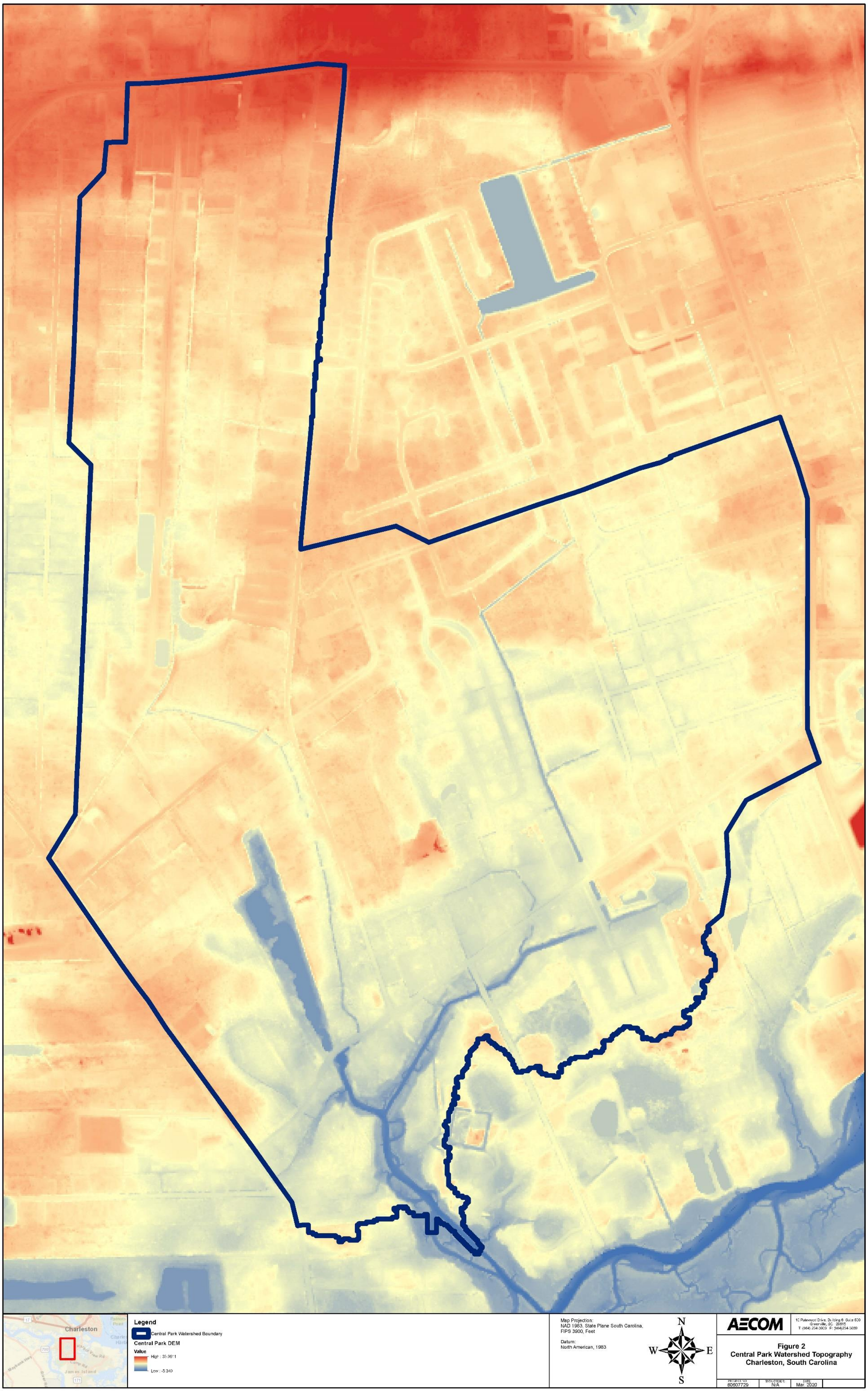


Figure 2 – Central Park Watershed Topography Map

3.2 Land Use

Land Use and land cover maps for the watershed were created using the latest Zoning Data obtained from the City and the Charleston County (County). The Land Use file was generated based on current conditions.

The land use/land cover types obtained from the City and County were consolidated to the following as listed in **Table 1** and used for the development of Curve Numbers:

Table 1 – Central Park Watershed Land Use Types

Land Use Type
Impervious Areas: Dirt (including right-of-way)
Impervious Areas: Paved parking lots, roofs, driveways, etc.
Impervious Areas: Paved; open ditches (including right-of-way)
Impervious Areas: Paved; curbs and storm sewers
Open Space - Good Condition
Residential: 1 Acre
Residential: 1/2 acre
Residential: 1/3 Acre
Residential: 1/4 Acre
Residential: 1/8 Acre or Less
Urban District: Commercial and Business
Urban District: Industrial
Water
Woods
Woods - Grass Combination
Urban District: Commercial and Office
Paved Streets

Three areas of potential development were identified in the Central Park watershed. They were Central Park Cluster, Fleming Cluster (also known as Marlborough), and the Brisbane Cluster. Out of these three areas, Fleming Cluster has already been fully developed, while Central Park Cluster and Brisbane cluster have been permitted and are about to be developed. All three developments are included in the existing conditions model.

About 60 percent of the land use in the Central Park watershed is categorized as residential and commercial development with the remaining portion open spaces/water. The land use/land cover types were used for setting the model rainfall/runoff curve numbers. **Figure 3** presents the land use map of the study area.

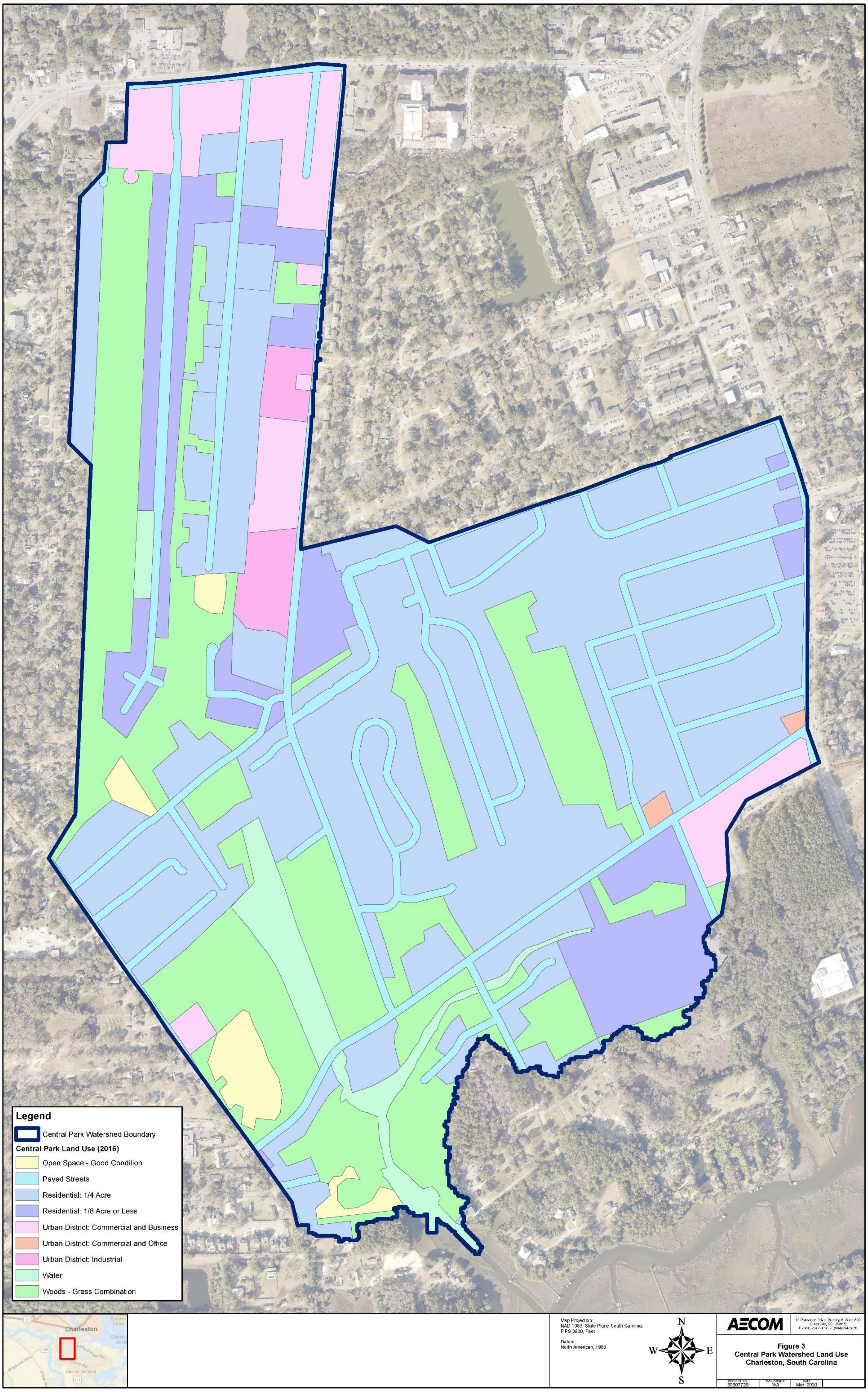


Figure 3 – Central Park Watershed Land Use/Land Cover Map

3.3 Soils

Soils for the Central Park Watershed are provided by the USDA NRCS via Web Soil Survey (WSS). The WSS provides soil data and information produced by the National Cooperative Soil Survey. It is operated by the USDA Natural Resources Conservation Service (NRCS) and provides access to natural resource information. The soil types range from sandy loam to clay loam. Approximately 59% of the watershed contains soils categorized as Hydrologic Soil Group (HSG) B, which have moderately low runoff potential when thoroughly wet and approximately 35% as HSG D, which have high runoff potential and low infiltration rates. **Figure 4** provides the soil classification of the study watershed.

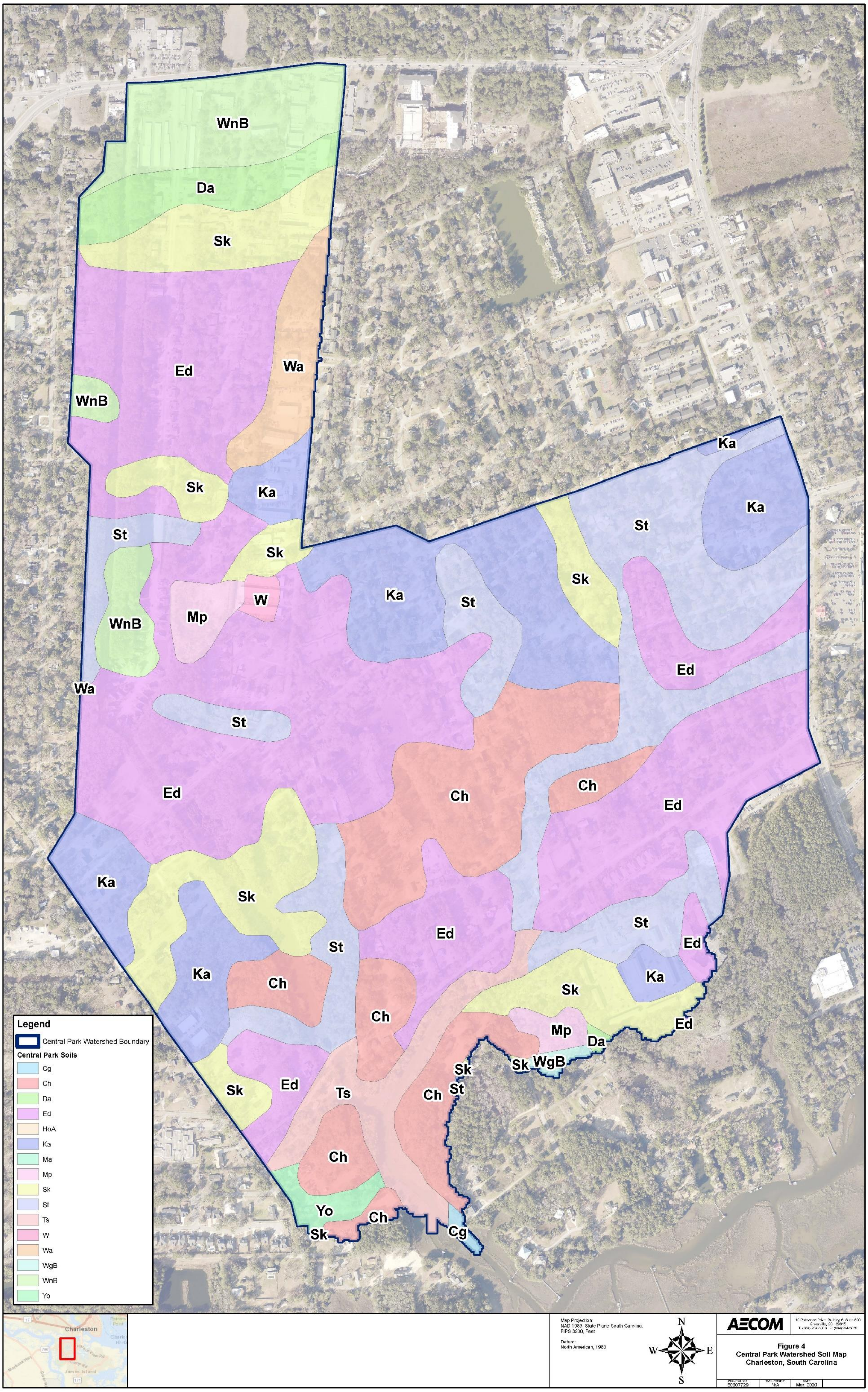


Figure 4 – Central Park Watershed Soil Classification Map

3.4 Rainfall

The mean annual rainfall in the City is approximately 50 to 52 inches (South Carolina Climatology Office) and varies due to natural geographic features, such as the extensive river/marsh systems. The National Oceanic and Atmospheric Administration (NOAA) estimates the mean annual rainfall to be 51.03 inches at the Charleston International Airport, whereas the mean annual rainfall on the peninsula (downtown Charleston) is 44.42 inches. Mean annual rainfall is shown in **Table 2**.

Table 2 – Mean Annual Rainfall for Charleston, South Carolina

Mean Annual Rainfall (inches)	Data Source and Date
50-52	South Carolina State Climatology Office. Accessed 2019
51.06	US Climate Data, 2019
44.42 – Downtown Charleston	National Oceanic and Atmospheric Administration, 2010
51.03 – Charleston Airport	National Oceanic and Atmospheric Administration, 2010

3.5 Tidal Boundary Conditions

The Central Park watershed's final point of discharge is to James Island Creek, which is tidally influenced. A NOAA weather station (ID 8665530) is in the vicinity of the DuWap/Central Park watershed at the mouth of Cooper River. Station 8665530 was established in 1899 and is currently operational. Data obtained from Station 8665530 show that it recorded a maximum water level of 6.76 feet MHHW on September 21, 1989, and a minimum water level of −4.09 feet MLLW on March 13, 1993, with a mean range of 5.22 feet and diurnal range of 5.76 feet.

4. DATA COLLECTION AND REVIEW

Information and data collection included the review of existing relevant drainage studies and master plans prepared over several decades, as well as numerous reference materials from regulatory and governmental agencies and other technical sources. Data collection and review allows for a thorough understanding of the work that has been previously performed, work that is ongoing, and areas that need to be improved.

The Data Collection and Review aspect of this study is grouped into the following five sections:

- Existing Drainage Studies, Manuals, Reports, and Stormwater Master Plans
- Geographic Information System (GIS) Data Collection and Review
- CAD Drawings/As-builts Data and Review
- Field Reconnaissance and Survey
- Other Relevant Sources

A description of each follows and includes the type of data collected and how the data were used.

4.1 Existing Drainage Studies, Manuals, Reports, and Stormwater Master Plans

Table 3 lists the existing drainage studies, stormwater master plans, stormwater manuals, and other similar data sources used to assess and evaluate how the City has been managing stormwater infrastructure. The studies were examined for relevancy to existing stormwater issues facing the City. Relevant documents associated with the Fleming Cluster, Brisbane Cluster and Marlborough subdivisions were also reviewed to provide a comprehensive understanding of the current state of the City's stormwater management system and areas that may need to be upgraded.

Table 3 – List of Previous Master Plans, Drainage Studies, Drawings, and Manuals

Year	Title of Document	By
1984	Master Drainage and Floodplain Management Plan	Davis and Floyd, Inc.
2007	City of Charleston Stormwater Management Ordinance	City of Charleston
2013	Stormwater Design Standards Manual	City of Charleston
2016	City of Charleston Redevelopment Standards for Stormwater	AECOM
2019	Central Park Cluster Development SWPPP	Seamon Whiteside
2018	Brisbane Cluster Development	Empire Engineering, LLC
2018	Fleming Road Cluster Subdivision as Built Drawings	Foresight Surveying, LLC
2019	Stormwater Management Report James Island Drainage Study	Thomas and Hutton

4.2 GIS Data Collection and Review

The City maintains its stormwater data in a GIS database. Most stormwater GIS data in the current database were acquired from as-built plans, aerial imagery, and previously scanned stormwater plans and reports such as the 1984 Master Plan and South Carolina Department of Transportation (SCDOT) record drawings. The stormwater system data from the scanned record drawings were converted into GIS format as geodatabase features. The data are currently available for download and used as shapefiles and as comma delimited values, or .CSV files.

The City's current GIS database contains limited data within the Central Park watershed. The watershed has experienced significant redevelopment and growth in recent years and the current GIS database has information gaps or missing data for the stormwater infrastructure within the watershed.

To ensure and deliver a reasonable level of accuracy in the modeling analysis, the GIS data gaps were further augmented with additional details from CAD drawings, information collected during field visit and finally information collected through field survey. This approach allowed AECOM to streamline data collection efforts while ensuring a reasonable level of accuracy in our modeling analysis.

4.3 CAD/As-builts Data Collection and Review

The existing data was further updated with the information collected from the CAD drawings for the following:

- Hollings Road Stormwater Survey CADD Drawing
- Howle Road Stormwater Survey CADD Drawing
- Wambaw Stormwater Survey CADD Drawing

As-built information was also provided for the Fleming Road Cluster Development from which information applicable for modeling was extracted.

4.4 Field Reconnaissance and Survey

AECOM conducted field reconnaissance of the study area. The following items were assessed for use as input parameters in the development of the hydrologic and hydraulic model:

- Existing conditions, material, and type of drainage ditches, channels, culverts, and other control structures
- Extent of vegetative growth in the channels to determine the roughness coefficient ranges to be used in the model

- Condition of the pipes and culverts, including the degree of sedimentation that could reduce the conveyance
- Sizes and inverts of the pipes, culverts, and channel dimensions for structures that were not surveyed and for which no data were available from other sources

Additionally, data related to stormwater best management practices (BMPs) such as outfall pipes, dam crest, normal water surface elevations, and outlet control structures were collected.

Based on the review of existing information and hydraulic features verification in the field reconnaissance, AECOM developed a data gap analysis. The gap analysis identified hydraulic features in the watershed for which hydraulic parameters are needed and locations of missing/inconsistent topographic data. AECOM completed a field survey to obtain missing information identified by the gap analysis.

4.5 Other Relevant Sources

Additional key reference sources were obtained from several federal, state, and local governmental agencies, including the following:

- U.S. Geological Survey (USGS) – Topographic maps, rain gage data, stream flow data
- NOAA - Precipitation data, tidal gage data, Unit Hydrograph (UHG) Technical Manual
- SCDOT - Drainage maps, SCDOT Requirements for Hydraulic Design Studies
- USDA NRCS
  - *Urban Hydrology for Small Watersheds*
  - WSS maps
- South Carolina Department of Natural Resources LiDAR data
- Aerial imagery - City of Charleston
- Easement records – City of Charleston.

In addition to the field data collection, AECOM staff contacted the City Stormwater Operations and Maintenance staff to discuss existing surface water management issues and concerns. Information obtained from these meetings aided in the development of the surface water management model and contributed to the documentation of the observed drainage conditions in the Central Park watershed.

4.5.1 Public Involvement

AECOM and City Staff held one Central Park watershed public meeting in September 2019 to inform the public about the project, the timeline, and expected outcomes; to seek their input regarding issues of concern; and to obtain contact information for interviews with residents. Residential stakeholders were invited. Public input was received and considered as part of the study. Subsequent information was received from the public for significant rain events such as the December 23-24, 2019 event; March 5, 2020 event; and the April 23, 2020 event.

4.5.2 Flooding Hot Spots Map

Flooding hot spot maps identify areas or zones that experience chronic flooding. A flooding hotspot map was developed using data collected from the SCDOT Request for Action (RFA) Complaint database, and photos/videos collected through the public meeting. **Figure 5** shows the compiled flooding hotspot map for the study area. This map was used as a reference for evaluating the model and aided in the determination of proposed improvements.

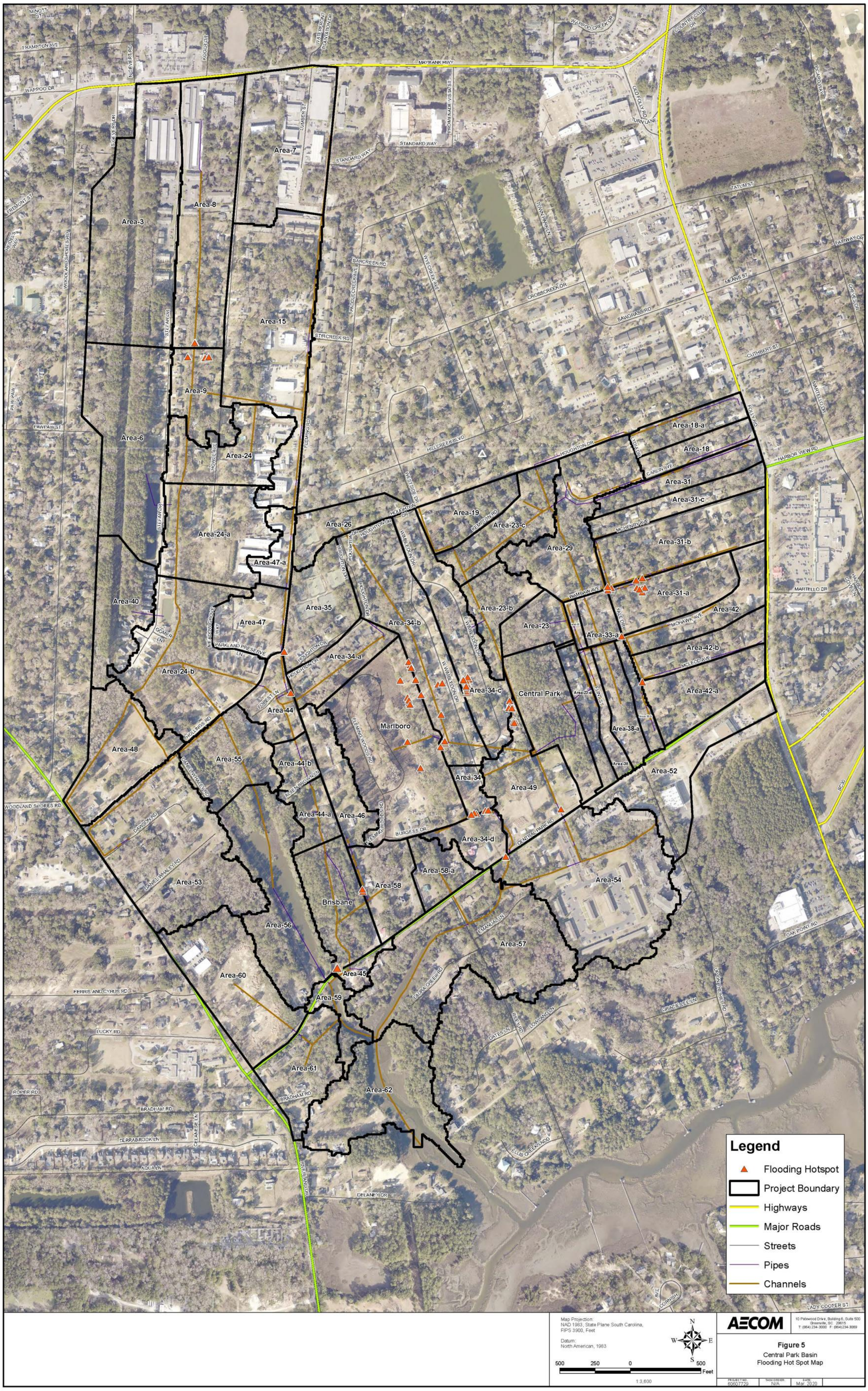


Figure 5 – Central Park Watershed Flooding Hotspots Map

5. WATERSHED STORMWATER MODELING

A one dimensional working hydrologic/hydraulic model was developed using Interconnected Pond Routing Model (ICPR) Version 4.0 developed by Streamline Technologies. The development of input parameters such as the curve numbers, time of concentration, and other elements needed to construct the existing conditions hydrologic and hydraulic model are described within this Section. At the conclusion of this project, the model will ultimately be used as a Stormwater analysis tool for the City to provide solutions to their Stormwater management issues/questions as they arise.

5.1 Water Quantity Model - Hydrology

Development of the hydrologic model included the following tasks:

- Delineation of Subbasins
- Determination of NRCS Runoff Curve Number
- Determination of Time of Concentration
- UH Peaking Factor
- Delineation of Design Storms Frequency and Rainfall Depth and Distribution

5.2 Delineation of Sub-basins

A watershed must be delineated into drainage sub-basins to evaluate the stormwater management features that collect and convey stormwater throughout the watershed to the basin outfalls. The sub-basins define the contributing drainage area for each of the major conveyance elements in the watershed.

The sub-basins for the Central Park watershed were delineated using ESRI© ArcHydro tools version 10.6. The delineation was initially performed using 2017 LiDAR and further refined using the stormwater network and information gathered via field investigation and the City's input. Basins were mainly delineated based on natural hydrologic boundaries such as ridges, channels, and other waterways, as well as constructed boundaries such as roadways. A total of 66 sub-basins were delineated for a total contributing area of approximately 500 acres. Sub-basins include 61 sub-basins representing land areas that contribute runoff and 5 sub-basins representing the ponds incorporated into the Central Park model. The ponds receive runoff from their respective contributing sub-basins as well as from precipitation that falls directly on the pond. Therefore, each pond must have an associated basin that represents the pond area itself. The sub-basins delineated using the 2017 LiDAR were compared to the drainage features and the stormwater network within the Central Park basin and were modified to account for flow redirection that was not obvious from the LiDAR assessment. The sub-basins within the watershed, as shown on **Figure 6**, vary in size from approximately 0.6 acre to 23 acres. Sub-basin names and their corresponding areas are listed in **Appendix A**.

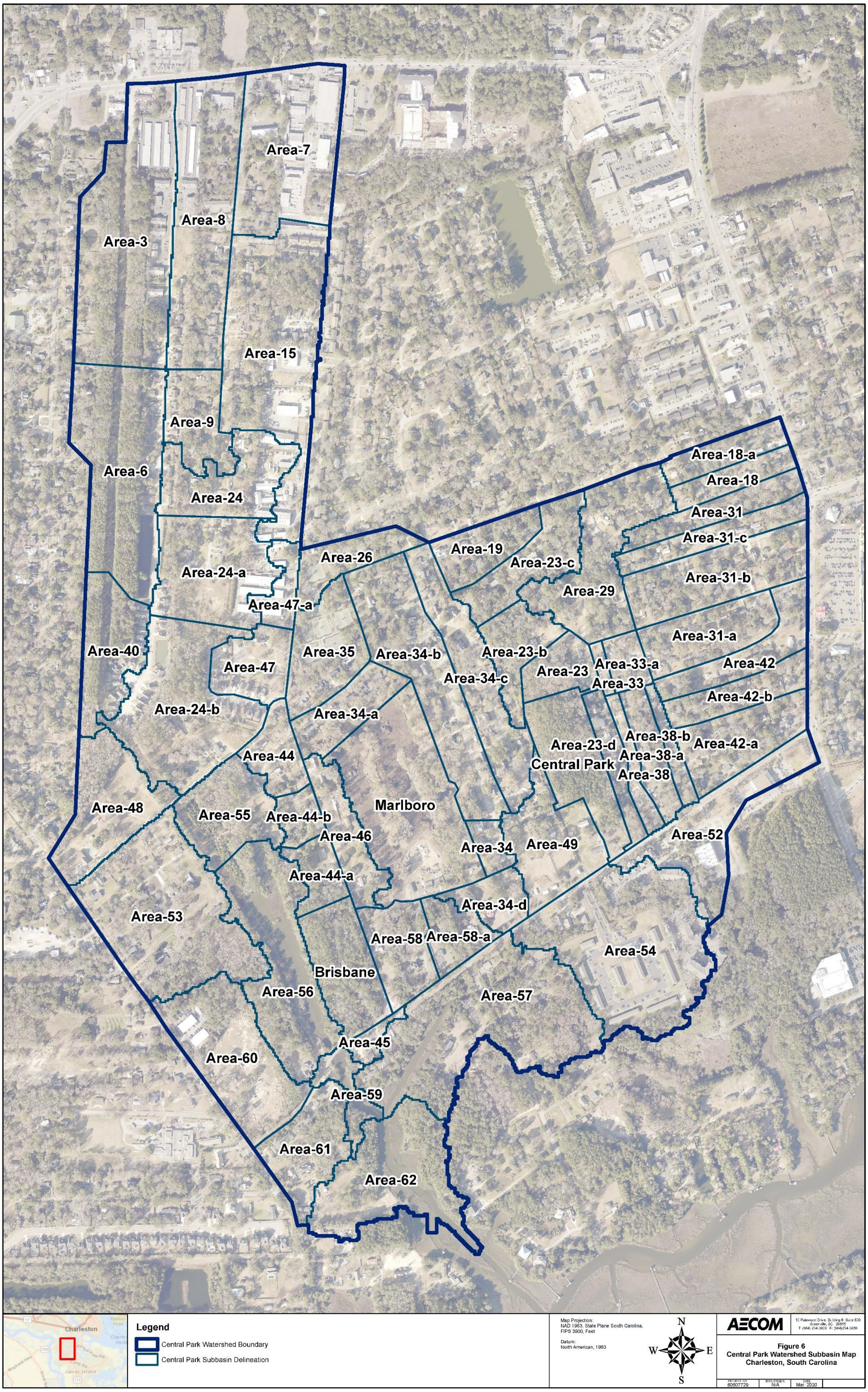


Figure 6 – Central Park Watershed Subbasin Map

5.3 Determination of NRCS Runoff Curve Number

The NRCS Curve Number methodology estimates precipitation excess (i.e. runoff) as a function of cumulative precipitation, soil cover, land use, and antecedent moisture conditions. Curve Numbers (CN) are developed for each subbasin and are used to estimate how much of the rain runs off the surface.

The CNs were developed for existing conditions apart from the three developments (Central Park Cluster, Fleming Cluster (also known as Marlboro), and the Brisbane Cluster) based on existing soil group and land use category. CNs for those three developments were considered based on the reports and drawings as provided. The soil group and land use were categorized based on factors described below.

5.3.1 Soils

Soils data for the City watersheds were provided by the USDA National Resources Conservation Service (NRCS) via Web Soil Survey (WSS). The WSS provides soil data and information produced by the National Cooperative Soil Survey. It is operated by the USDA NRCS and provides access to the largest natural resource information system in the world. The site is updated and maintained online as the single authoritative source of soil survey information.

Approximately 59% of the watershed contains soils categorized as Hydrologic Soil Group (HSG) B, which is moderately low runoff potential when thoroughly wet and approximately 35% as HSG D, which has high runoff potential and low infiltration rates.

5.3.2 Land Use

Land Use and land cover maps for the watershed were created using the latest Zoning Data obtained from the City and the County. The Land Use file was generated based on current conditions.

Three areas of existing and expected development were identified in the Central Park watershed. They are Central Park Cluster, Fleming Cluster (also known as Marlboro), and the Brisbane Cluster. All three areas are modeled in their fully developed condition.

5.3.3 Curve Numbers and Antecedent Moisture Condition

Antecedent Moisture Condition (AMC) is defined as the soil moisture before a precipitation event. It represents the ability for soils to absorb and infiltrate surface runoff. In Central Park, the nature of the soils and frequency of rainfall events warrant adjustment of the AMC to reflect existing conditions more accurately. Typical soil curve numbers (CN) values fall under category AMC II. Recent studies such as the Church Creek Drainage Project prepared by Weston and Sampson and Dupont Wappoo Watershed Study, both of which are in close proximity of the Central Park watershed, used AMC III for their curve number because a large percentage of their total area contained soils that retain moisture. Therefore, curve numbers based on AMC III will be used to represent the existing soil conditions in the Central Park watershed

The CN values used in the model were taken directly from NRCS published values for TR-55 methodology for Urban Hydrology and Agricultural land uses which represents AMC II. The CN values were adjusted from the average AMC II conditions to wet soil moisture conditions (AMC III).

Subbasin, soil data, and land use data were used to develop Curve Numbers for each subbasin. CN for each unique combination of soil type and land use within the subbasin along with their respective areas was incorporated in to the ICPR Model. The model determines the composite CN for each subbasin.

5.4 Determination of Time of Concentration

Time of concentration is defined as the time required for a drop of water to travel from the most hydraulically distant part of a watershed to the point of discharge or outfall. In order to determine the time of concentration, the longest flow path was generated using ArcHydro 10.6. and modified according to the latest available information on the sub-basin.

Surface runoff initially flows through a watershed as sheet flow for the first 100 feet after which it starts to concentrate and flow as shallow concentrated flow for the next 1,200 feet. Beyond 1200 feet, flow is assumed to concentrate in open channels or pipes. The type of surface flow that occurs in a watershed is a function of surface cover. Time of concentration for surface flow was calculated for each sub-basin using the TR-55 methodology.

The maximum sheet flow length recommended in the TR-55 publication was 300 feet; however, recent studies and publications by NRCS National Water and Climate Center recommend a maximum flow length of 100 feet for sheet flow. Therefore, in the current model, a maximum sheet flow length of 100 feet and a 50% Annual Exceedance Probability (AEP) rainfall depth of 4.16 inches was used for sheet flow travel time calculations.

The shallow concentrated flow length was divided by the average velocity determined to get the travel time for shallow concentrated flow. The maximum shallow concentrated length considered was 1,200 feet. The time of travel for shallow concentrated flow is calculated using flow length and flow velocity. Flow length is measured directly from the map. The flow velocity is calculated as a function of the watercourse slope and the surface cover type.

For open channel flow travel time, the flow velocity was calculated based on the physical parameters of the conveyance such as dimensions of the pipe or channel, roughness coefficient, bottom slope, and hydraulic radius. The calculated flow velocity was then used with the open channel flow length to determine the travel time component for open channel flow for each sub-basin.

The total time of concentration for each sub-basin was calculated as the sum of travel times for the three flow components, namely sheet flow, shallow concentrated flow, and open channel flow. Time of concentration was calculated for each of the 66 sub-basins and varies from 10 minutes to 60 minutes. Since most of the Central Park watershed is highly urbanized with a large percentage of paved areas, some of the sub-basins had a time of concentration of less than 10 minutes. For all such sub-basins the time of concentration was set at a minimum of 10 minutes.

The time of concentration for each sub-basin is included in **Appendix B.**

5.5 Unit Hydrograph Peaking Factor

The conversion constant (or peaking factor) is the result of the large number of unit hydrographs from a wide range of basin characteristics and reflects the ability of the watershed to retain and delay the flow. The "peaking factor" essentially controls the volume of water on the rising and recession limbs. This constant must be customized to all watershed types.

Steep terrain and urban areas tend to produce higher early peaks and thus values of the peaking factor tend towards the higher range of 600. Conversely, flat swampy regions tend to retain and store the water, causing a delayed, lower peak. For these conditions peaking factor values tend towards 300 or lower (SCS 1972; Wanielista, et al. 1997).

Table 4 below shows Hydrograph peaking factors and recession limb ratios (Wanielista, et al. 1997):

Table 4 – Unit Hydrographs Peaking Factors and Recession Limb Ratios

General Description	Peaking Factors	Limb Ratio (Recession to Rising)
Urban Areas; steep slopes	575	1.25
Typical SCS	484	1.67
Mixed Urban/Rural	400	2.25
Rural, rolling hills	300	3.33
Rural, slight slopes	200	5.5
Rural, Very flat	100	12.0

The City's current Stormwater Manual recommends a Unit Hydrograph Peaking Factor of 323. However, because the Central Park watershed is predominantly residential with a mixed urban and rural characteristic, a hydrograph peaking factor of **400** was used in the model as highlighted in **Table 4** above.

For additional information refer to the NOAA Unit Hydrograph Technical Manual.

5.6 Rainfall Depths and Durations

The City Stormwater Design Standards Manual references three types of data sources for design storms that may be used in any stormwater-related design in the City. After meeting with City staff, it was agreed that the storm data developed by NOAA would be used for the Central Park watershed model. The 24-hour duration precipitation depths corresponding to various return periods are shown in **Table 5**.

Table 5 – Storm Return Period and Precipitation Depths (inches)

50% AEP	20% AEP	10% AEP	4% AEP	2% AEP	1% AEP
4.16	5.38	6.36	7.75	8.88	10.1

NRCS Rainfall distribution types for continental United States are shown in **Figure 7**. Charleston lies in the coastal region of South Carolina, which falls under the NRCS Type III rainfall distribution as shown on **Figure 8**. Therefore, for all the design storm simulations, the NRCS Type III rainfall distribution was used.

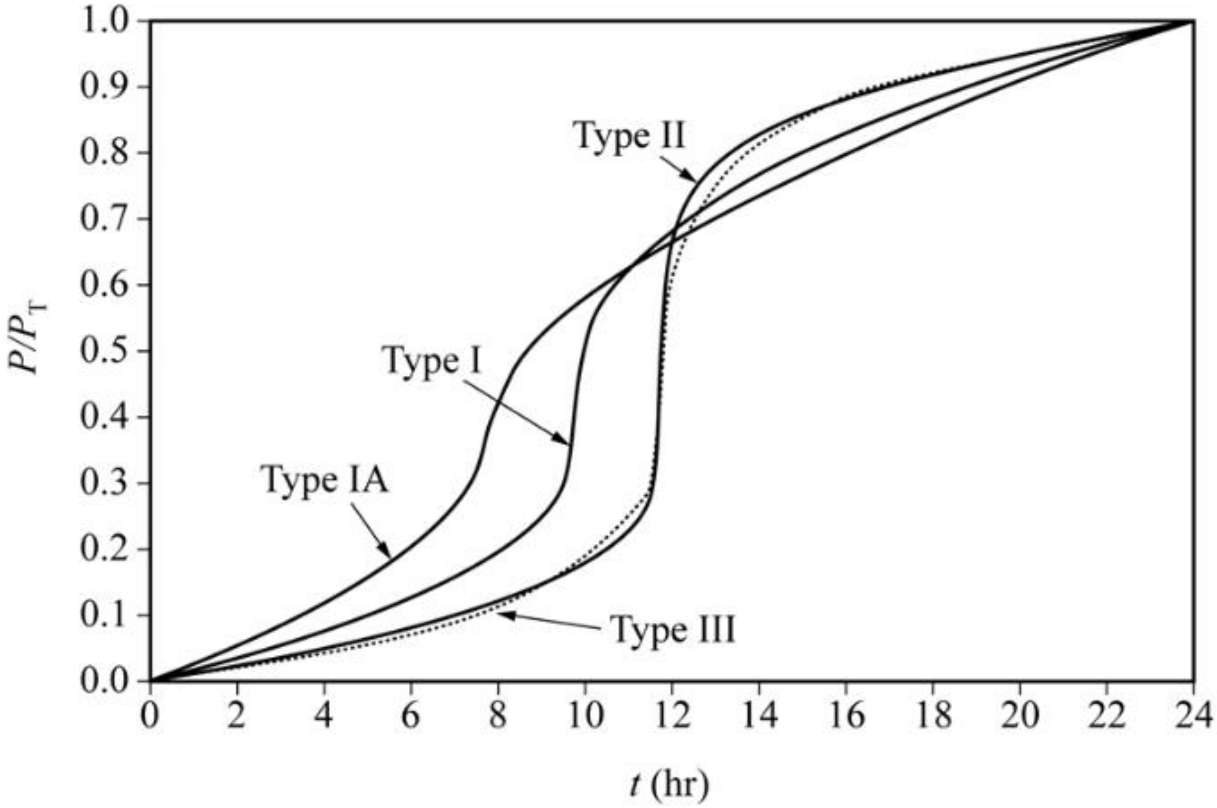


Figure 7 – NRCS Rainfall Distribution

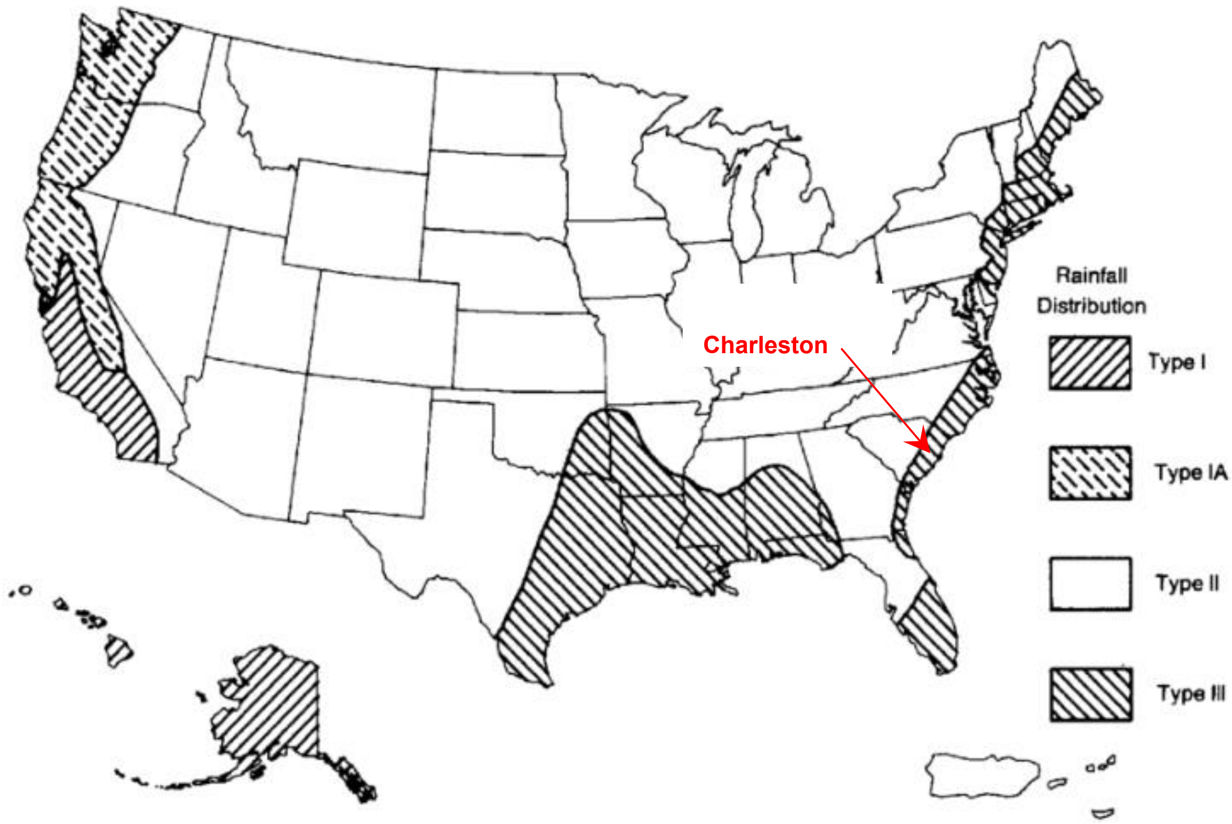


Figure 8 – NRCS Rainfall Type Distribution Boundaries

5.7 Water Quantity Model - Hydraulics

The objective of the water quantity modeling effort was to determine flows and flood levels in the main drainage features of the Central Park watershed for the 50% AEP, 10% AEP, and 4% AEP frequency and 24-hour duration storm events. Information needed to develop the hydraulic model includes the node-link configuration, channel cross-sections, Manning's roughness coefficients, initial stages, stage-area determination, and boundary conditions. The current Central Park watershed model was developed as a 1D model. A 1D model can be used effectively to determine the capacity and performance of linear features in a stormwater management system such as pipes, culverts, and channels. However, a 1D model has only limited capability in predicting the amount of overland flooding in a watershed.

Development of the hydraulic model includes the following tasks:

- Delineation of the Stormwater Network,
- Development of Surface Storage,
- Development of Boundary Conditions.

5.7.1 Development of Stormwater Network

The stormwater network was developed based on the information acquired from the City GIS database, as built drawings, 1984 Master Plan as well as the field survey data. A spatially connected network of all the stormwater assets, including inlets, pipes, channels, flow control structures, etc., was created. Flow directions were determined based on invert elevation and slopes which were obtained from as built drawings, City GIS database, and LiDAR. Areas within the overall stormwater network where information such as pipe diameters and drop structures was not available from any data source were identified for field survey.

For stormwater pipes in the model network that lack geometric information such as pipe/culvert diameters and inverts, a step-by-step approach was followed to fill in the missing information. The approach was applied on a case-by-case basis and is described in detail below.

- While creating the hydraulic network for the Central Park watershed basin, the highest priority was given to survey data.
- In cases where some inverts from the field survey were available in the upstream and downstream sections of a flow path but inverts were missing in the intermediate sections of the flow path, the inverts were calculated with interpolation using the known upstream and downstream inverts as well as the length of the asset with missing invert information.
- Some flow paths in the Central Park stormwater network only had a downstream invert available, and therefore, it was not possible to calculate the inverts of the upstream assets using interpolation. In such cases the upstream inverts were calculated using the known downstream invert, the length of the asset, and an assumed 0.3 percent slope.
- Where connectivity information was missing altogether, appropriate assumptions were made based on upstream and downstream pipe data and sound engineering judgement to build a complete network.

For channels, missing inverts and channel cross-sections were determined based on the 2017 Digital Elevation Model (DEM) that was used for the initial delineation of the Central Park watershed. The DEM was incorporated into the model as a surface, allowing channel cross sections to be created within the ICPR model itself rather than developing cross sections externally and importing them into the model. To describe each channel, one representative cross section was cut at a point near the middle of the channel run and applied to the entire length of the channel.

Drop/control structures from the ponds were also built into the model based on information obtained from survey data. In cases where sufficient information was not available, a standard drop structure template was used to build the complete network.

5.7.2 **Development of Surface Storage**

ArcHydro 10.6 was used to calculate the surface storage in the form of an elevation-area table for each sub-basin in the watershed. A portion of each basin's storage was applied to the first node of each sub-basin where the sub-basin is assumed to drain. The portion of the storage applied to the first drainage node depends on the elevation of the node. The remaining storage was applied to subsequent downstream nodes based on their respective ground elevation.

5.7.3 **Development of Boundary/Tailwater Conditions**

Tailwater conditions for the watershed are influenced by daily diurnal tide water levels. Tailwater elevation for the existing conditions model was determined at the final outfall of the Central Park watershed, which is the James Island Creek. Since there was no tidal gage data available for the James Island Creek, the tidal gage weather station (ID 8665530) located at the mouth of Cooper River was used for the analysis same as the ones used for DuWap watershed study. Station 8665530 was established in 1899 and remains operational. To accurately model the actual performance of the stormwater management system for the Central Park watershed, 36-hour dynamic tailwater conditions were developed for each design storm event. For the base model and for model validation, the tailwater elevation based on normal tide water levels was used for the analysis. Storm surge, wave effects, and sea level rise were added after the existing conditions model was verified for future analysis.

Dynamic tailwater conditions were updated to account for potential storm surge and sea level rise impacts. These dynamic boundary conditions were necessary to evaluate the response of the City's stormwater infrastructure (or system) to varying water levels and storm scenarios over a 24-hour ICPR simulation. The modeling results were used to identify problems in the drainage system, make recommendations for proposed drainage improvements, evaluate the performance of drainage improvements, and evaluate the response of the stormwater system to potential future conditions. **Figure 9** shows the tailwater condition for the base model.

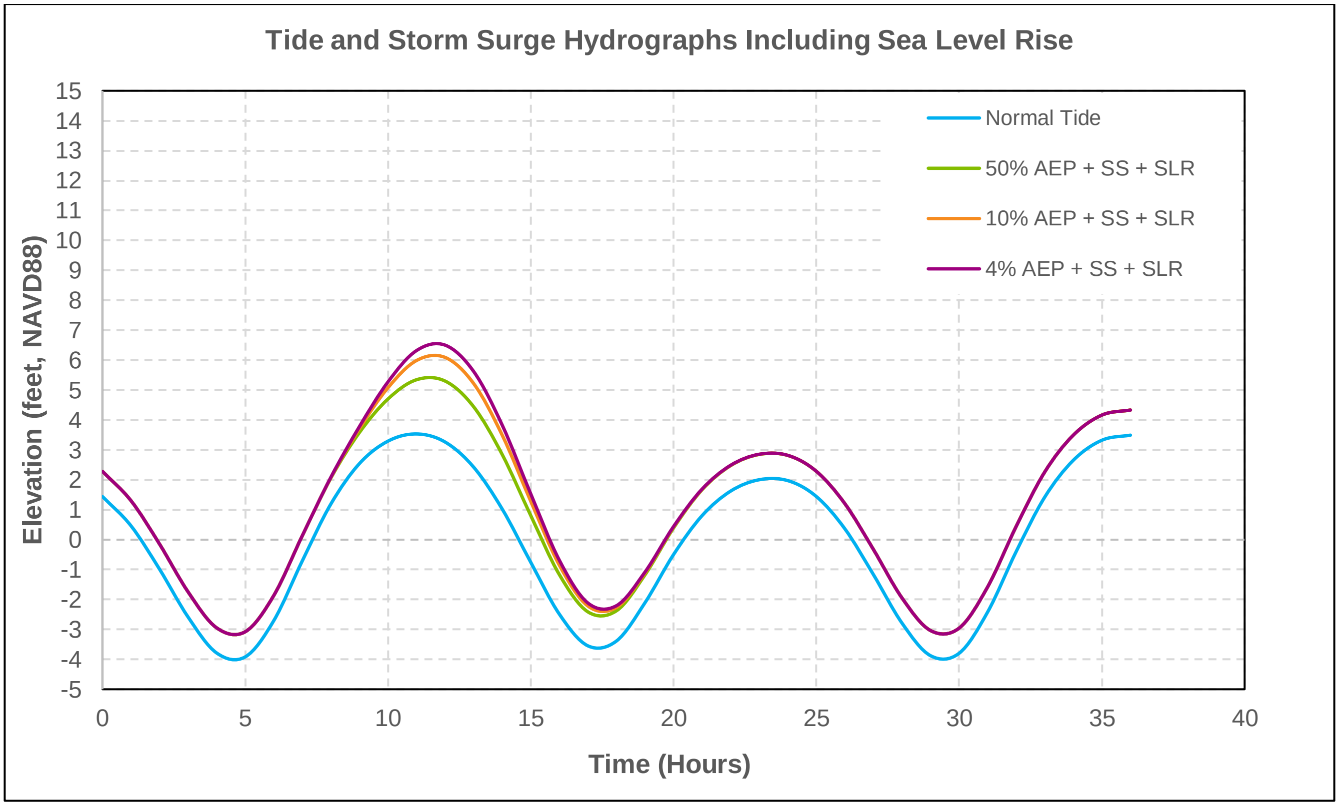


Figure 9 – Tailwater Conditions

5.8 Model Validation

All models must be calibrated and validated to ascertain that they represent the observed/measured data. No measured flow or stage data exists in the Central Park Study Area. Therefore, no model calibration for specific rain events was performed. However, for the purpose of this study, model validation was performed by comparing model results to anecdotal information obtained through the various sources listed below:

- Flooding complaints from City Portal Website/GIS Database
- General complaints provided at Public Meetings
- Photos/Videos of flooding locations within the watershed provided by residents living within the watershed

Results from the model shows flooding locations matched well with the flooding complaints. These areas were further analyzed with multiple design storms coupled with storm surge and sea level rise assumptions.

5.9 Final Existing Conditions Model Analysis with Sea Level Rise and Storm Surge

Simulations were performed using the validated model for several design storm events coupled with storm surge and sea level rise. The results are summarized below.

The Central Park watershed is drained by a network of channels and pipes. Channels traverse the watershed generally from north to the south and eventually drain into James Island Creek that is tidally influenced. Flooding in the Central Park watershed is exacerbated by high tide and/or storm surges in James Island Creek. Because James Island Creek is the principal outlet for the entire Central Park watershed, flooding in the creek can prevent runoff from other areas of the watershed from draining freely.

Each node in the model was assigned an initial stage and a warning stage. The initial stage is the water surface elevation at a node before the beginning of precipitation. The warning stage is the ground surface elevation at the node. The model calculates the elevation of the water surface at each node in the model throughout the selected simulation duration and records the maximum value (maximum stage). If the maximum stage at a node is higher than the warning stage, it indicates that the node is experiencing flooding. The depth of flooding is calculated by subtracting the warning stage, which is also the ground surface elevation at the node, from the maximum stage, which is the highest water surface elevation calculated by the model for that node. When the water level reaches the ground surface for a particular node or above the warning stage, the model determines the maximum/peak water levels by accounting for the stage-area relationship incorporated into the model. The stage-area relationship is provided for each 1-foot increment and the model calculates the storage volume for each incremental depth above the warning stage.

Based on the evaluation of results for the 50% AEP and 4% AEP design storm events, the existing conditions model shows that several locations across the Central Park watershed have a high potential for flooding. The degree and depth of flooding varies depending on the type of design storm event selected.

Figures 10 and 11 present the model nodes that experience flooding during a 50% AEP and 4% AEP design storm event with storm surge and sea level rise. The flooding extent is broken into four categories ranging from minimal flooding with flooding depth of less than 3 inches to major flooding with flooding depth exceeding 12 inches. All the nodes shown on the figures as flooding may not experience flooding at the same time. The figures also show an estimate on the extent of flooding for each design event. The estimated floodplain extent shown in the figures is based on the depth raster which was developed by subtracting the DEM from the raster created from maximum stage for each node. The depth raster is created only around the conveyance features with a 100-foot buffer. Because the simulation uses a 1-dimensional model and results are only calculated at nodes, pipes, and channels, it is not appropriate to extend the raster beyond a 100-foot buffer. More extensive spatial flooding results would require a 2-dimensional model. The floodplain extent shown provides a general sense of how dispersed the flooding is and the areas of most concern.

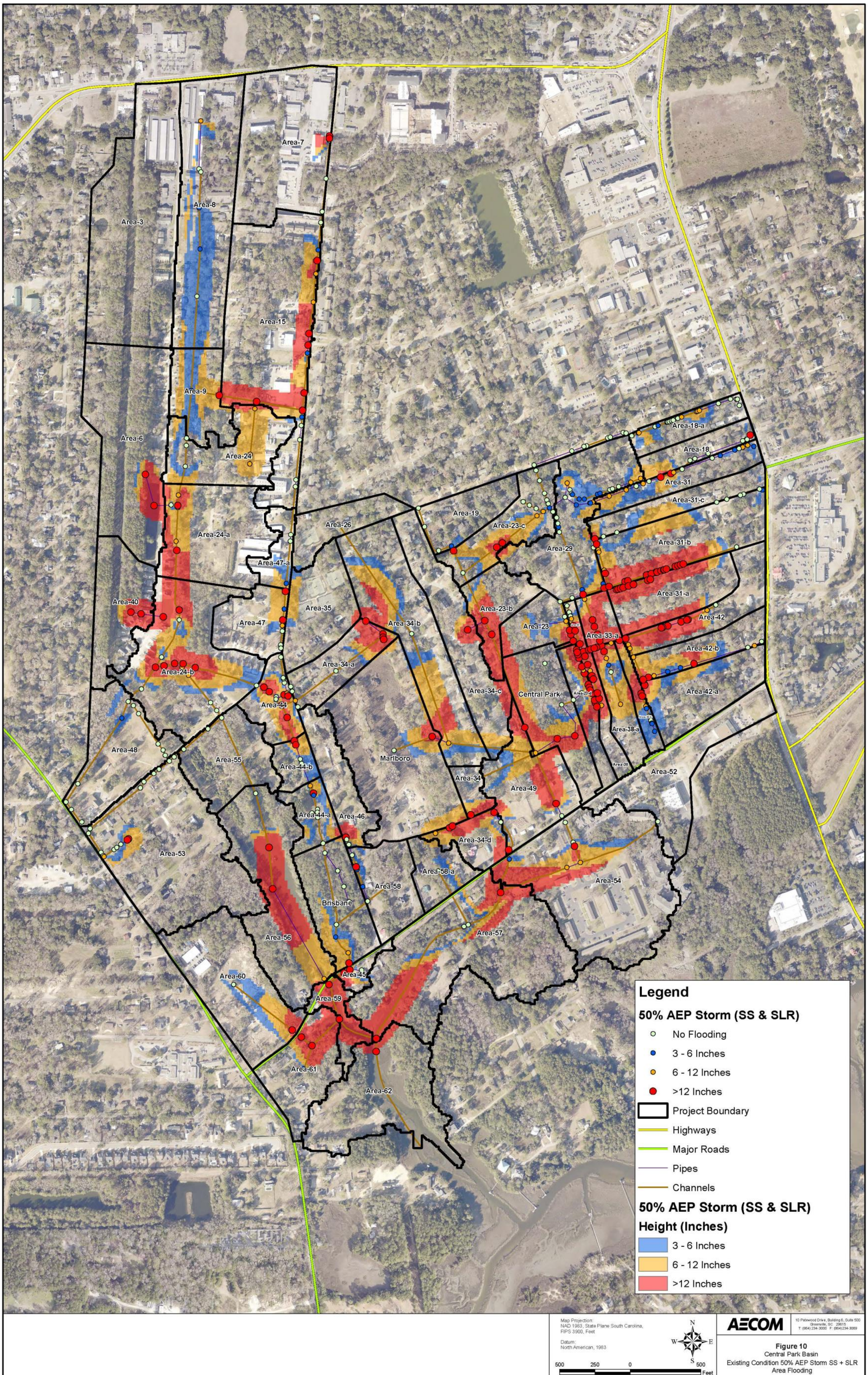


Figure 10 – Central Park 50% AEP Storm Flooding – Existing Conditions (SS+SLR)

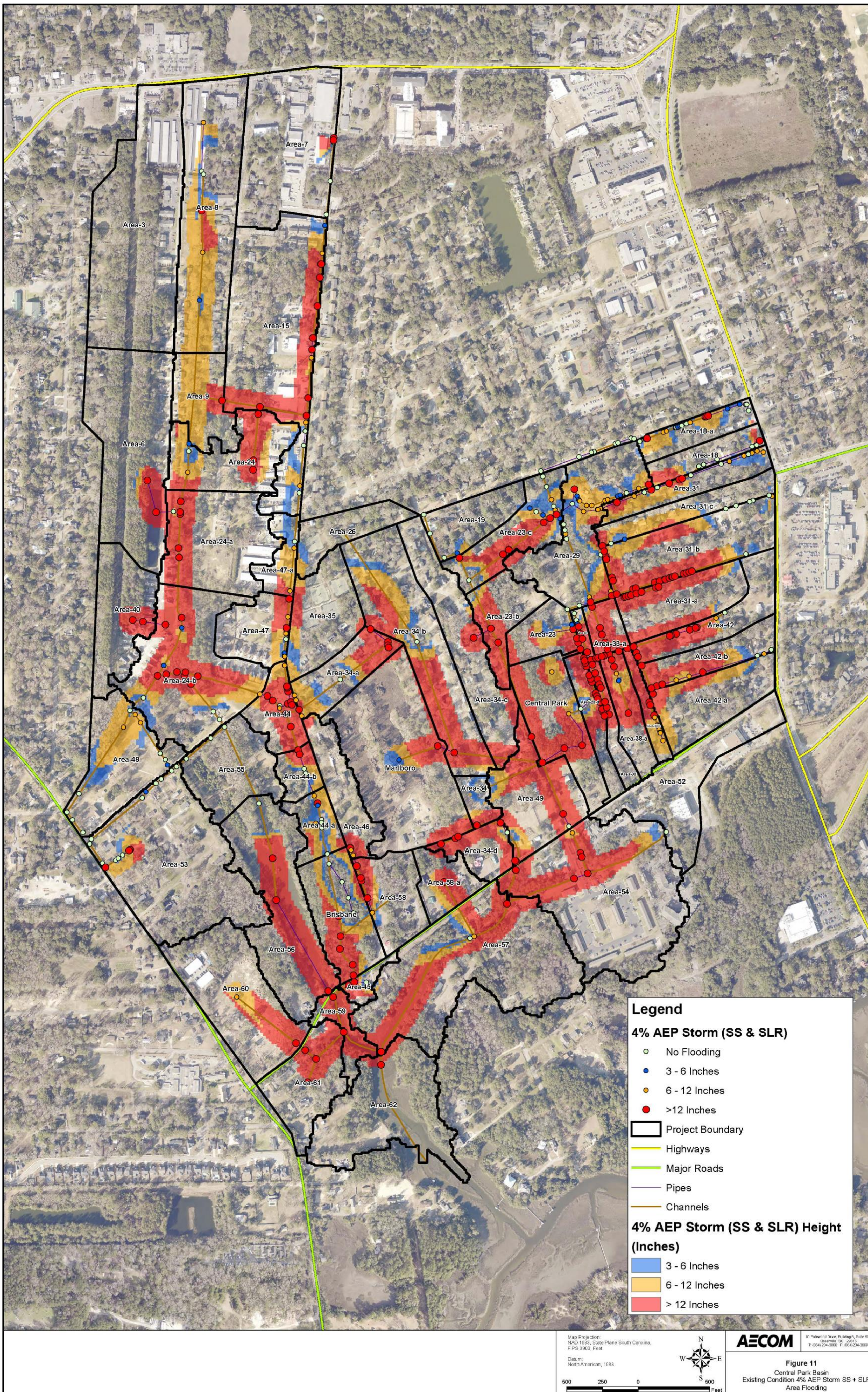


Figure 11 – Central Park 4%AEP Storm Flooding – Existing Conditions (SS+SLR)

6. RECOMMENDED IMPROVEMENTS AND PRIORITIZATION

This section lists and describes recommendations for improvements in the Central Park watershed that will reduce flooding and contribute to attaining LOS.

6.1 Water Quantity Level of Service

For stormwater management, LOS standards represent degrees of protection for various structures and natural features expressed in terms of storm events anticipated to be accommodated by the applicable drainage infrastructure and facilities. LOS standards apply to both water quantity, in terms of providing an efficient and effective stormwater management system that protects the public and property from flooding, and water quality, in terms of protecting surface waters from erosion and degradation of water quality. For water quantity, LOS standards are used for the design of facilities such as roads, drainage systems such as conveyance and outfalls, and buildings.

Specifying the frequency and duration of rainfall to be handled by a drainage system establishes the degree of protection that the facility can be expected to provide. For example, the chance of overloading a facility designed to accommodate runoff from a 20% AEP storm of specified duration (e.g., 24 hours) is one in five and, correspondingly, the chance is four in five in any given year that the system will perform satisfactorily for storms of that duration. Generally, the greater the potential threat to life and property should a drainage system fail, the more severe or less frequent the design storm used in determining the drainage capacity required for that system.

The City has adopted the LOS listed in **Table 6**; they were used to develop recommend improvements for the Central Park watershed.

Table 6 – LOS Allowable Flooding Criteria

Description	20% AEP	10% AEP	4% AEP	1% AEP
Roadway: Evacuation	None	None	None	None
Roadway: Collectors/Arterials	None	None	6 inches	9 inches
Roadway: Neighborhood	None	6 inches	9 inches	12 inches
Structural: Buildings	None	None	None	None

6.2 Surface Water Management Improvement Projects

This section lists potential stormwater infrastructure improvement recommendations on a sub-basin level. AECOM combined the model results, which identified areas of flooding, and the list of areas of known concerns (identified by City staff and residents) to propose areas where future stormwater infrastructure improvements are needed.

Flooding locations were determined based on the existing conditions model results. Based on these flooding locations, surface water management improvement projects were proposed to provide corrective measures to meet the LOS criterion listed in Table 6. These proposed improvement projects were analyzed in a proposed conditions model for each LOS.

Capital Improvement Projects (CIPs) are intended to restore infrastructure function and augment the existing system to solve flooding issues. Projects proposed for the Central Park Watershed considered the following groups of technologies:

- Stormwater storage facilities such as retention and detention systems to capture and retain or detain excess flood waters and reduce downstream peak discharge rates.

- Enhanced conveyance systems through either channel or structure improvements to improve the hydraulic efficiency of the drainage system and reduce peak flood elevations.
- Raising of roadways to prevent floodwater encroachment.
- Check valves to control the flow direction and limit tidally or storm surge influenced backwater from downstream areas.

6.3 Constraints, Limitations and Assumptions

The following list of constraints, limitations, and assumptions were considered as part of the project evaluation and selection process:

- The post-development flowrate should be less than or equal to the pre-development flowrate at the point of discharge.
- No adverse impacts, either upstream or downstream, should result from the proposed improvements within the watershed. This was assured by checking that the model estimated maximum stage in the proposed conditions model result was less than or equal to the model estimated maximum stage in the existing conditions model result. Model predicted maximum stages less than the warning stage were considered acceptable (contained within and adequately managed by the drainage system).
- No modifications to the main watershed outlet channel within the study area were considered because it is tidally influenced and cannot be hydraulically improved.
- All improvement projects were within areas over which the City has jurisdiction and can assure operation and maintenance is performed.

6.4 System Improvements Selection Criteria

Surface water management improvement projects are recommended based on the following criteria as listed below in order of priority:

- Achieve LOS for the smaller magnitude 50% AEP design storm
- Maximize the benefit for the 4% AEP LOS criterion
- Implement improvements recommended in the 1984 Master Plan as applicable
- Implement improvements within the existing rights-of-way and drainage easements
- Utilize City-owned lands for storage facilities
- Utilize open/vacant lands for additional storage
- Consider cost-benefit ratios for recommended improvements.

6.5 Proposed Watershed Improvements

Table 7 lists selected roads in the Central Park Watershed along the primary drainage system that show flooding and currently do not meet LOS for the 50% AEP and 4% AEP design storm events. The table includes the roadway classification (based on speed limits) as represented in the City's GIS database. The table also lists the associated model node identification (ID).

Table 7 – Roadway LOS Existing Condition

Road Name	Road Classification	Associated Model ID	Edge of Pavement Elevation (ft)	4% AEP Design Storm Event		50% AEP Design Storm Event	
				Existing Conditions Node Max Stage (ft)	Flood Depth (inch)	Existing Conditions Node Max Stage (ft)	Flood Depth (inch)
Central Park Road	Major Collector/Arterial	N-S2	8.5	6.6	0	8.5	0
Fleming Road	Major Collector/Arterial	N-M391	10.9	10.65	0	11.1	2.4
Wambaw Avenue	Neighborhood Road	N-A567	7.4	8.9	18	9.4	24
Yale Drive	Neighborhood Road	N-M252	8.3	8.8	6	9.4	13.2

NOTE: Flooding depth meeting LOS criteria are highlighted in green; flood depths not achieving LOS criteria are highlighted in red.

The recommended improvements were analyzed to not only meet the desired LOS criteria for Roadways but also to alleviate flooding in specific locations reported by the City and residents. These locations are listed below:

- Along Wimbledon Drive
- Along Central Park Road
- Intersection of Yale Drive and Central Park
- East Neighborhood (Wambaw)
- Intersection of Holling’s Road and Fleming Road
- Along Howle Avenue

Prior to recommending CIPs within the watershed, AECOM used the validated model to simulate improvements identified in the 1984 Master Plan and determine if implementation of those improvements on their own achieved the desired LOS. Proposed improvements from the 1984 Master Plan do not alleviate flooding in the upper reaches of the watershed. This is because a significant portion of the stormwater infrastructure that conveys the runoff from the upper reaches of the Central Park watershed to James Island Creek is inadequate. The major improvements recommended in the 1984 Master Plan are at the lower reach of the watershed. For the projects recommended by the 1984 Master Plan to be effective, additional CIPs are needed within the watershed as described below. AECOM’s proposed conditions model included the recommended 1984 Master Plan improvements and was used for modeling additional CIPs to meet the desired LOS and address flooding at the specific locations listed above.

To address the flooding and meet the LOS criteria, AECOM recommends the following categories of capital improvement projects for the watershed:

- Increase the number of culverts and/or their dimensions at locations where the model shows inadequate capacity.
- Widen existing channels where the model shows inadequate cross-section area by maintaining the existing banks and increasing the cross section. Widening is especially critical for the Wimbledon channel that runs along Wimbledon Drive.
- Improve the slopes of existing pipes and channels including reversing negative slopes. Pipe and channel slope improvements must assure positive slope over the entire flow path to the outfall.

- Install Check Valves to culverts that are tidally influenced to prevent the tide and storm surge from backflowing into the upstream system. Culverts to which check valve installation is recommended either discharge into, or are directly on, James Island Creek.

- Add a new channel along Central Park Road to convey runoff from the Yale Drive area to James Island Creek. The new channel will convey re-routed flow from the Yale Drive area on the south side of Central Park Road. During this preliminary evaluation, the conveyance reach along Central Park Road was modeled and cost developed assuming an open channel. During the design phase, alternative closed system conveyance option will be reviewed.

- Add additional storage near the intersection of Hollings Road and Fleming Road.

Table 8 presents a general list of recommended capital improvements. Details are contained in **Appendix C.**

Figure 12 graphically presents the location of these improvements.

Table 8 Stormwater Asset Improvements

Asset	Diameter (in)	Length (ft)	New / Improvement
Pipes	8' x 4.5' Box Culvert	618	Improvement
	12	183	Improvement
	15	1085	Improvement
	24	245	Improvement
	24	231	New
	30	66	Improvement
	36	129	Improvement
	42	139	Improvement
	48	54	Improvement
	54	38	Improvement
Channels	-	8213	Improvement
	-	913	New
Check Valves (7 Total)	-	-	New
Storage (0.5 acre near Hollings Rd and Parkland Preserve Ln)	-	-	New

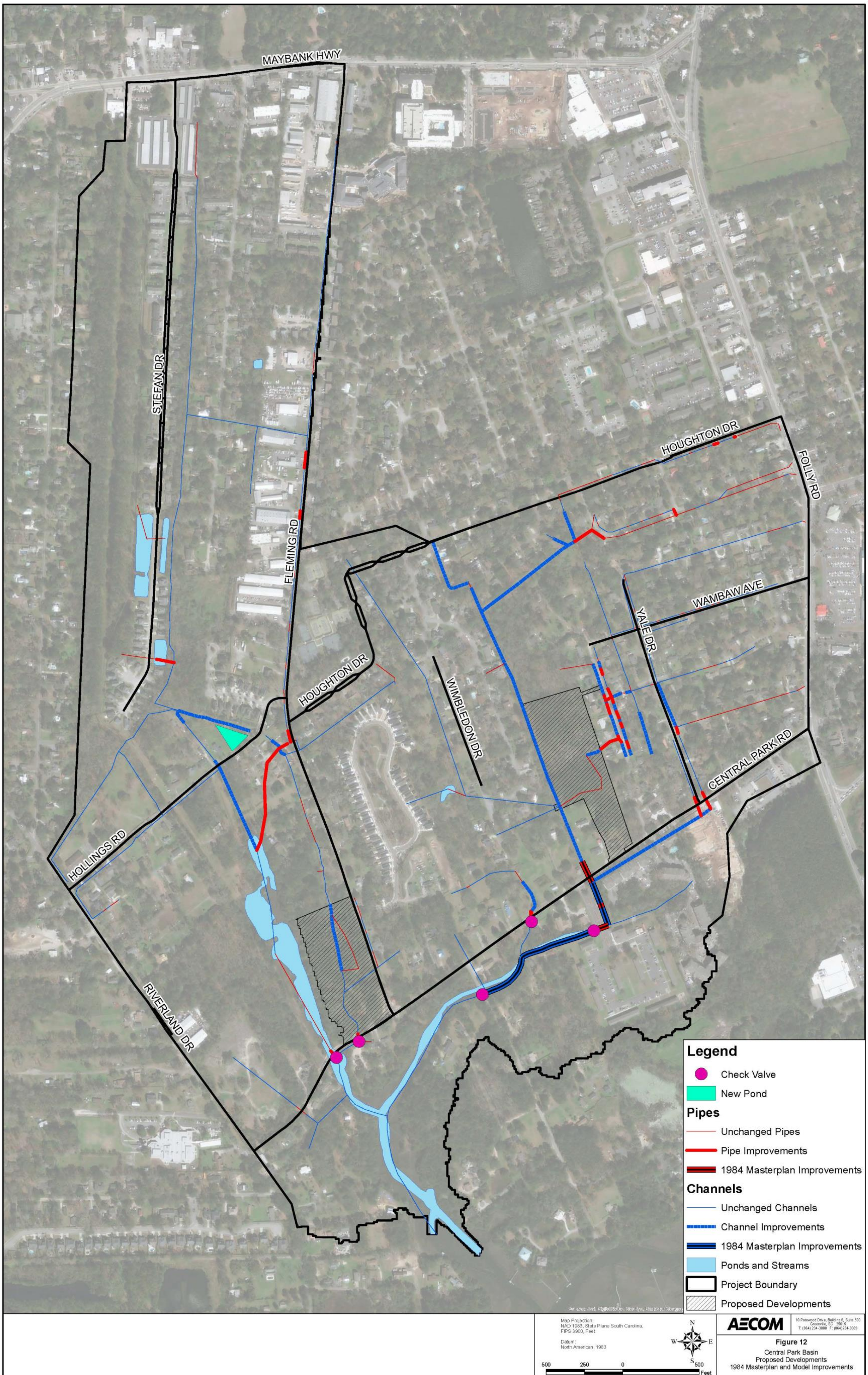


Figure 12 – Central Park Recommended Improvements

Figures 13 and 14 graphically presents the range of flooding depths in the Central Park Watershed after the recommendations are implemented. **Table 9** presents the improved condition compared to LOS criteria for each of the road intersections.

Table 9 – Roadway LOS Improved Condition

Road Name	Road Classification	Associated Model ID	Edge of Pavement Elevation (ft)	50% AEP **Design Storm Event**			4% AEP **Design Storm Event**		
				Improved Conditions Node Max Stage (ft)	**Flood Depth (inch)**	**Reduction in Stage from Existing (inch)**	**Improved Conditions Node Max Stage (ft)**	**Flood Depth (inch)**	**Reduction in Stage from Existing (inch)**
Central Park Road	Major Collector	N-S2	8.5	5.3	0	15.6	7.2	0	15.6
Fleming Road	Major Collector	N-M391	10.9	10.6	0	0.6	11.1	2.5	0
Wambaw Avenue	Neighborhood Road	N-A567	7.4	8.1	8.4	9.6	8.9	18.6	6
Yale Drive	Neighborhood Road	N-M252	8.3	7.8	0	12	8.7	5.2	8.4
Howle Avenue	Neighborhood Road	N-M129	10.5	11.3	9.6	0	11.5	12	0

NOTE: Flooding depth meeting LOS criteria are highlighted in green; flood depths not achieving LOS criteria are highlighted in red.

Folly Road runs along the eastern boundary of the Central Park Watershed and connects with Central Park Road. It is classified as a major Collector/Arterial road. The road is just outside the boundary of the Central Park Watershed, so it is not included in the model. The Central Park Watershed model nodes that are near Folly Road are at the highest elevation points in the sub-basin and flow paths drain in a westerly direction away from Folly Road. Therefore, the analysis shows that the Central Park Watershed does not contribute to any flooding that may be occurring on Folly Road.

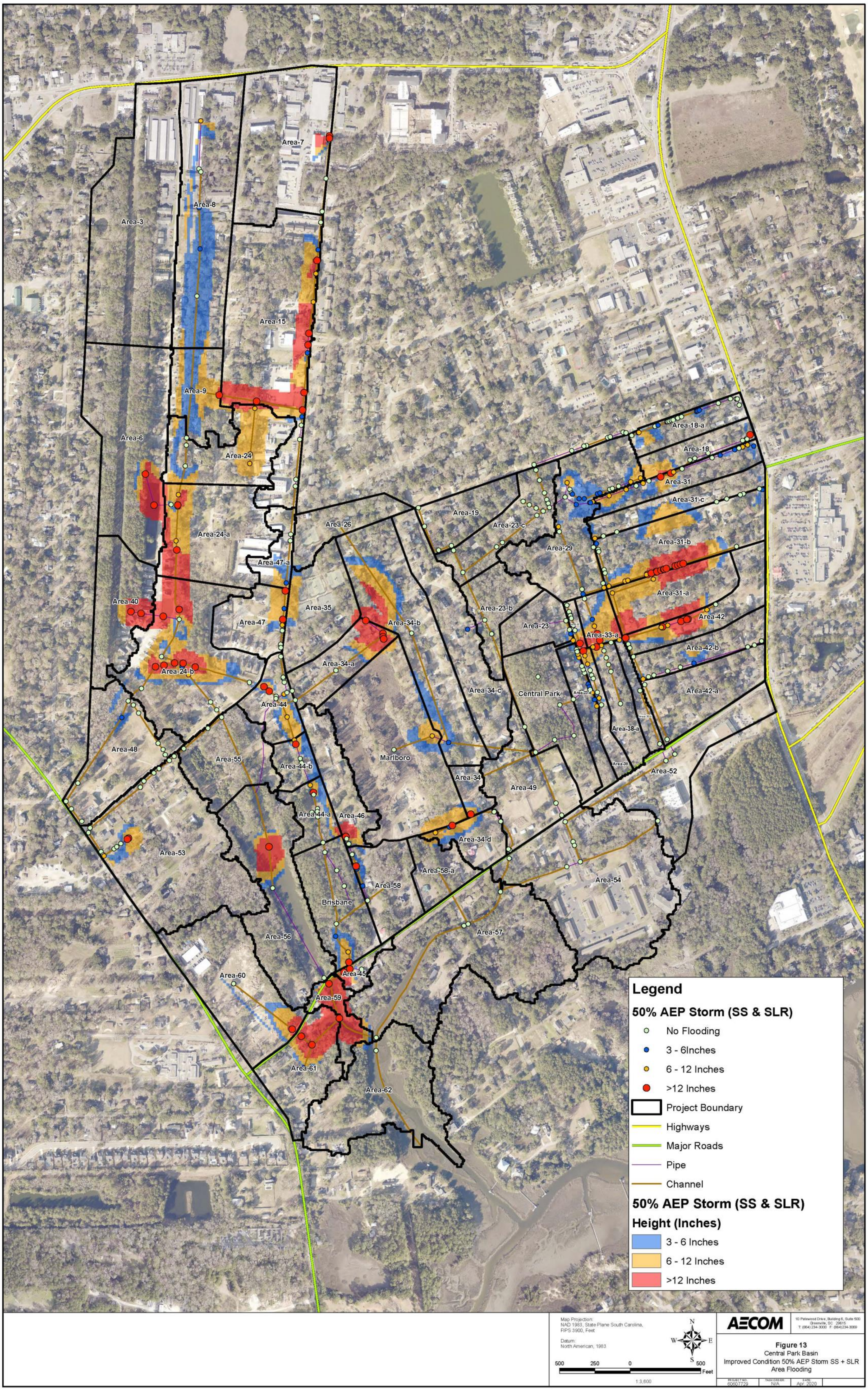


Figure 13 – Central Park 50% AEP Storm Flooding – Improved Conditions (SS+SLR)

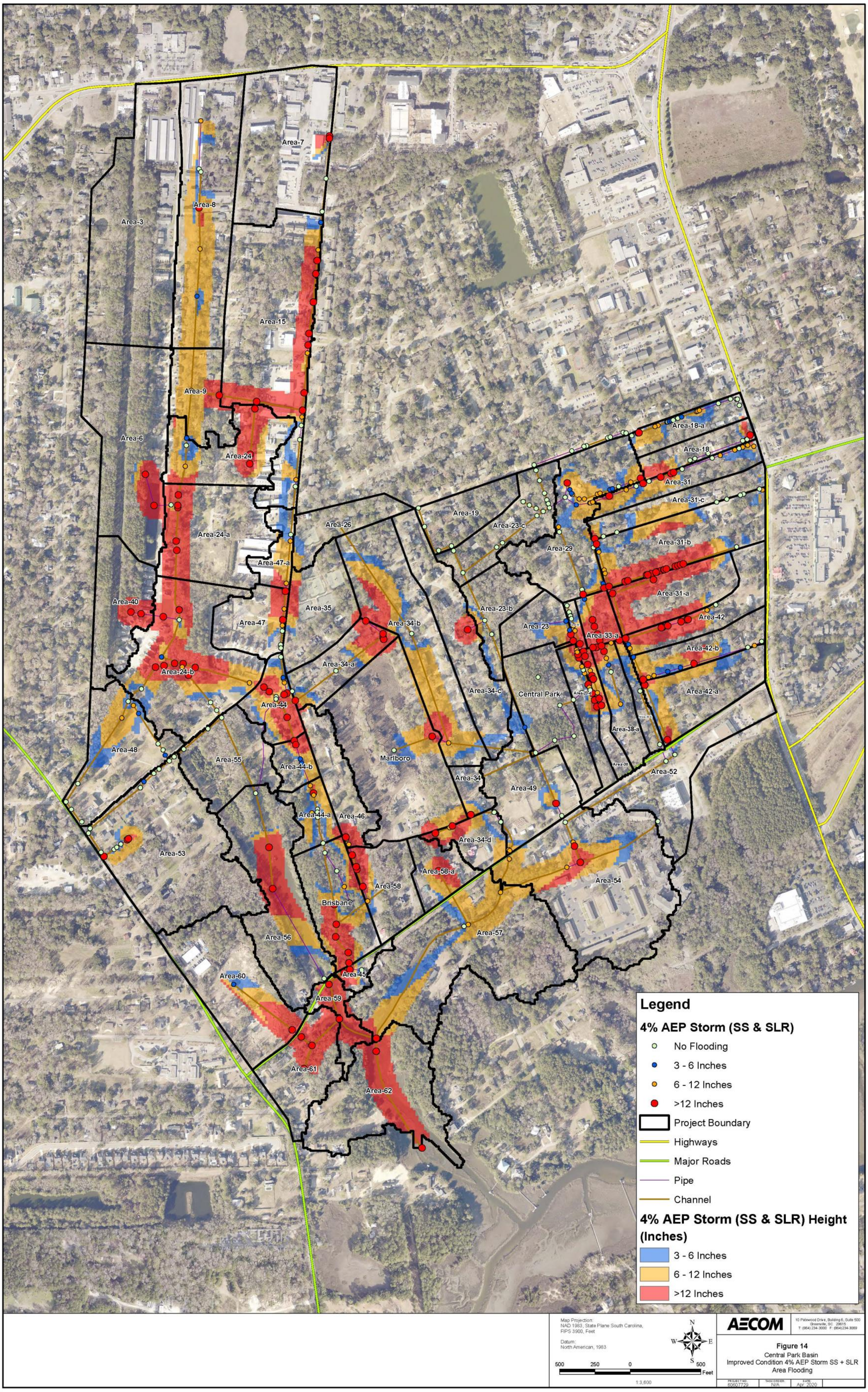


Figure 14 – Central Park 4% AEP Storm Flooding – Improved Conditions (SS+SLR)

Figure 13 shows that there are certain locations within the watershed with water levels above criteria during the 50% AEP design storm even after the implementation of the recommended improvements.

Those areas are:

- Along Wambaw Avenue: This area has numerous short sections of channels with intermediate 12-inch diameter driveway culverts. This area is in the most upstream section of the Central Park watershed and does not receive any additional runoff from other sections of the watershed. The flooding in this area can be mitigated by cleaning out the existing channels and culvert and maintaining a positive slope. Multiple transitions from channel to pipe and vice versa over a very short distance can lead to instabilities in the model and cause it to over predict the stage at these nodes. Because of the proximity of nodes along Wambaw Ave. and the tendency for the model to overpredict flooding in these circumstances, AECOM is not adequately confident in the model to recommend further improvements.

- Central Park Road crossing James Island Creek: This location floods because the roadway elevation is less than the maximum water surface elevation of the spring tide. Therefore, improvements to stormwater features will not alleviate flooding on Central Park Road at this location. The only solution to resolve the flooding is to raise the road to an elevation that is higher than the elevation of the tide with storm surge and sea level rise during a 4% AEP storm, which will eliminate flooding for the 50% AEP

- West Side along Fleming Road: This area shows that flooding still exists under proposed conditions with improvements. However, the overall flooding duration and depth is reduced because of the proposed improvements downstream in the watershed. Additional conveyance and storage improvements would be needed to completely alleviate this flooding. There are no available vacant parcels/city owned parcels within the vicinity of this area and therefore it will be cost prohibitive with marginal benefit.

Recommended improvements will result in a reduction in the depth and duration of flooding along key roadways even though the LOS for the 4% AEP storm is not fully achieved. This is shown in **Figures 15 - 18**. The location where Central Park Road crosses James Island Creek, the road elevation is below the elevation of the spring tide. Therefore, improvements to stormwater features will not alleviate flooding on Central Park Road at this location. The only solution to resolving the flooding of Central Park road at this location is to raise the road to an elevation that is higher than the elevation of the tide with storm surge and sea level rise during a 4% AEP storm.

Figure 16 shows that there is only marginal improvement in the flood stage and flood duration at this node along Fleming Rd. This is because this node did not experience any significant flooding for the 4% AEP storm for the existing condition. Therefore, improvements were not designed to reduce the stage at this node. The marginal reduction in flood stage and flood duration at this node is only due to the improvements proposed for other locations.

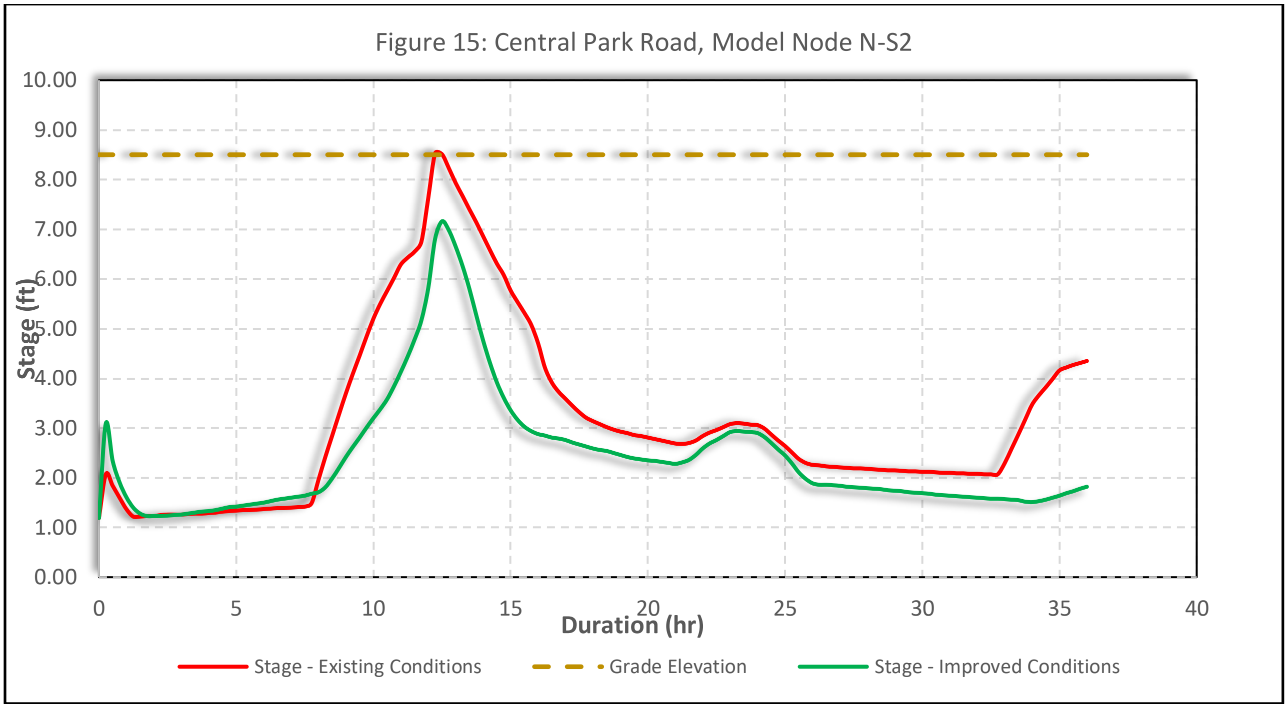


Figure 15 – Flood depth and duration mitigation along Central Park Road

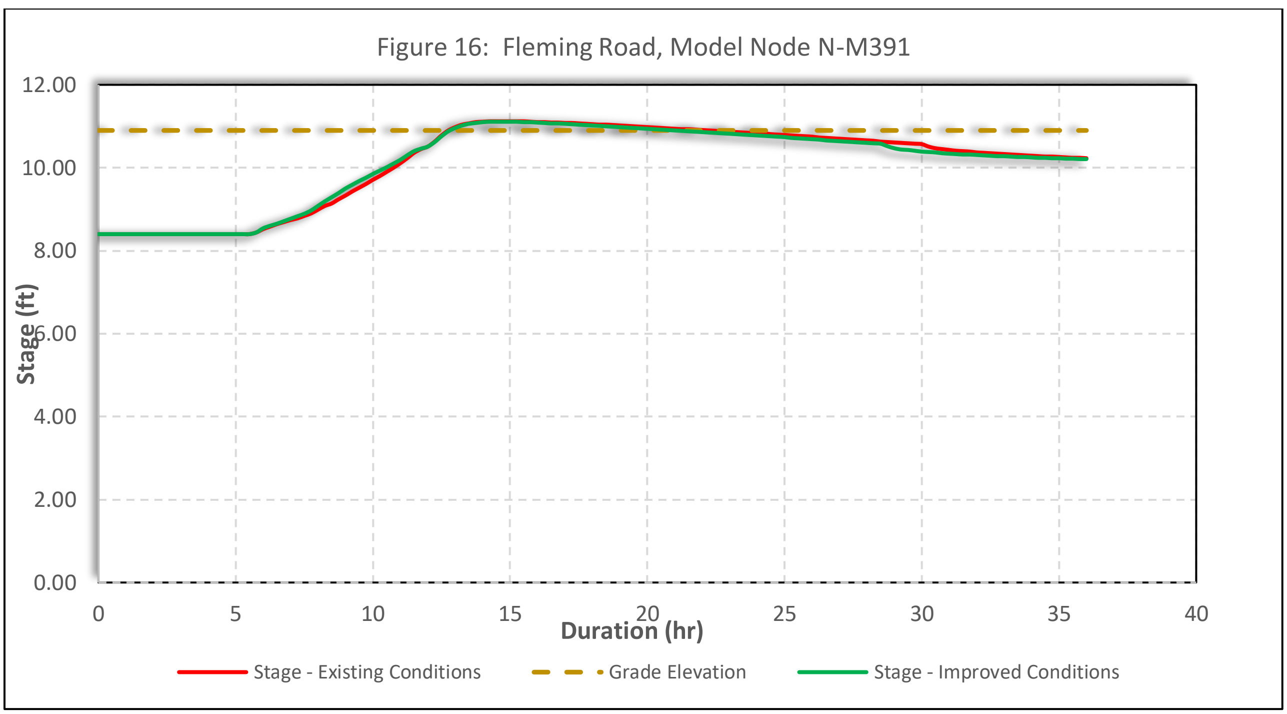


Figure 16 – Flood depth and duration mitigation along Fleming Road

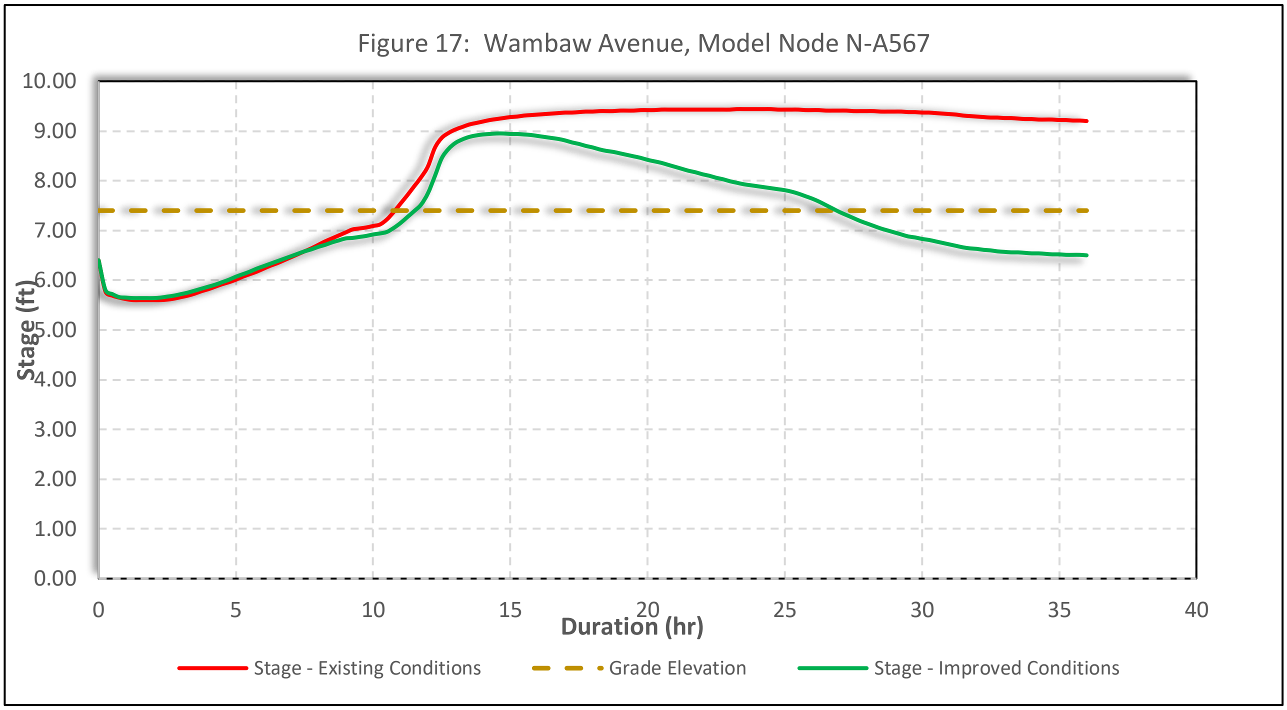


Figure 17 – Flood depth and duration mitigation along Wambaw Avenue

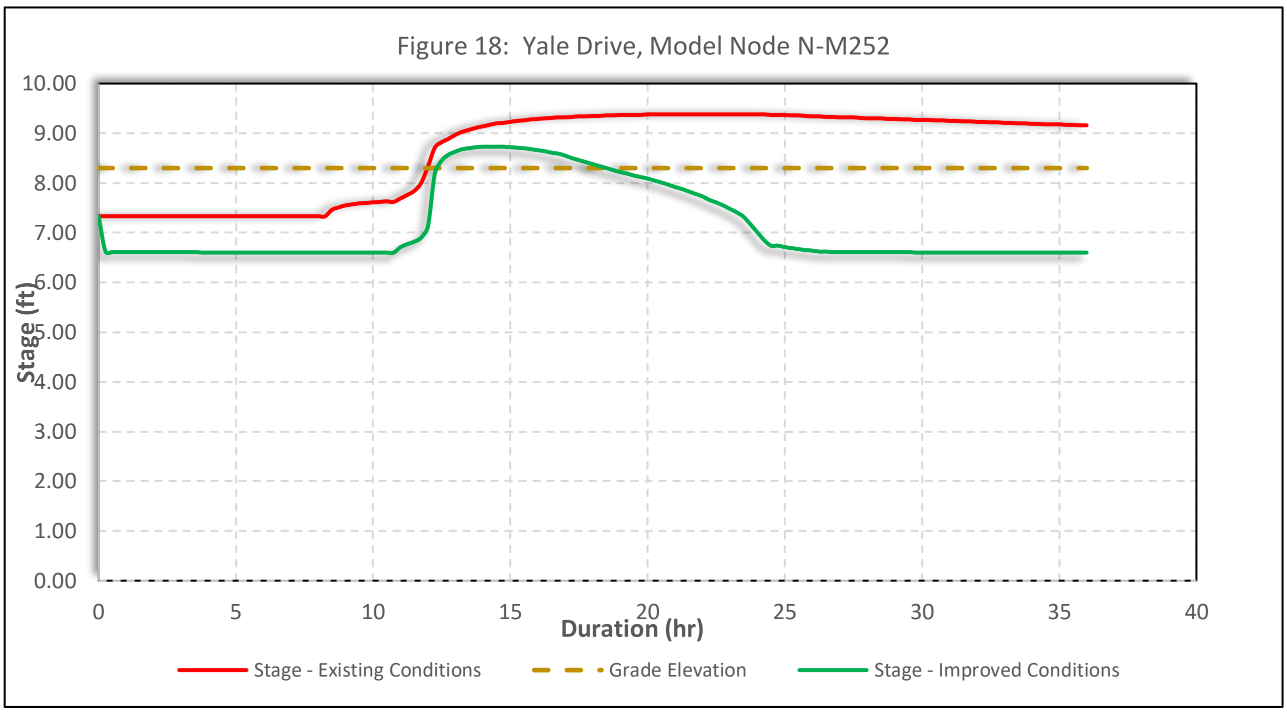


Figure 18 – Flood depth and duration mitigation along Yale Drive

In addition to flood improvements along the key roadways, the recommended improvements also reduce the severity and duration of flooding at most flooding locations. The locations listed below are representative examples of where the recommended improvements reduce the severity and duration of flooding for the 4% AEP storm:

- Neighborhoods Along Wimbledon Drive, Model Node N-M327
- Neighborhoods Along Central Park Road, Model Node N-M416
- Neighborhoods Along Yale Drive, Model Node N-M383
- Neighborhoods Along Fleming Road, Model Node N-M424
- Neighborhoods Along Wambaw Avenue, Model Node N-Area_33-a

Flood elevation and duration for existing conditions and with recommended improvements for the above locations is presented in the following **Figure 19** through **Figure 23**.

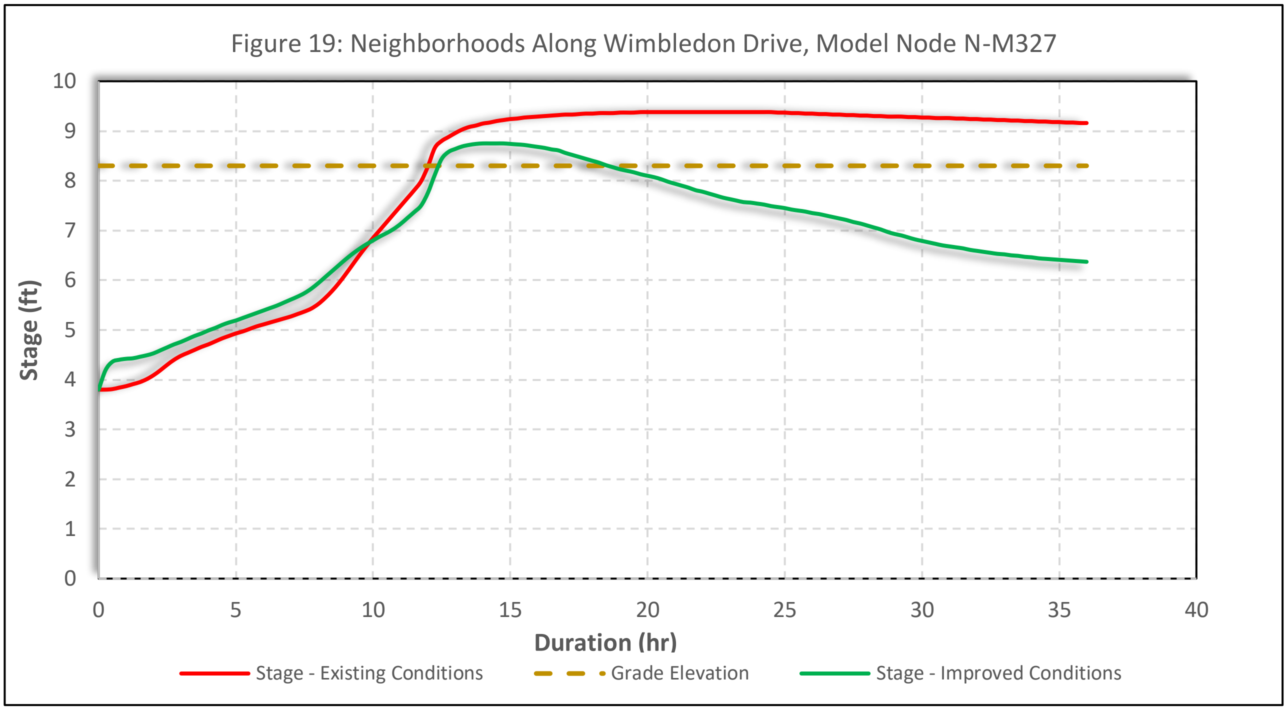


Figure 19 – Flood depth and duration mitigation along Wimbledon Drive

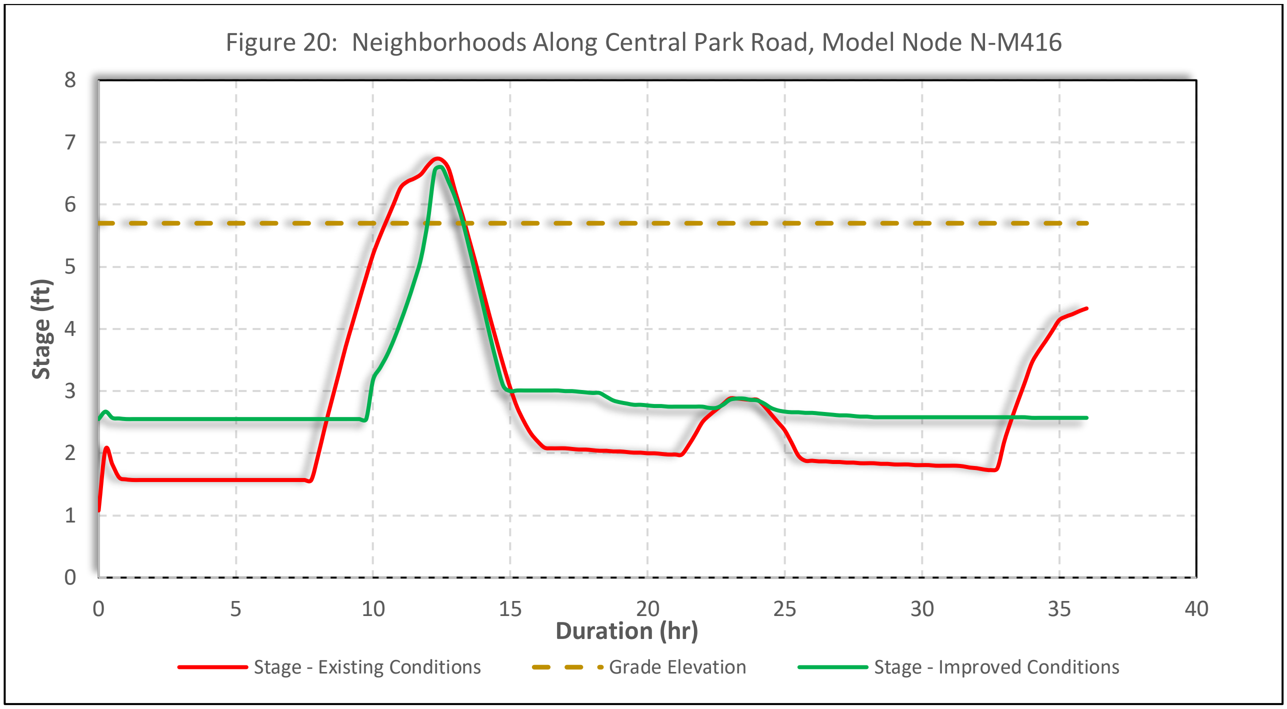


Figure 20 – Flood depth and duration mitigation along Central Park Road

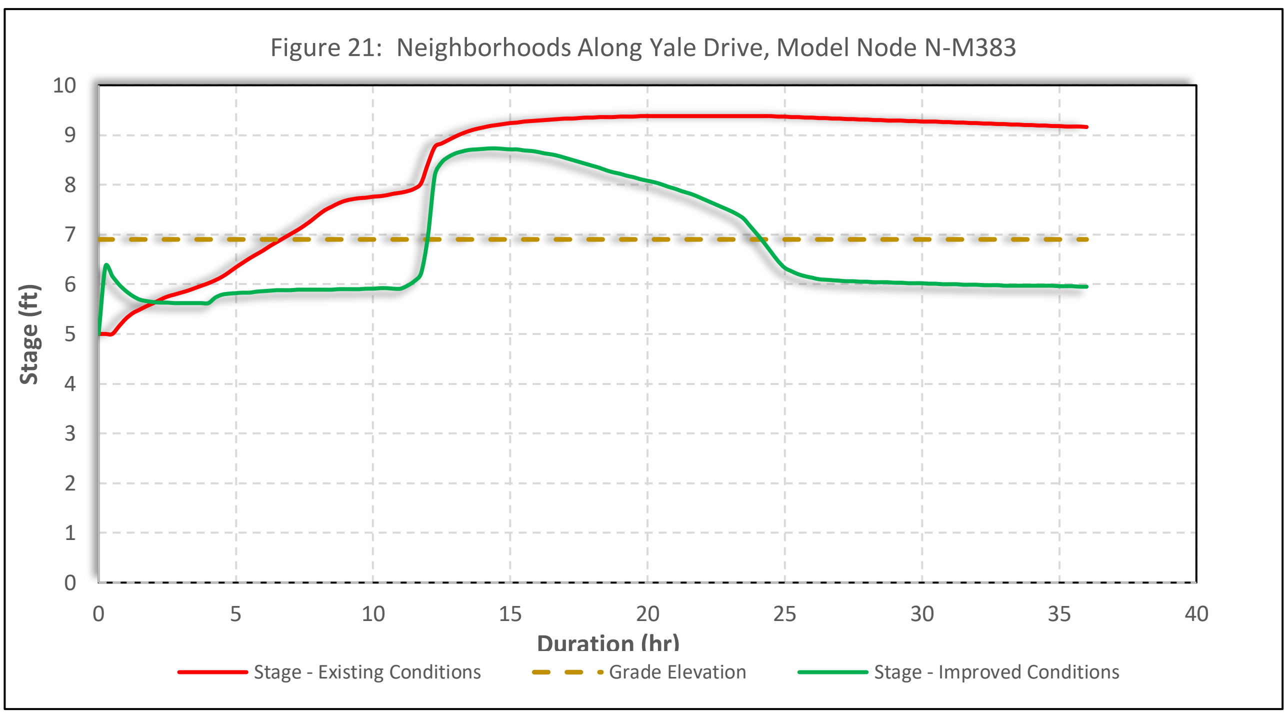


Figure 21 – Flood depth and duration mitigation along Yale Drive

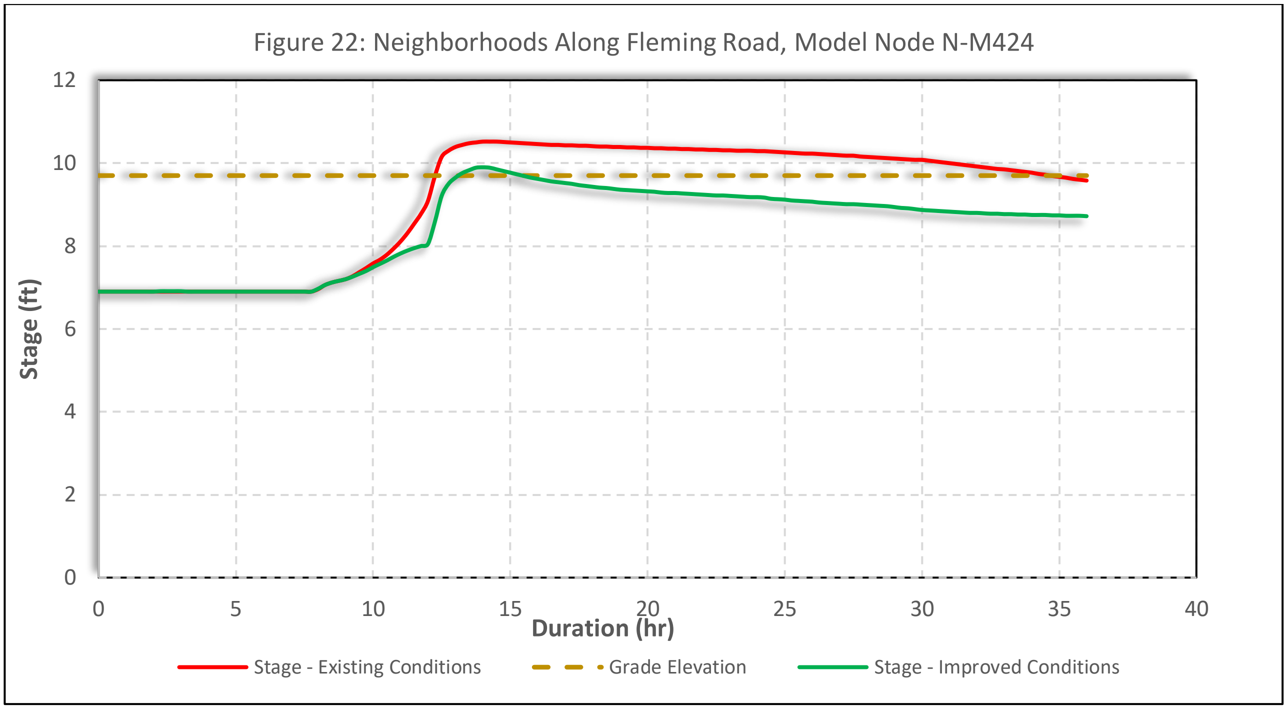


Figure 22 – Flood depth and duration mitigation along Fleming Road

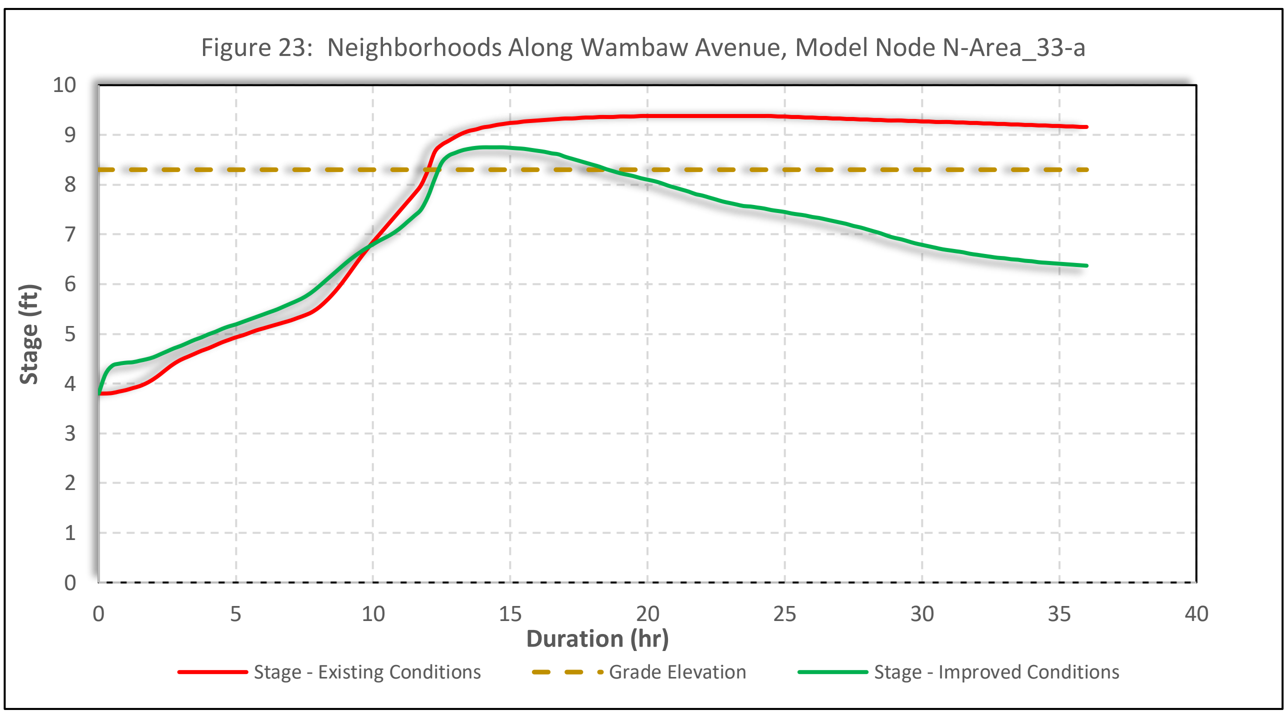


Figure 23 – Flood depth and duration mitigation along Wambaw Avenue

6.6 Improvements Prioritization

In this section AECOM provides an opinion of how the recommended improvements should be prioritized. This will inform the City's decision process for sequencing or phasing implementation of the recommended improvements. The four priority groupings are described below and visually presented in **Figure 24**.

Figures E-1 through E-4 in Appendix E show the location and details of proposed improvements for each of these priority areas.

6.6.1 Priority-1 – Improvement of James Island Creek Upstream of Riley Rd

Improvements at the most downstream end of the watershed are considered highest priority. These include improving the flow capacity of the conveyance system upstream and to the West of Riley Road, adding a flow-variable ("muted") check valve to the culverts under Riley Road, and replacing circular culverts with box culverts. These improvements increase the capacity of the stormwater conveyance system and will reduce flooding in the upstream areas of the watershed. The entire Central Park watershed drains through the Priority 1improvement features. Improvements in upstream areas of the watershed will not be effective if the stormwater assets in the downstream reaches of the watershed are deficient. Priority 1 improvements to a large extent replicate and are in accordance with recommendations in the 1984 Master Plan.

6.6.2 Priority-2 – Wimbledon Channel

Priority 2 areas are concentrated around the Wimbledon channel. This is the location where the City receives numerous flooding complaints from residents. Model results show that the Wimbledon channel does not meet LOS. Photographs provided by the residents show that the channel cross-section has been significantly reduced in some areas due to accumulation of debris/erosion of side banks. There are sections within this channel with adverse slopes. The recommended improvements in this area include fixing the sections with adverse slope and improving and maintaining the restricted cross-sections. Because this channel flows through a residential area, and the frequent flooding complaints and property damage records provided by the residents has been well documented, recommended improvements to this channel and its tributaries was assigned the second highest priority. Furthermore, improvements to the Priority 2 area will facilitate and help alleviate flooding in areas on the eastern side of the watershed along Wambaw Avenue.

6.6.3 Priority-3 – Eastern Neighborhoods

Post implementation of Priority areas 1 and 2, the recommended next highest priority area is the eastern section of the watershed along Wambaw Avenue, Mohawk Avenue, McLeod Avenue, Yale Drive, and Flint Street. The runoff from these areas drains into the Wimbledon Channel. Several culverts and channels in this area were found to have adverse slope and compromised with sediment and debris. As part of recommended improvements to this area, a portion of the runoff from this area was directed south via proposed new culverts and channel towards James Island Creek. Implementation of Priority 3 improvements will alleviate localized flooding in this area.

6.6.4 Priority-4 – Western Neighborhoods

Priority 4 areas are on the west side of the watershed. The improvements to this area include adding a new detention pond, widening channels, and increasing pipe slopes. This area is assigned a lower priority because the areal extent of flooding is less and the density of housing is lower in this area when compared to the other three priority areas.

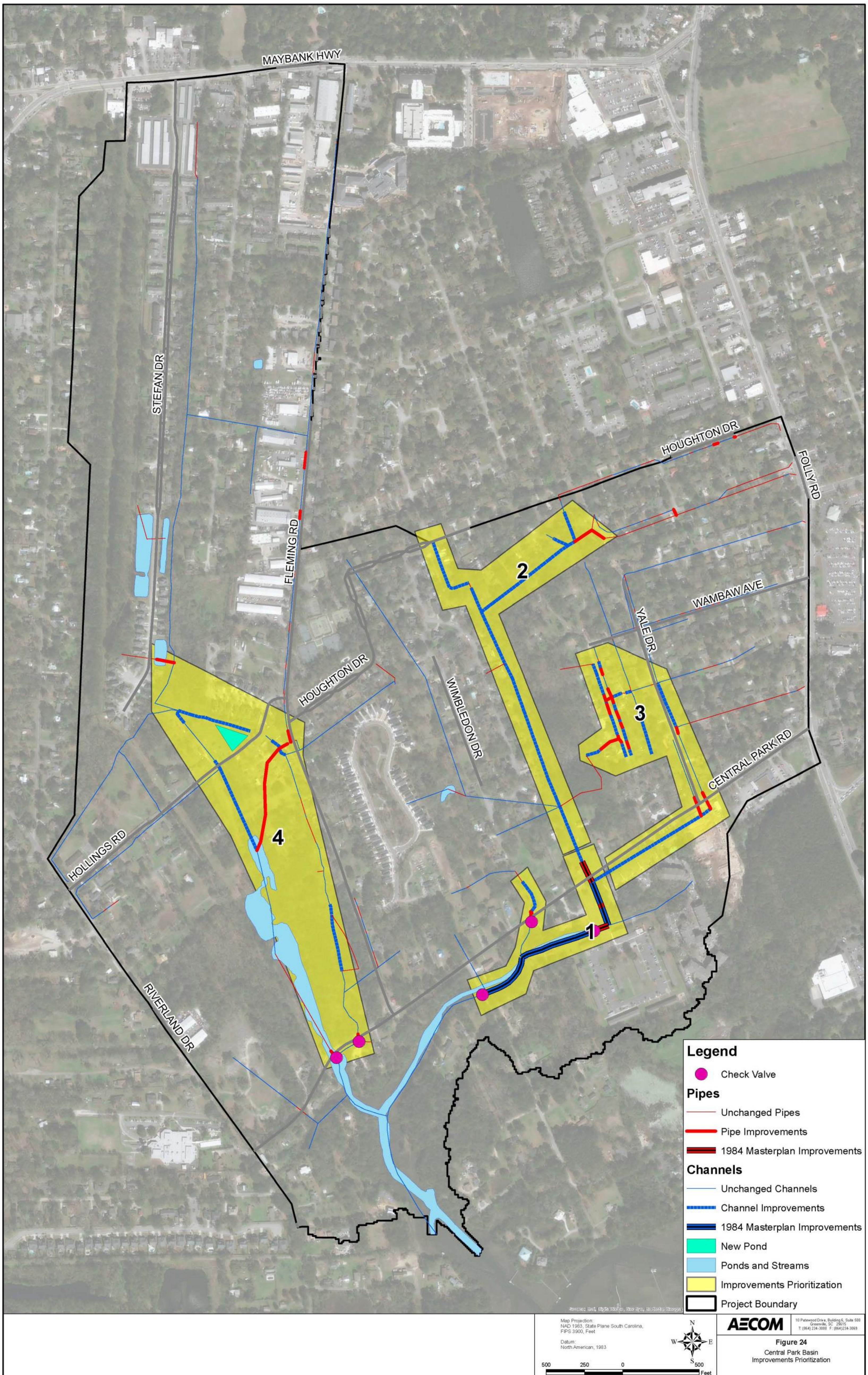


Figure 24 – Central Park Recommended Improvement Prioritization

7. COST ESTIMATE

Engineer's Class 5 Opinion of Probable Construction Cost was developed for all the proposed improvements implemented for the Central Park watershed. The total cost of the improvements if all the improvements are carried out in one phase is approximately $3.8 million dollars. Cost summary by each element is provided in **Table 10**.

Table 10 Cost Estimate (All Improvements Implemented in One Project)

Item	Cost
General, Mobilization, and Administration Costs	$ 486,892
Channel Improvements	$ 288,465
Pipe Improvements	$ 865,607
Check Valves	$ 120,000
Addition of Storage	$ 25,000
Sub Total	**$ 1,785,964**
Construction Phase Contingency	$ 642,752
Escalation, Bonds, Insurance, and Markups	$ 444,558
Construction Cost	**$ 2,873,247**
Preliminary Engineering and Survey	$ 287,327
Design and Construction Engineering Cost	$ 574,655
TOTAL COST	**$ 3,735,229**

If the improvements are implemented as two separate projects, the estimated probable cost will be higher than if implemented as a single project. Separate projects require independent mobilization and will not benefit from the economy of scale of implementing all at once. Probable cost estimates for implementing as two separate projects are listed below. Project 1 is assumed to be all the improvements for priority areas 1, 2, and 3 along with miscellaneous adjacent improvements. Project 2 is assumed to be all improvements for priority area 4 along with miscellaneous adjacent improvements.

Project 1: Priority areas 1, 2, 3 and miscellaneous improvements near Area 2: $2,873,000

Project 2: Priority area 4 and miscellaneous improvements near Area 4: $1,521,000

Total Cost of Phased Implementation of All Improvements: $4,394,000

APPENDIX-A

SUB-BASIN NAMES AND THEIR CORRESPONDING AREAS

APPENDIX-A SUB-BASINS AREA

Sub-basin Table

Sub-basin	Area (ac.)
Area-3	24.6
Area-7	10
Area-8	28.2
Area-15	21.6
Area-23-c	10
Area-24-b	10
Area-29	10
Area-31-b	40.8
Area-33-a	10
Marlboro	33.6
Area-38-a	59.4
Area-42	10
Area_44	10
Area-48	21.9
Area-49	35.4
Area-53	52.4
Area-54	10
Area-55	28.1
Area-56	10
Area-57	10.1
Area-59	10
Area-60	10
Area-62	10
Area-18-a	24.6
Area-45	10
Area-46	10
Area-58	32.1
Area-35	10
Area-47	10
Area-9	10
Area-6	22.8
Area-61	10
Area-40	10
Area-52	20.5
Area-47-a	53.4
Area-26	25.8
Area-31-a	10
Area-31	10
Area-31-c	10
Area-42-a	10
Area-42-b	10
Area-34-d	10
Area-19	10
Brisbane	10
Area-44-a	10

Sub-basin	Area (ac.)
Area-44-b	10
Area-34-c	10
Area-34-b	10
Area-34	10
Area-34-a	10
Area-23	10
Area-18	24.6
Area-23-b	10
Area-33	10
Area-38	59.4
Area-38-b	59.4
Area-58-a	31.8
Area-24	10
Area-24-a	10
Central Park	35.4
Area-23-d	10
Pond_5	5
Pond_3	5
Pond_1	5
Pond_2	5
Pond_6	5

APPENDIX-B

TIME OF CONCENTRATION TABLE

APPENDIX-B TIME OF CONCENTRATION CALCULATION

Time of Concentration Calculations using TR-55 Methodology:

ID	Basin	ToC	Sheet Flow L	SC Flow L	Sheet Flow US EL	Sheet Flow DS EL	Shallow Conc US EL	Shallow Conc DS EL	Channel US EL	Channel DS EL	Channel Area(ft^2)	Channel Dia(ft.)	Length	Surface Cover Type	SC	TOC (min)	TOC (min 10 minute)
61	CPB_38a	0.26	100.00	1200.00	21.35	20.40	20.40	8.99	8.99	8.26	18	4.79	1194	Smooth surface (pavement, gravel or bare soil)	Paved	15.34	15.34
0	CPB_38b	0.02	100.00	700.00	12.37	9.86	9.86	0.00	0.00	0	0	0.00	0	Smooth surface (pavement, gravel or bare soil)	Paved	1.27	10.00
2	CPB_3	0.41	100.00	1200.00	17.69	10.82	10.82	10.63	10.63	7.13	25	5.64	2500	Smooth surface (pavement, gravel or bare soil)	Unpaved	24.37	24.37
1	CPB_33a	0.12	100.00	1200.00	13.30	12.41	12.41	9.58	9.58	8.35	18	4.79	900	Smooth surface (pavement, gravel or bare soil)	Paved	7.30	10.00
60	CPB_5	0.58	100.00	832.00	8.72	8.20	8.20	6.96	6.96	0	0	0.00	0	Light underbrush woods	Unpaved	34.67	34.67
57	CPB_6	0.38	100.00	1200.00	9.00	8.07	8.07	7.56	7.56	0	0	0.00	0	Dense grasses	Unpaved	23.06	23.06
3	CPB_7	0.11	100.00	1200.00	20.13	18.75	18.75	12.90	12.90	11.18	5	2.52	800	Smooth surface (pavement, gravel or bare soil)	Paved	6.47	10.00
4	CPB_8	0.47	100.00	1200.00	18.37	17.33	17.33	9.93	9.93	7.92	5.25	2.59	2000	Smooth surface (pavement, gravel or bare soil)	Paved	28.41	28.41
58	CPB_9	0.07	100.00	530.00	9.96	8.79	8.79	8.65	8.65	0	0	0.00	0	Smooth surface (pavement, gravel or bare soil)	Unpaved	4.33	10.00
5	CPB_10	0.06	100.00	1200.00	14.88	14.38	14.38	11.00	11.00	7.36	0	0.00	0	Smooth surface (pavement, gravel or bare soil)	Paved	3.81	10.00
6	CPB_11	0.71	100.00	1200.00	17.20	16.65	16.65	11.38	11.38	7.82	18	4.79	1600	Light underbrush woods	Unpaved	42.42	42.42
59	CPB_12	0.77	100.00	1140.00	10.34	10.12	10.12	7.10	7.10	0	0	0.00	0	Light underbrush woods	Unpaved	46.11	46.11
7	CPB_24a	0.27	100.00	1200.00	8.80	8.06	8.06	8.82	8.82	8.25	12	3.91	300	Smooth surface (pavement, gravel or bare soil)	Paved	16.10	16.10
8	CPB_14	0.16	100.00	1200.00	12.20	11.01	11.01	9.28	9.28	8.52	1.8	1.51	600	Smooth surface (pavement, gravel or bare soil)	Paved	9.69	10.00
9	CPB_15	0.36	100.00	1200.00	12.33	11.07	11.07	8.78	8.78	7.91	4.4	2.37	1700	Smooth surface (pavement, gravel or bare soil)	Paved	21.70	21.70
10	CPB_16	0.48	100.00	1200.00	11.68	10.32	10.32	9.25	9.25	9.22	12	3.91	150	Light underbrush woods	Paved	28.93	28.93
11	CPB_Mar	0.09	100.00	1200.00	10.20	9.60	9.60	7.26	7.26	6.97	22	5.29	200	Smooth surface (pavement, gravel or bare soil)	Paved	5.55	10.00
56	CPB_18	0.41	100.00	745.00	10.28	9.20	9.20	0.00	0.00	0	0	0.00	0	Light underbrush woods	Unpaved	24.43	24.43
55	CPB_19	0.04	100.00	362.00	10.50	9.40	9.40	8.87	8.87	0	0	0.00	0	Smooth surface (pavement, gravel or bare soil)	Unpaved	2.46	10.00
13	CPB_20	0.42	100.00	1070.00	13.13	11.99	11.99	8.90	8.90	0	0	0.00	0	Light underbrush woods	Paved	25.19	25.19
14	CPB_21	0.51	100.00	1200.00	11.01	10.21	10.21	8.90	8.90	7.52	10	3.57	0	Light underbrush woods	Paved	30.47	30.47
15	CPB_22	0.06	100.00	1200.00	12.75	11.97	11.97	8.88	8.88	4.42	0	0.00	0	Smooth surface (pavement, gravel or bare soil)	Paved	3.63	10.00
16	CPB_23	0.06	100.00	1200.00	12.00	10.75	10.75	7.55	7.55	6.47	0	0.00	0	Smooth surface (pavement, gravel or bare soil)	Paved	3.32	10.00
17	CPB_24	0.08	100.00	1200.00	10.50	10.30	10.30	7.80	7.80	6.42	0	0.00	0	Smooth surface (pavement, gravel or bare soil)	Paved	5.06	10.00
18	CPB_25	0.14	100.00	1200.00	12.66	12.05	12.05	9.65	9.65	8.84	15	4.37	800	Smooth surface (pavement, gravel or bare soil)	Paved	8.14	10.00
21	CPB_26	0.43	100.00	900.00	12.87	11.75	11.75	9.70	9.70	0	0	0.00	0	Light underbrush woods	Unpaved	25.76	25.76
19	CPB_27	0.25	100.00	1200.00	17.27	11.60	11.60	8.40	8.40	6.36	52.5	8.18	200	Light underbrush woods	Unpaved	15.28	15.28
20	CPB_28	0.21	100.00	1200.00	10.84	7.99	7.99	6.45	6.45	3.18	24	5.53	615	Range (nature)	Unpaved	12.69	12.69
22	CPB_29	0.14	100.00	125.00	10.50	9.00	9.00	8.21	8.21	0	0	0.00	0	Range (nature)	Paved	8.67	10.00
23	CPB_30	0.12	100.00	183.00	10.23	8.05	8.05	6.01	6.01	0	0	0.00	0	Range (nature)	Paved	7.47	10.00
52	CPB_31	0.68	100.00	1100.00	10.69	10.25	10.25	7.92	7.92		4	2.26	1400	Light underbrush woods	Unpaved	41.03	41.03
27	CPB_32	0.13	100.00	1200.00	12.26	11.21	11.21	8.88	8.88	6.74	105	11.56	1725	Smooth surface (pavement, gravel or bare soil)	Paved	7.93	10.00
28	CPB_33	0.08	100.00	0.00	6.97	6.93	6.93	0.00	0.00	0	0	0.00	0	Smooth surface (pavement, gravel or bare soil)	Paved	5.06	10.00
29	CPB_34	0.13	100.00	1200.00	11.58	10.50	10.50	7.97	7.97	5.92	90	10.70	1150	Smooth surface (pavement, gravel or bare soil)	Paved	8.08	10.00
50	CPB_35	0.10	100.00	750.00	11.60	10.50	10.50	9.60	9.60	0	40	7.14	1100	Smooth surface (pavement, gravel or bare soil)	Paved	5.85	10.00
30	CPB_36	0.77	100.00	1200.00	10.70	10.35	10.35	7.50	7.50	6.64	15	4.37	700	Light underbrush woods	Unpaved	46.18	46.18
31	CPB_37	0.85	100.00	760.00	9.30	8.60	8.60	6.02	6.02	0	0	0.00	0	Dense underbrush woods	Unpaved	51.02	51.02
32	CPB_38	0.99	100.00	450.00	9.62	9.14	9.14	8.71	8.71	0	0	0.00	0	Dense underbrush woods	Paved	59.12	59.12
33	CPB_39	0.05	100.00	865.00	8.23	7.42	7.42	4.35	4.35	0	0	0.00	0	Smooth surface (pavement, gravel or bare soil)	Paved	2.72	10.00
34	CPB_40	0.15	100.00	600.00	10.18	8.50	8.50	6.80	6.80	0	0	0.00	0	Range (nature)	Paved	9.16	10.00
35	CPB_41	0.26	100.00	1200.00	28.36	25.26	25.26	9.77	9.77	8.44	8	3.19	900	Range (nature)	Paved	15.34	15.34
36	CPB_42	0.06	100.00	661.00	9.20	8.91	8.91	7.00	7.00	0	0	0.00	0	Smooth surface (pavement, gravel or bare soil)	Paved	3.35	10.00
37	CPB_43	1.20	100.00	720.00	6.60	6.27	6.27	6.22	6.22	0	0	0.00	0	Dense underbrush woods	Unpaved	71.84	71.84
38	CPB_44	0.05	100.00	226.00	9.00	8.50	8.50	8.40	8.40	0	0	0.00	0	Smooth surface (pavement, gravel or bare soil)	Paved	2.74	10.00

APPENDIX-B TIME OF CONCENTRATION CALCULATION

Time of Concentration Calculations using TR-55 Methodology:

ID	Basin	ToC	Sheet Flow L	SC Flow L	Sheet Flow US EL	Sheet Flow DS EL	Shallow Conc US EL	Shallow Conc DS EL	Channel US EL	Channel DS EL	Channel Area(ft^2)	Channel Dia(ft.)	Length	Surface Cover Type	SC	TOC (min)	TOC (min 10 minute)
49	CPB_45	0.02	100.00	0.00	4.00	2.50	2.50	0.00	0.00	0	0	0.00	0	Smooth surface (pavement, gravel or bare soil)	Paved	1.19	10.00
26	CPB_46	0.05	100.00	500.00	11.55	10.90	10.90	10.30	10.30	0	0	0.00	0	Smooth surface (pavement, gravel or bare soil)	Paved	3.02	10.00
25	CPB_47	0.89	100.00	300.00	9.87	9.72	9.72	9.00	9.00	0	0	0.00	0	Light underbrush woods	Unpaved	53.51	53.51
39	CPB_48	0.37	100.00	350.00	12.22	10.45	10.45	10.41	10.41	0	0	0.00	0	Light underbrush woods	Unpaved	21.91	21.91
40	CPB_49	0.24	100.00	622.00	6.97	6.30	6.30	5.03	5.03			0.00		Short grass prairie	Paved	14.51	14.51
41	CPB_50	0.56	100.00	900.00	9.28	8.77	8.77	5.42	5.42	0	0	0.00	0	Light underbrush woods	Unpaved	33.87	33.87
42	CPB_51	0.26	100.00	1200.00	11.24	10.40	10.40	8.10	8.10	6.27	12	3.91	350	Short grass prairie	Paved	15.34	15.34
43	CPB_52	0.34	100.00	1200.00	10.40	9.50	9.50	7.75	7.75	5.57	4	2.26	1175	Short grass prairie	Paved	20.54	20.54
44	CPB_53	0.41	100.00	1200.00	9.30	9.11	9.11	6.80	6.80	6	7.5	3.09		Short grass prairie	Paved	24.45	24.45
45	CPB_54	0.06	100.00	1200.00	11.08	9.98	9.98	5.55	5.55	1.24	6	2.76	300	Smooth surface (pavement, gravel or bare soil)	Unpaved	3.82	10.00
46	CPB_55	0.47	100.00	950.00	10.40	9.62	9.62	1.60	1.60	0	0	0.00	0	Light underbrush woods	Unpaved	28.12	28.12
47	CPB_56	0.13	100.00	300.00	10.00	7.96	7.96	2.24	2.24	0	0	0.00	0	Range (nature)	Unpaved	7.69	10.00
48	CPB_57	0.17	100.00	1200.00	12.20	10.27	10.27	5.13	5.13	0	0	0.00	0	Short grass prairie	Paved	10.12	10.12
24	CPB_58	0.22	100.00	500.00	7.10	6.50	6.50	5.50	5.50	0	0	0.00	0	Range (nature)	Paved	9.74	10.00
51	CPB_59	0.02	100.00	200.00	5.80	4.72	4.72	0.00	0.00	0	0	0.00	0	Smooth surface (pavement, gravel or bare soil)	Paved	1.41	10.00
53	CPB_60	0.03	100.00	634.00	10.83	9.54	9.54	3.80	3.80	0	10	3.57	100	Smooth surface (pavement, gravel or bare soil)	Paved	1.76	10.00
12	CPB_61	0.02	100.00	100.00	4.40	2.60	2.60	0.00	0.00	0	0	0.00	0	Smooth surface (pavement, gravel or bare soil)	Paved	1.13	10.00
54	CPB_62	0.03	100.00	848.00	9.66	8.13	8.13	0.00	0.00	0	0	0.00	0	Smooth surface (pavement, gravel or bare soil)	Unpaved	1.82	10.00

APPENDIX-C

LIST OF STORMWATER ASSETS FOR CAPITAL IMPROVEMENTS

APPENDIX-C LIST OF STORMWATER ASSETS FOR CAPITAL IMPROVEMENTS

CHANNEL IMPROVEMENTS

		Before				After			
Channel	Length	US Inv	DS Inv	Station	Elevation	US Inv	DS Inv	Station	Elevation
C-100	81	5.881	5.801	0	7.161	5.7	5.7	0	7.161
C-100	81	5.881	5.801	10	6.767	5.7	5.7	10	6.767
C-100	81	5.881	5.801	20	5.184	5.7	5.7	20	5.184
C-100	81	5.881	5.801	30	6.223	5.7	5.7	30	6.223
C-100	81	5.881	5.801	40	7.225	5.7	5.7	40	7.225
C-101	22	5.801	6.431	0	6.978	5.7	5.7	0	6.978
C-101	22	5.801	6.431	10	6.643	5.7	5.7	10	6.643
C-101	22	5.801	6.431	20	5.6	5.7	5.7	20	5.6
C-101	22	5.801	6.431	30	6.252	5.7	5.7	30	6.252
C-101	22	5.801	6.431	40	7.407	5.7	5.7	40	7.407
C-12	51	3	3.9	0	8.612	6.9	6.1	0	8.612
C-12	51	3	3.9	10	6.615	6.9	6.1	10	6.615
C-12	51	3	3.9	20	6.949	6.9	6.1	20	6.949
C-12	51	3	3.9	30	8.973	6.9	6.1	30	8.973
C-12	51	3	3.9	40	10.793	6.9	6.1	40	10.793
C-121	60	6.649	9.083	0	7.293	6.649	6.2	0	8.346
C-121	60	6.649	9.083	5	6.9075	6.649	6.2	7.91	8.184
C-121	60	6.649	9.083	10	6.522	6.649	6.2	15.83	8.069
C-121	60	6.649	9.083	15	6.9085	6.649	6.2	23.74	8.083
C-121	60	6.649	9.083	20	7.295	6.649	6.2	31.66	7.647
C-121	60	6.649	9.083	25	7.949	6.649	6.2	39.57	6.241
C-121	60	6.649	9.083	30	8.603	6.649	6.2	47.48	7.219
C-121	60	6.649	9.083	35	8.544	6.649	6.2	55.4	8.301
C-121	60	6.649	9.083	40	8.485	6.649	6.2	63.31	8.611
C-122	16	9.083	8.682	0	8.914	6.2	6.1	0	8.326
C-122	16	9.083	8.682	5	8.957	6.2	6.1	7.64	8.167
C-122	16	9.083	8.682	10	9	6.2	6.1	15.29	8.087
C-122	16	9.083	8.682	15	9.055	6.2	6.1	22.93	8.133
C-122	16	9.083	8.682	20	9.11	6.2	6.1	30.57	7.72
C-122	16	9.083	8.682	25	8.8065	6.2	6.1	38.21	6.172
C-122	16	9.083	8.682	30	8.503	6.2	6.1	45.86	7.279
C-122	16	9.083	8.682	35	8.373	6.2	6.1	53.5	8.374
C-122	16	9.083	8.682	40	8.243	6.2	6.1	61.14	8.699
C-136	89	6.407	7.724	0	9.579	6.407	6.3	0	9.579
C-136	89	6.407	7.724	10	8.5	6.407	6.3	10	8.5
C-136	89	6.407	7.724	20	7.526	6.407	6.3	20	7.526
C-136	89	6.407	7.724	30	7.847	6.407	6.3	30	7.847
C-136	89	6.407	7.724	40	8.038	6.407	6.3	40	8.038
C-137	61	8.682	5.911	0	7.872	6.1	5.911	0	7.822
C-137	61	8.682	5.911	5	7.8005	6.1	5.911	5.5	7.614
C-137	61	8.682	5.911	10	7.729	6.1	5.911	10.99	7.193
C-137	61	8.682	5.911	15	7.5705	6.1	5.911	16.49	6.309
C-137	61	8.682	5.911	20	7.412	6.1	5.911	21.98	6.273
C-137	61	8.682	5.911	25	6.7375	6.1	5.911	27.48	6.941
C-137	61	8.682	5.911	30	6.063	6.1	5.911	32.97	7.619

APPENDIX-C LIST OF STORMWATER ASSETS FOR CAPITAL IMPROVEMENTS

CHANNEL IMPROVEMENTS

		Before				After			
Channel	Length	US Inv	DS Inv	Station	Elevation	US Inv	DS Inv	Station	Elevation
C-137	61	8.682	5.911	35	6.701	6.1	5.911	38.47	7.631
C-137	61	8.682	5.911	40	7.339	6.1	5.911	43.96	7.666
C-14	30	4.9	3	0	10.5	7.1	6.9	0	10.5
C-14	30	4.9	3	10	9.146	7.1	6.9	10	9.146
C-14	30	4.9	3	20	6.842	7.1	6.9	20	6.842
C-14	30	4.9	3	30	7.342	7.1	6.9	30	7.342
C-14	30	4.9	3	40	8.486	7.1	6.9	40	8.486
C-141	70	4.607	5.509	0	7.2	4.607	4.4	0	7.2
C-141	70	4.607	5.509	10	5.208	4.607	4.4	10	5.208
C-141	70	4.607	5.509	20	4.267	4.607	4.4	20	4.267
C-141	70	4.607	5.509	30	6.994	4.607	4.4	30	6.994
C-141	70	4.607	5.509	40	7.774	4.607	4.4	40	7.774
C-142	373	4.4	4.161	0	4.946	4.4	4.161	0	6.978
C-142	373	4.4	4.161	5	4.687	4.4	4.161	6.87	6.977
C-142	373	4.4	4.161	10	4.428	4.4	4.161	13.73	5.531
C-142	373	4.4	4.161	15	5.2085	4.4	4.161	20.6	3.979
C-142	373	4.4	4.161	20	5.989	4.4	4.161	27.46	3.137
C-142	373	4.4	4.161	25	6.3805	4.4	4.161	34.33	4.942
C-142	373	4.4	4.161	30	6.772	4.4	4.161	41.19	5.801
C-142	373	4.4	4.161	35	6.7345	4.4	4.161	48.06	5.941
C-142	373	4.4	4.161	40	6.697	4.4	4.161	54.93	5.909
C-167	63	9.994	9.856	0	10.054	9.3	9.1	0	10.054
C-167	63	9.994	9.856	10	9.983	9.3	9.1	10	9.983
C-167	63	9.994	9.856	20	10.049	9.3	9.1	20	10.049
C-167	63	9.994	9.856	30	10.305	9.3	9.1	30	10.305
C-167	63	9.994	9.856	40	10.424	9.3	9.1	40	10.424
C-170	73	8.051	8.44	0	8.251	8.44	8.051	0	8.251
C-170	73	8.051	8.44	10	8.043	8.44	8.051	10	8.043
C-170	73	8.051	8.44	20	8.322	8.44	8.051	20	8.322
C-170	73	8.051	8.44	30	9.915	8.44	8.051	30	9.915
C-170	73	8.051	8.44	40	10.24	8.44	8.051	40	10.24
C-171	23	8.44	6.407	0	6.454	8.051	6.407	0	6.454
C-171	23	8.44	6.407	10	6.427	8.051	6.407	10	6.427
C-171	23	8.44	6.407	20	6.525	8.051	6.407	20	6.525
C-171	23	8.44	6.407	30	6.714	8.051	6.407	30	6.714
C-171	23	8.44	6.407	40	6.999	8.051	6.407	40	6.999
C-176	28	6.092	6.84	0	7.116	6.7	6.2	0	7.116
C-176	28	6.092	6.84	10	6.687	6.7	6.2	10	6.687
C-176	28	6.092	6.84	20	7.055	6.7	6.2	20	7.055
C-176	28	6.092	6.84	30	7.482	6.7	6.2	30	7.482
C-176	28	6.092	6.84	40	7.552	6.7	6.2	40	7.552
C-177	52	6.756	5.629	0	6.361	6.2	5.9	0	6.361
C-177	52	6.756	5.629	10	5.886	6.2	5.9	10	5.886
C-177	52	6.756	5.629	20	6.583	6.2	5.9	20	6.583

APPENDIX-C LIST OF STORMWATER ASSETS FOR CAPITAL IMPROVEMENTS

CHANNEL IMPROVEMENTS

		Before				After			
Channel	**Length**	**US Inv**	**DS Inv**	**Station**	**Elevation**	**US Inv**	**DS Inv**	**Station**	**Elevation**
C-177	52	6.756	5.629	30	7.342	6.2	5.9	30	7.342
C-177	52	6.756	5.629	40	7.406	6.2	5.9	40	7.406
C-178	51	6.52	6.855	0	7.541	6.855	6.7	0	7.541
C-178	51	6.52	6.855	10	6.965	6.855	6.7	10	6.965
C-178	51	6.52	6.855	20	6.567	6.855	6.7	20	6.567
C-178	51	6.52	6.855	30	6.968	6.855	6.7	30	6.968
C-178	51	6.52	6.855	40	7.136	6.855	6.7	40	7.136
C-182	51	7.071	6.842	0	7.726	7.62	6.842	0	7.726
C-182	51	7.071	6.842	10	7.532	7.62	6.842	10	7.532
C-182	51	7.071	6.842	20	7.641	7.62	6.842	20	7.641
C-182	51	7.071	6.842	30	8.124	7.62	6.842	30	8.124
C-182	51	7.071	6.842	40	7.979	7.62	6.842	40	7.979
C-183	63	6.129	6.025	0	7.45	5.9	5.8	0	7.45
C-183	63	6.129	6.025	10	6.186	5.9	5.8	10	6.186
C-183	63	6.129	6.025	20	6.202	5.9	5.8	20	6.202
C-183	63	6.129	6.025	30	6.628	5.9	5.8	30	6.628
C-183	63	6.129	6.025	40	6.614	5.9	5.8	40	6.614
C-184	50	8.079	7.44	0	8.143	7.5	7.44	0	8.143
C-184	50	8.079	7.44	10	7.628	7.5	7.44	10	7.628
C-184	50	8.079	7.44	20	7.36	7.5	7.44	20	7.36
C-184	50	8.079	7.44	30	8.032	7.5	7.44	30	8.032
C-184	50	8.079	7.44	40	7.712	7.5	7.44	40	7.712
C-197	54	5.496	6.622	0	7.658	6.1	5.9	0	7.658
C-197	54	5.496	6.622	10	6.34	6.1	5.9	10	6.34
C-197	54	5.496	6.622	20	7.092	6.1	5.9	20	7.092
C-197	54	5.496	6.622	30	7.9	6.1	5.9	30	7.9
C-197	54	5.496	6.622	40	6.959	6.1	5.9	40	6.959
C-198	51	5.846	5.58	0	7.295	4.9	4.7	0	10.898
C-198	51	5.846	5.58	5	6.0705	4.9	4.7	6.52	11.05
C-198	51	5.846	5.58	10	4.846	4.9	4.7	13.04	10.985
C-198	51	5.846	5.58	15	7.2945	4.9	4.7	19.55	8.666
C-198	51	5.846	5.58	20	9.743	4.9	4.7	26.07	5.504
C-198	51	5.846	5.58	25	10.5515	4.9	4.7	32.59	5.358
C-198	51	5.846	5.58	30	11.36	4.9	4.7	39.11	7.542
C-198	51	5.846	5.58	35	11.3355	4.9	4.7	45.63	9.978
C-198	51	5.846	5.58	40	11.311	4.9	4.7	52.14	11.231
C-199	55	6.382	5.496	0	8.822	6.2	6.1	0	8.822
C-199	55	6.382	5.496	10	6.811	6.2	6.1	10	6.811
C-199	55	6.382	5.496	20	10.208	6.2	6.1	20	10.208
C-199	55	6.382	5.496	30	10.208	6.2	6.1	30	10.208
C-199	55	6.382	5.496	40	10.202	6.2	6.1	40	10.202
C-200	52	7.934	6.382	0	10.084	6.4	6.2	0	10.084
C-200	52	7.934	6.382	10	7.772	6.4	6.2	10	7.772
C-200	52	7.934	6.382	20	8.503	6.4	6.2	20	8.503

APPENDIX-C LIST OF STORMWATER ASSETS FOR CAPITAL IMPROVEMENTS

CHANNEL IMPROVEMENTS

		Before				After			
Channel	**Length**	**US Inv**	**DS Inv**	**Station**	**Elevation**	**US Inv**	**DS Inv**	**Station**	**Elevation**
C-200	52	7.934	6.382	30	8.867	6.4	6.2	30	8.867
C-200	52	7.934	6.382	40	9.154	6.4	6.2	40	9.154
C-202	30	8.567	4.9	0	9.654	7.3	7.1	0	9.654
C-202	30	8.567	4.9	10	9.382	7.3	7.1	10	9.382
C-202	30	8.567	4.9	20	8.426	7.3	7.1	20	8.426
C-202	30	8.567	4.9	30	8.396	7.3	7.1	30	8.396
C-202	30	8.567	4.9	40	8.48	7.3	7.1	40	8.48
C-203	49	7.07	8.567	0	9.588	7.5	7.3	0	9.588
C-203	49	7.07	8.567	10	9.133	7.5	7.3	10	9.133
C-203	49	7.07	8.567	20	7.211	7.5	7.3	20	7.211
C-203	49	7.07	8.567	30	7.788	7.5	7.3	30	7.788
C-203	49	7.07	8.567	40	8.466	7.5	7.3	40	8.466
C-204	97	8.177	7.07	0	9.127	8.177	7.5	0	9.127
C-204	97	8.177	7.07	10	8.775	8.177	7.5	10	8.775
C-204	97	8.177	7.07	20	7.842	8.177	7.5	20	7.842
C-204	97	8.177	7.07	30	7.324	8.177	7.5	30	7.324
C-204	97	8.177	7.07	40	8.516	8.177	7.5	40	8.516
C-207	31	6.457	6.191	0	6.656	7	6.8	0	7.204
C-207	31	6.457	6.191	10	6.603	7	6.8	10	7.11
C-207	31	6.457	6.191	20	6.562	7	6.8	20	6.9
C-207	31	6.457	6.191	30	7.196	7	6.8	30	6.9
C-207	31	6.457	6.191	40	7.262	7	6.8	40	7.508
C-208	70	7.228	6.457	0	7.204	7.228	7	0	7.204
C-208	70	7.228	6.457	10	7.11	7.228	7	10	7.11
C-208	70	7.228	6.457	20	6.993	7.228	7	20	6.9
C-208	70	7.228	6.457	30	7.304	7.228	7	30	6.9
C-208	70	7.228	6.457	40	7.508	7.228	7	40	7.508
C-211	49	6.191	5.792	0	6.37	6.8	6.4	0	6.37
C-211	49	6.191	5.792	10	6.316	6.8	6.4	10	6.316
C-211	49	6.191	5.792	20	6.019	6.8	6.4	20	6.019
C-211	49	6.191	5.792	30	6.693	6.8	6.4	30	6.693
C-211	49	6.191	5.792	40	7.089	6.8	6.4	40	7.089
C-221	96	10.185	9.518	0	9.979	10.185	9.518	0	10.694
C-221	96	10.185	9.518	5	10.168	10.185	9.518	7.65	10.18
C-221	96	10.185	9.518	10	10.357	10.185	9.518	15.3	8.88
C-221	96	10.185	9.518	15	10.614	10.185	9.518	22.96	8.845
C-221	96	10.185	9.518	20	10.871	10.185	9.518	30.61	8.88
C-221	96	10.185	9.518	25	11.0475	10.185	9.518	38.26	8.88
C-221	96	10.185	9.518	30	11.224	10.185	9.518	45.91	9.974
C-221	96	10.185	9.518	35	11.222	10.185	9.518	53.57	9.943
C-221	96	10.185	9.518	40	11.22	10.185	9.518	61.22	10.095
C-222	138	11.313	10.794	0	10.948	11.313	10.794	0	11.555
C-222	138	11.313	10.794	5	10.8455	11.313	10.794	6.37	11.106
C-222	138	11.313	10.794	10	10.743	11.313	10.794	12.74	10.4

APPENDIX-C LIST OF STORMWATER ASSETS FOR CAPITAL IMPROVEMENTS

CHANNEL IMPROVEMENTS

		Before				After			
Channel	Length	US Inv	DS Inv	Station	Elevation	US Inv	DS Inv	Station	Elevation
C-222	138	11.313	10.794	15	10.8055	11.313	10.794	19.1	10.4
C-222	138	11.313	10.794	20	10.868	11.313	10.794	25.47	10.4
C-222	138	11.313	10.794	25	10.9935	11.313	10.794	31.84	10.4
C-222	138	11.313	10.794	30	11.119	11.313	10.794	38.21	10.847
C-222	138	11.313	10.794	35	11.2315	11.313	10.794	44.58	10.762
C-222	138	11.313	10.794	40	11.344	11.313	10.794	50.95	10.429
C-223	216	10.794	10.185	0	10.734	10.794	10.185	0	11.474
C-223	216	10.794	10.185	5	10.5595	10.794	10.185	5.36	11.172
C-223	216	10.794	10.185	10	10.385	10.794	10.185	10.72	10
C-223	216	10.794	10.185	15	10.2785	10.794	10.185	16.08	10
C-223	216	10.794	10.185	20	10.172	10.794	10.185	21.45	9.994
C-223	216	10.794	10.185	25	10.413	10.794	10.185	26.81	10.139
C-223	216	10.794	10.185	30	10.654	10.794	10.185	32.17	10.49
C-223	216	10.794	10.185	35	10.7635	10.794	10.185	37.53	10.61
C-223	216	10.794	10.185	40	10.873	10.794	10.185	42.89	10.555
C-237	29	7.139	7.334	0	7.852	6.6	6.2	0	7.852
C-237	29	7.139	7.334	10	7.684	6.6	6.2	10	7.684
C-237	29	7.139	7.334	20	6.855	6.6	6.2	20	6.855
C-237	29	7.139	7.334	30	7.257	6.6	6.2	30	7.257
C-237	29	7.139	7.334	40	7.334	6.6	6.2	40	7.334
C-238	48	7.334	4.3	0	7.548	7.334	6.6	0	7.548
C-238	48	7.334	4.3	10	7.198	7.334	6.6	10	7.198
C-238	48	7.334	4.3	20	6.665	7.334	6.6	20	6.665
C-238	48	7.334	4.3	30	7.068	7.334	6.6	30	7.068
C-238	48	7.334	4.3	40	7.048	7.334	6.6	40	7.048
C-239	67	7.34	7.139	0	8.029	6.2	5.8	0	8.029
C-239	67	7.34	7.139	10	7.95	6.2	5.8	10	7.95
C-239	67	7.34	7.139	20	6.961	6.2	5.8	20	6.961
C-239	67	7.34	7.139	30	7.259	6.2	5.8	30	7.259
C-239	67	7.34	7.139	40	7.603	6.2	5.8	40	7.603
C-240	172	5	7.34	0	7.776	5.8	5.6	0	7.776
C-240	172	5	7.34	10	7.422	5.8	5.6	10	7.422
C-240	172	5	7.34	20	7.196	5.8	5.6	20	7.196
C-240	172	5	7.34	30	7.613	5.8	5.6	30	7.613
C-240	172	5	7.34	40	7.687	5.8	5.6	40	7.687
C-247	231	6.26	2.55	0	5.257	6.26	2.55	0	5.257
C-247	231	6.26	2.55	10	4.173	6.26	2.55	10	3.5
C-247	231	6.26	2.55	20	3.395	6.26	2.55	20	3.395
C-247	231	6.26	2.55	30	4.41	6.26	2.55	30	3.5
C-247	231	6.26	2.55	40	4.954	6.26	2.55	40	4.954
C-253	169	8.34	9.754	0	11.426	8.34	4.5	0	11.426
C-253	169	8.34	9.754	10	11.268	8.34	4.5	10	9
C-253	169	8.34	9.754	20	8.042	8.34	4.5	20	8.042
C-253	169	8.34	9.754	30	10.875	8.34	4.5	30	9

APPENDIX-C LIST OF STORMWATER ASSETS FOR CAPITAL IMPROVEMENTS

CHANNEL IMPROVEMENTS

		Before				After			
Channel	Length	US Inv	DS Inv	Station	Elevation	US Inv	DS Inv	Station	Elevation
C-253	169	8.34	9.754	40	11.226	8.34	4.5	40	11.226
C-269	371	2.98	3.394	0	8.689	4.5	3.6	0	9.576
C-269	371	2.98	3.394	5	7.237	4.5	3.6	8.5	9.371
C-269	371	2.98	3.394	10	5.785	4.5	3.6	17.01	5
C-269	371	2.98	3.394	15	4.2445	4.5	3.6	25.51	4
C-269	371	2.98	3.394	20	2.704	4.5	3.6	34.02	3.115
C-269	371	2.98	3.394	25	5.0795	4.5	3.6	42.52	4.016
C-269	371	2.98	3.394	30	7.455	4.5	3.6	51.03	9.394
C-269	371	2.98	3.394	35	8.771	4.5	3.6	59.53	11.182
C-269	371	2.98	3.394	40	10.087	4.5	3.6	68.04	11.088
C-273	587	9.994	1.9	0	9.711	9.1	1.9	0	9.711
C-273	587	9.994	1.9	10	9.318	9.1	1.9	10	9.318
C-273	587	9.994	1.9	20	9.053	9.1	1.9	20	9.053
C-273	587	9.994	1.9	30	9.101	9.1	1.9	30	9.101
C-273	587	9.994	1.9	40	9.217	9.1	1.9	40	9.217
C-274	106	5.4	5.141	0	7.574	5.4	5.141	0	7.639
C-274	106	5.4	5.141	5	7.497	5.4	5.141	6.64	7.232
C-274	106	5.4	5.141	10	7.42	5.4	5.141	13.28	5.868
C-274	106	5.4	5.141	15	7.4115	5.4	5.141	19.92	4.088
C-274	106	5.4	5.141	20	7.403	5.4	5.141	26.56	4.611
C-274	106	5.4	5.141	25	7.342	5.4	5.141	33.2	5.921
C-274	106	5.4	5.141	30	7.281	5.4	5.141	39.84	6.911
C-274	106	5.4	5.141	35	6.663	5.4	5.141	46.48	7.031
C-274	106	5.4	5.141	40	6.045	5.4	5.141	53.12	6.965
C-276	300	5.58	2.98	0	5.967	4.7	4.5	0	10.854
C-276	300	5.58	2.98	5	6.043	4.7	4.5	7.47	10.566
C-276	300	5.58	2.98	10	6.119	4.7	4.5	14.94	9.845
C-276	300	5.58	2.98	15	7.7805	4.7	4.5	22.41	7.863
C-276	300	5.58	2.98	20	9.442	4.7	4.5	29.88	5.661
C-276	300	5.58	2.98	25	10.1065	4.7	4.5	37.36	6.016
C-276	300	5.58	2.98	30	10.771	4.7	4.5	44.83	8.313
C-276	300	5.58	2.98	35	11.1255	4.7	4.5	52.3	10.014
C-276	300	5.58	2.98	40	11.48	4.7	4.5	59.77	10.658
C-279	388	6.03	1.34	0	4.07	1.5	1.34	0	6.383
C-279	388	6.03	1.34	5	3.014	1.5	1.34	9.6	6.572
C-279	388	6.03	1.34	10	1.958	1.5	1.34	19.2	2.6
C-279	388	6.03	1.34	15	2.965	1.5	1.34	28.79	2.592
C-279	388	6.03	1.34	20	3.972	1.5	1.34	38.39	2.592
C-279	388	6.03	1.34	25	5.3765	1.5	1.34	47.99	2.5
C-279	388	6.03	1.34	30	6.781	1.5	1.34	57.59	7.523
C-279	388	6.03	1.34	35	7.0065	1.5	1.34	67.19	7.19
C-279	388	6.03	1.34	40	7.232	1.5	1.34	76.78	6.519
C-287	236	7.055	8.079	0	8.342	7.8	7.5	0	8.342
C-287	236	7.055	8.079	10	8.134	7.8	7.5	10	8.134

APPENDIX-C LIST OF STORMWATER ASSETS FOR CAPITAL IMPROVEMENTS

CHANNEL IMPROVEMENTS

		Before				After			
Channel	**Length**	**US Inv**	**DS Inv**	**Station**	**Elevation**	**US Inv**	**DS Inv**	**Station**	**Elevation**
C-287	236	7.055	8.079	20	7.897	7.8	7.5	20	7.897
C-287	236	7.055	8.079	30	8.397	7.8	7.5	30	8.397
C-287	236	7.055	8.079	40	8.88	7.8	7.5	40	8.88
C-288	100	6.71	6.379	0	7.276	6.6	6.4	0	7.276
C-288	100	6.71	6.379	10	6.898	6.6	6.4	10	6.898
C-288	100	6.71	6.379	20	6.913	6.6	6.4	20	6.913
C-288	100	6.71	6.379	30	7.465	6.6	6.4	30	7.465
C-288	100	6.71	6.379	40	7.635	6.6	6.4	40	7.635
C-289	37	6.262	7.004	0	7.3	6.262	6.08	0	7.3
C-289	37	6.262	7.004	10	6.159	6.262	6.08	10	6.159
C-289	37	6.262	7.004	20	6.909	6.262	6.08	20	6.909
C-289	37	6.262	7.004	30	7.114	6.262	6.08	30	7.114
C-289	37	6.262	7.004	40	7.521	6.262	6.08	40	7.521
C-291	110	3.394	3.064	0	6.146	3.6	3.064	0	6.146
C-291	110	3.394	3.064	10	4.769	3.6	3.064	10	4.769
C-291	110	3.394	3.064	20	2.925	3.6	3.064	15	2.925
C-291	110	3.394	3.064	30	4.406	3.6	3.064	30	2.925
C-291	110	3.394	3.064	40	7.587	3.6	3.064	40	7.587
C-308	312	6.622	5.846	0	6.986	5.9	4.9	0	9.653
C-308	312	6.622	5.846	5	6.006	5.9	4.9	6.8	9.306
C-308	312	6.622	5.846	10	5.026	5.9	4.9	13.61	8.695
C-308	312	6.622	5.846	15	6.351	5.9	4.9	20.41	5.6
C-308	312	6.622	5.846	20	7.676	5.9	4.9	27.21	5.548
C-308	312	6.622	5.846	25	8.4695	5.9	4.9	34.01	5.652
C-308	312	6.622	5.846	30	9.263	5.9	4.9	40.82	7.186
C-308	312	6.622	5.846	35	9.3675	5.9	4.9	47.62	9.031
C-308	312	6.622	5.846	40	9.472	5.9	4.9	54.42	10.011
C-92	37	6.089	5.516	0	6.188	6.089	5.9	0	6.188
C-92	37	6.089	5.516	10	5.389	6.089	5.9	10	5.389
C-92	37	6.089	5.516	20	6.367	6.089	5.9	20	6.367
C-92	37	6.089	5.516	30	6.53	6.089	5.9	30	6.53
C-92	37	6.089	5.516	40	6.265	6.089	5.9	40	6.265
C-94	38	4.58	5.71	0	6.15	5.9	5.71	0	6.15
C-94	38	4.58	5.71	10	5.479	5.9	5.71	10	5.479
C-94	38	4.58	5.71	20	5.557	5.9	5.71	20	5.557
C-94	38	4.58	5.71	30	6.331	5.9	5.71	30	6.331
C-94	38	4.58	5.71	40	6.246	5.9	5.71	40	6.246
C-95	25	5.766	6.25	0	7.077	5.71	5.7	0	7.077
C-95	25	5.766	6.25	10	6.763	5.71	5.7	10	6.763
C-95	25	5.766	6.25	20	5.272	5.71	5.7	20	5.272
C-95	25	5.766	6.25	30	6.899	5.71	5.7	30	6.899
C-95	25	5.766	6.25	40	7.122	5.71	5.7	40	7.122
C-96	69	5.792	6.847	0	5.979	6.4	6.2	0	5.979
C-96	69	5.792	6.847	10	5.831	6.4	6.2	10	5.831

APPENDIX-C LIST OF STORMWATER ASSETS FOR CAPITAL IMPROVEMENTS

CHANNEL IMPROVEMENTS

		Before				After			
Channel	**Length**	**US Inv**	**DS Inv**	**Station**	**Elevation**	**US Inv**	**DS Inv**	**Station**	**Elevation**
C-96	69	5.792	6.847	20	6.04	6.4	6.2	20	6.04
C-96	69	5.792	6.847	30	6.756	6.4	6.2	30	6.756
C-96	69	5.792	6.847	40	6.996	6.4	6.2	40	6.996
C-97	18	6.376	5.766	0	6.623	5.8	5.71	0	6.623
C-97	18	6.376	5.766	10	6.468	5.8	5.71	10	6.468
C-97	18	6.376	5.766	20	6.501	5.8	5.71	20	6.501
C-97	18	6.376	5.766	30	6.953	5.8	5.71	30	6.953
C-97	18	6.376	5.766	40	7.057	5.8	5.71	40	7.057
C-98	25	7.018	5.881	0	7.292	5.7	5.7	0	7.292
C-98	25	7.018	5.881	10	7.115	5.7	5.7	10	7.115
C-98	25	7.018	5.881	20	7.005	5.7	5.7	20	7.005
C-98	25	7.018	5.881	30	7.172	5.7	5.7	30	7.172
C-98	25	7.018	5.881	40	7.36	5.7	5.7	40	7.36
C-99	27	6.67	7.018	0	7.484	5.7	5.7	0	7.484
C-99	27	6.67	7.018	10	6.908	5.7	5.7	10	6.908
C-99	27	6.67	7.018	20	4.681	5.7	5.7	20	4.681
C-99	27	6.67	7.018	30	6.657	5.7	5.7	30	6.657
C-99	27	6.67	7.018	40	7.365	5.7	5.7	40	7.365
C-270	698	3.064	5.141	0	3.849	3.064	2	0	6.173
C-270	698	3.064	5.141	5	3.1675	3.064	2	8.25	5.531
C-270	698	3.064	5.141	10	2.486	3.064	2	16.51	2.785
C-270	698	3.064	5.141	15	3.502	3.064	2	24.76	2.733
C-270	698	3.064	5.141	20	4.518	3.064	2	33.01	2.733
C-270	698	3.064	5.141	25	5.81	3.064	2	41.26	3
C-270	698	3.064	5.141	30	7.102	3.064	2	49.52	7.735
C-270	698	3.064	5.141	35	7.587	3.064	2	57.77	8.491
C-270	698	3.064	5.141	40	8.072	3.064	2	66.02	8.314
C-281	194	5.141	6.03	0	1.862	2	1.5	0	6.537
C-281	194	5.141	6.03	2.5	2.314	2	1.5	5.54	6.311
C-281	194	5.141	6.03	5	2.766	2	1.5	11.09	6.059
C-281	194	5.141	6.03	7.5	3.218	2	1.5	16.63	5.659
C-281	194	5.141	6.03	10	3.67	2	1.5	22.18	3.5
C-281	194	5.141	6.03	12.5	4.89075	2	1.5	25	2.095
C-281	194	5.141	6.03	15	6.1115	2	1.5	33.27	2.095
C-281	194	5.141	6.03	17.5	7.33225	2	1.5	38.81	2.095
C-281	194	5.141	6.03	20	8.553	2	1.5	44.36	2.053
C-281	194	5.141	6.03	22.5	8.71575	2	1.5	49.9	3.01
C-281	194	5.141	6.03	25	8.8785	2	1.5	55.45	5.214
C-281	194	5.141	6.03	27.5	9.04125	2	1.5	60.99	7.999
C-281	194	5.141	6.03	30	9.204	2	1.5	66.54	9.15
C-281	194	5.141	6.03	32.5	9.07025	2	1.5	72.08	9.21
C-281	194	5.141	6.03	35	8.9365	2	1.5	77.63	9.009
C-281	194	5.141	6.03	37.5	8.80275	2	1.5	83.17	8.61

APPENDIX-C LIST OF STORMWATER ASSETS FOR CAPITAL IMPROVEMENTS

CHANNEL IMPROVEMENTS

		Before				After			
Channel	**Length**	**US Inv**	**DS Inv**	**Station**	**Elevation**	**US Inv**	**DS Inv**	**Station**	**Elevation**
C-281	194	5.141	6.03	40	8.669	2	1.5	88.72	8.244
C-310	451	7.724	8.843	0	7.94	7.724	6.8	0	8.42
C-310	451	7.724	8.843	10	7.617	7.724	6.8	7.79	8.547
C-310	451	7.724	8.843	20	6.521	7.724	6.8	15.58	8.236
C-310	451	7.724	8.843	30	7.328	7.724	6.8	23.38	7.345
C-310	451	7.724	8.843	40	7.853	7.724	6.8	31.17	6.306
C-310	451	7.724	8.843			7.724	6.8	38.96	7.007
C-310	451	7.724	8.843			7.724	6.8	46.75	7.317
C-310	451	7.724	8.843			7.724	6.8	54.55	7.545
C-310	451	7.724	8.843			7.724	6.8	62.34	7.76
C_1002	835.45					3.9	1.06	0	7
C_1002	835.45					3.9	1.06	34	7
C-272	1052	-1.31	-1.147	0	-0.269	-1.31	-1.147	0	3.311
C-272	1052	-1.31	-1.147	10	-1.053	-1.31	-1.147	5.71	2.928
C-272	1052	-1.31	-1.147	20	-1.8	-1.31	-1.147	11.42	2.944
C-272	1052	-1.31	-1.147	30	-2.316	-1.31	-1.147	17.13	3.263
C-272	1052	-1.31	-1.147	40	0.327	-1.31	-1.147	22.84	3.445
C-272						-1.31	-1.147	28.55	2.94
C-272						-1.31	-1.147	34.25	2.236
C-272						-1.31	-1.147	39.96	1.665
C-272						-1.31	-1.147	45.67	1.148
C-272						-1.31	-1.147	51.38	0.244
C-272						-1.31	-1.147	57.09	-0.969
C-272						-1.31	-1.147	62.8	-1.926
C-272						-1.31	-1.147	68.51	-2.231
C-272						-1.31	-1.147	74.22	-1.541
C-272						-1.31	-1.147	79.93	-0.224
C-272						-1.31	-1.147	85.64	1.198
C-272						-1.31	-1.147	91.34	2.097
C-272						-1.31	-1.147	97.05	2.752
C-272						-1.31	-1.147	102.76	2.958
C-272						-1.31	-1.147	108.47	2.277
C-272						-1.31	-1.147	114.18	1.817
C-272						-1.31	-1.147	119.89	1.675
C-272						-1.31	-1.147	125.6	1.632
C-272						-1.31	-1.147	131.31	1.723
C-272						-1.31	-1.147	137.02	2.125
C-272						-1.31	-1.147	142.73	2.61
C-272						-1.31	-1.147	148.44	3.079
C-272						-1.31	-1.147	154.14	3.568
C-272						-1.31	-1.147	159.85	4.208
C-272						-1.31	-1.147	165.56	4.816
C-272						-1.31	-1.147	171.27	5.202
C-272						-1.31	-1.147	176.98	5.292
C-272						-1.31	-1.147	182.69	5.335

APPENDIX-C LIST OF STORMWATER ASSETS FOR CAPITAL IMPROVEMENTS

PIPES AND CULVERTS IMPROVEMENTS

Asset	Length (ft)	Dia-Pre (ft)	Dia-Post (ft)	Barrel Count-Pre	Barrel Count-Post	Comments**
P_1001	118	0	2	1	1	New Pipe
P_1002	127	0	2	1	1	New culvert
DS-Pond_5	50	0	2	1	1	New Pipe
P-Flemming	703	0	1.25	1	1	New Pipe
P-40	76	1.25	1.25	1	1	New Pipe, Change: Swapped US and DS Inverts from EX Conditions
P-47	8	1	1	1	1	New Pipe, Change: Reduced US Invert from 8 to 7.7
P-48	29	1	1	1	1	New Pipe, Change: Reduced US Invert from 9.7 to 8.0
P-63	66	2.5	2.5	1	1	New Pipe, Change: Increased US Invert from 1.57 to 2.55
P-139	54	4	4	1	1	New Pipe, Change: Increase US Invert from -0.13 to 2.55. DS Invert from
P-148	42	1	1	1	1	New Pipe, Change: Reduced US Invert from 7 to 6.8
P-149	8	1.25	1.25	1	2	
P-171	64	3	3	1	1	New Pipe, Changed US and DS inverts. No slope available.Negative slope
P-172	45	3	3	1	1	New Pipe, Changed US and DS inverts.
P-181	16	1.5	1.5	1	1	New Pipe, Changed US and DS inverts.
P-183	63	3.5	3.5	1	2	New Pipe, Link count changed to 2. Adjusted US and DS inverts.
P-192	102	1.25	1.25	1	1	New Pipe, Change: Swapped US and DS Inverts from EX Conditions
P-195	76	3.5	3.5	1	2	New Pipe, Link count changed to 2. Updated US and DS inverts.
P-197	26	1	1	1	1	New Pipe, Adjusted the US and DS inverts
P-198	20	3	3	1	1	New Pipe, Changed US and DS inverts. No slope available.Negative slope
P-199	42	1.5	1.5	1	1	New Pipe, Changed US and DS inverts.
P-200	35	1.5	1.5	1	1	New Pipe, Changed US and DS inverts.
P-202	26	1.5	1.5	1	1	New Pipe, Changed US and DS inverts.
P-203	38	1	1	1	1	New Pipe, Changed US and DS invert
P-204	60	1.25	1.25	1	1	New Pipe, Changed US and DS invert
P-208	101	4	4.5	1	2	Added check valve
P-59	40	1	1	1	1	New Pipe, Changed US and DS invert
P-83	48	1.25	1.25	1	1	New Pipe, Changed US and DS invert
P-135	133	2	2	1	1	New Pipe, Changed US and DS invert
P-136	96	1.25	1.25	1	1	New Pipe, Changed US and DS invert
P-138	53	4	4.5	2	2	New 4.5' x 8' Dual Box Culvert

APPENDIX-C LIST OF STORMWATER ASSETS FOR CAPITAL IMPROVEMENTS

PIPES AND CULVERTS IMPROVEMENTS

Asset	Length (ft)	Dia-Pre (ft)	Dia-Post (ft)	Barrel Count-Pre	Barrel Count-Post	Comments**
P-174	48	2	2	1	1	Added check valve
P-177	65	1.5	1.5	1	1	New Pipe, Changed DS invert
P-190	32	4	4.5	2	2	New 4.5' x 8' Dual Box Culvert
P-196	95	3.5	4.5	1	1	New 4.5' x 8' Single Box Culvert
P-201	46	1.5	1.5	1	1	New Pipe, Changed DS invert
P-207	28	3.5	4.5	2	2	New 4.5' x 8' Dual Box Culvert
P-208	101	4	4.5	2	2	Added check valve
P-58a	38	4.5	4.5	1	1	Added check valve
Box Culverts (DUAL 4.5 x 8 ft)	560					**Combined Length of New 4.5' x 8' Box Culverts (1984 Masterplan Improvements)**

APPENDIX-C LIST OF STORMWATER ASSETS FOR CAPITAL IMPROVEMENTS

CHECK VALVES

Asset Name	Node_From	Node_To	Barrel Count	Has Check Valve?	Pipe Size (in)
P-63	N-M416	N-M295	1	Yes	30
P-139	N-S43	N-M295	1	Yes	48
P-174	N-M112	N-M112a	1	Yes	24
P-190	N-M263	N-Area_57	2	Yes	54
P-208	N-Area_54	N-M330	2	Yes	54
P-58a	N-M401a	N-M401	1	Yes	54

Addition of Storage- Pond 7	
Elevation (ft)	Area (ac.)
6.8	0.1
7.5	0.2
8	0.3
8.5	0.4
9	0.5
9.5	0.55

APPENDIX-D

DETAIL CONSTRUCTION COST ESTIMATE FOR IMPLEMENTATION OF IMPROVEMENTS

ROHADFOX
CONSTRUCTION CONTROL SERVICES

OPINION OF PROBABLE COST - CONCEPTUAL DOCUMENTS

Project: Charleston, SC Stormwater GIS

BASE BID - DETAILED COST ESTIMATE

Drawing #	Detail	Spec Section	Item Description	Quantity	Unit	Unit $	Total $
Division 1	01000	01A	**General Requirements**				
			Mobilization/Demobilization	1	LS	$ 75,000.00	$ 75,000
			Permits	1	LS	$ 9,300.00	$ 9,300
			Temp. Utilities	1	LS	$ 8,000.00	$ 8,000
			Misc. PP&E	12	Months	$ 400.00	$ 4,800
			Trailers	12	Months	$ 2,000.00	$ 24,000
			Project Engineer, Full Time	12	Months	$ 5,000.00	$ 60,000
			Superintendent, Full Time	12	Months	$ 9,900.00	$ 118,800
			Project Manager, Part Time	12	Months	$ 6,000.00	$ 72,000
			Staging Area	1	LS	$ 25,000.00	$ 25,000
			Dumpsters	48	Pulls	$ 450.00	$ 21,600
			Porta-Johns	12	Months	$ 1,116.00	$ 13,392
			Surveying / Utility Locating	1	LS	$ 40,000.00	$ 40,000
			Site Clean-up	1	LS	$ 5,000.00	$ 5,000
			Temp. Weather & Dust Protection	1	LS	$ 10,000.00	$ 10,000
	32000	**32**	**Storm Drainage Channels (Total 9,221 Feet)**	*** Assumed: Average 5 foot wide ***			
			Grading:				
			Rough Grading	11,066	SY	$ 1.20	$ 13,279
			Fine Grading	11,066	SY	$ 2.00	$ 22,131
			Strip & Stockpile Topsoil	11,066	SY	$ 1.20	$ 13,279
			Spread Topsoil from Stockpile	1,844	CY	$ 9.00	$ 16,599
			Cut	1,075	CY	$ 15.00	$ 16,125
			Fill	2,108	CY	$ 27.50	$ 57,974
			Haul Off Excavated Spoils	1,075	CY	$ 16.00	$ 17,200
			Erosion Control:				
			Tree Protection Fence	9221	LF	$ 3.00	$ 27,664
			Silt Fence	9221	LF	$ 3.50	$ 32,275
			Allowance for Erosion Control Maintenance	1	LS	$ 12,000.00	$ 12,000
			Allowance for Erosion Control Matting, Rip-Rap and/or Concrete Channel Lining	1	LS	$ 25,000.00	$ 25,000
			Seeding & Mulching	99.59	MSF	$ 150.00	$ 14,939
			Allowance for Concrete and Rip-Rap aprons	1	LS	$ 20,000.00	$ 20,000

ROHADFOX CONSTRUCTION CONTROL SERVICES

OPINION OF PROBABLE COST - CONCEPTUAL DOCUMENTS

Project: Charleston, SC Stormwater GIS

BASE BID - DETAILED COST ESTIMATE

Drawing #	Detail	Spec Section	Item Description	Quantity	Unit	Unit $	Total $
	32000	32	**Storm Drainage Pipe (Total 3,641 Feet of New)**				
			Grading:				
			Fine Grading	8,285	SY	$ 0.80	$ 6,628
			Strip & Stockpile Topsoil	8,285	SY	$ 0.70	$ 5,800
			Spread Topsoil from Stockpile	1,381	CY	$ 6.00	$ 8,285
			Erosion Control:				
			Tree Protection Fence	3378	LF	$ 3.00	$ 10,135
			Silt Fence	3378	LF	$ 3.50	$ 11,824
			Allowance for Erosion Control Matting, Rip-Rap and/or Concrete Channel Lining	1	LS	$ 15,000.00	$ 15,000
			Allowance for Erosion Control Maintenance	1	LS	$ 8,000.00	$ 8,000
			Seeding & Mulching	75	MSF	$ 150.00	$ 11,185
			Pipe Demolition:				
			Demo 12" RCP Storm Drain Pipe	183	LF	$ 17.58	$ 3,218
			Demo 15" RCP Storm Drain Pipe	390	LF	$ 31.73	$ 12,373
			Demo 18" RCP Storm Drain Pipe	230	LF	$ 32.44	$ 7,460
			Demo 24" RCP Storm Drain Pipe	133	LF	$ 44.72	$ 5,948
	.		Demo 30" RCP Storm Drain Pipe	66	LF	$ 55.75	$ 3,680
			Demo 36" RCP Storm Drain Pipe	129	LF	$ 61.83	$ 7,977
			Demo 42" RCP Storm Drain Pipe	262	LF	$ 70.77	$ 18,541
			Demo 48" RCP Storm Drain Pipe	442	LF	$ 78.07	$ 34,505
			New Storm Drain Pipe:				
			New 12" RCP Storm Drainage	183	LF	$ 47.88	$ 8,761
			New 15" RCP Storm Drainage	1101	LF	$ 60.50	$ 66,607
			New 18" RCP Storm Drainage	230	LF	$ 62.68	$ 14,416
			New 24" RCP Storm Drainage	428	LF	$ 77.38	$ 33,137
			New 30" RCP Storm Drainage	66	LF	$ 117.02	$ 7,723
			New 36" RCP Storm Drainage	129	LF	$ 127.90	$ 16,499
			New 42" RCP Storm Drainage	278	LF	$ 170.33	$ 47,353
			New 48" RCP Storm Drainage	54	LF	$ 216.57	$ 11,695
			New 54" RCP Storm Drainage	404	LF	$ 277.57	$ 112,138
			New 4'x8' Single Box Culvert	655	LF	$ 466.57	$ 305,606
			New 4'x8' Dual Box Culvert	113	LF	$ 496.57	$ 56,113
			Allowance for Concrete and Rip-Rap aprons	1	LS	$ 15,000.00	$ 15,000

ROHADFOX CONSTRUCTION CONTROL SERVICES

OPINION OF PROBABLE COST - CONCEPTUAL DOCUMENTS

Project: Charleston, SC Stormwater GIS

BASE BID - DETAILED COST ESTIMATE

Drawing #	Detail	Spec Section	Item Description	Quantity	Unit	Unit $	Total $
	32000	**32**	**Check Valves (Total 8 Each New)**				
			Check Valves Allowance	8	EA	$ 15,000.00	$ 120,000

Subtotal #1=	**$**	**1,760,962**
Design Contingency - 30%=	$	528,288.50
Subtotal #2 =	**$**	**2,289,250**
Construction Contingency - 5%=	$	114,463
Subtotal #3 =	**$**	**2,403,713**
Contractor Mark-up -12% =	$	288,446
Builder's Risk - 0.25% =	$	6,009
General Liability Insurance - 0.96% =	$	23,076
Subtotal #4 =	**$**	**2,721,243**
P&P Bond - 1.04%=	$	28,301
Total Estimated Cost (April 2020 $) =	**$**	**2,749,544**
Escalation to Midpoint of Construction (.25% x 18 Months) =	$	123,729.48
Total Estimated Cost (January 2022 $) =	**$**	**2,873,274**

Scope Inclusions:

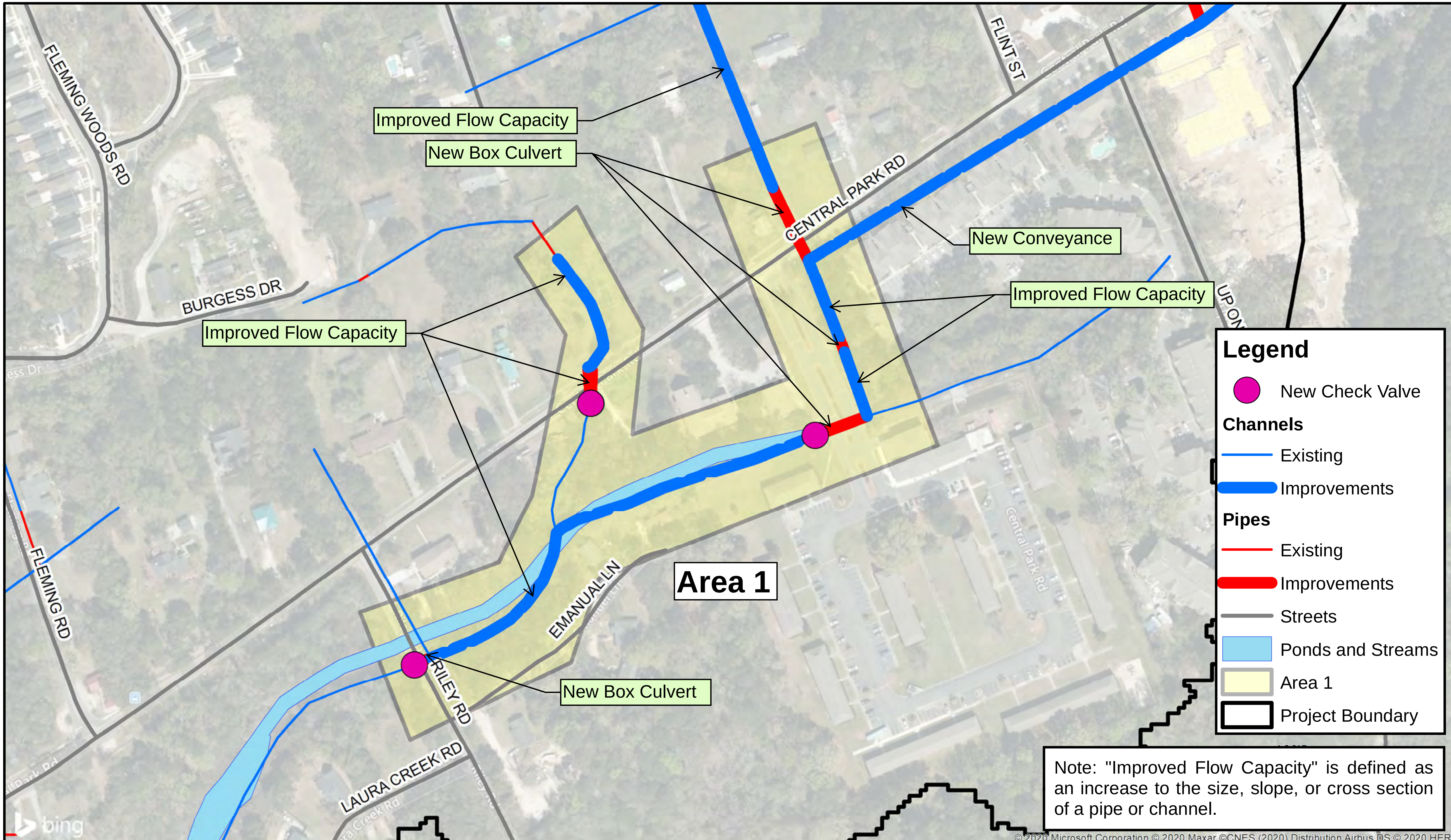
1. Utility locating
2. Surveying
3. Demolition, haul and dump costs
4. Grading, incl. strip & stockpile topsoil, excavation, backfill and disposal of spoils
5. All new piping assumed to be RCP, Class 3 with 6" stone bedding
6. Erosion control
7. Tree protection
8. Topsoil, Seeding & mulching of
9. Dust control allowance
10. Allowance for turf matting, rip-rap and/or concrete lining at portions of new channels
11. Rip rap & concrete aprons allowance
12. Assumed average five foot wide channels

Scope Exclusions:

1. Underground utility relocation
2. Existing pavement removal and replacement
3. Landscaping replacement
4. Rock removal
5. Undercutting

APPENDIX-E

IMPROVEMENT PRIORITY AREA DETAILS

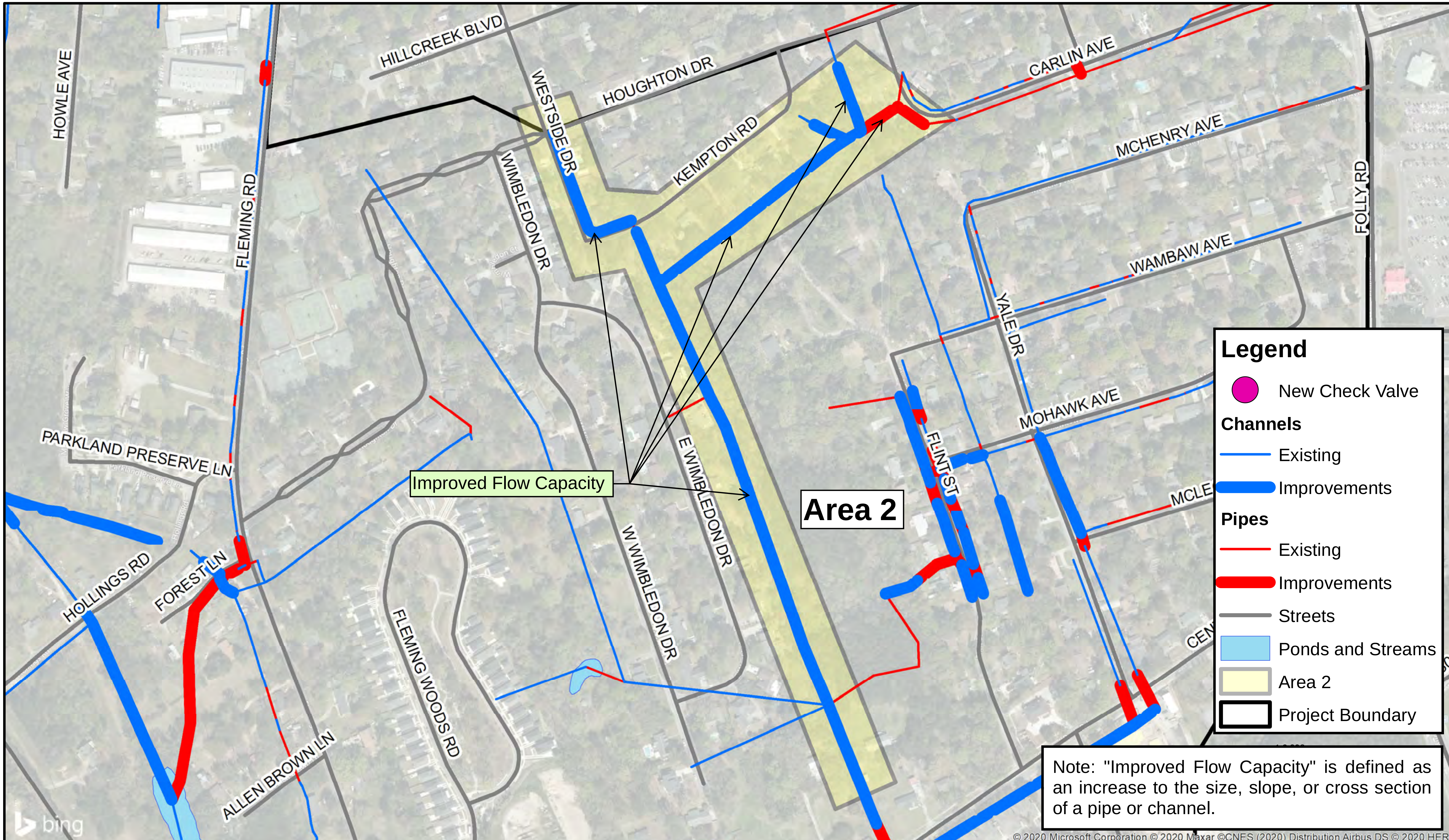


Note: "Improved Flow Capacity" is defined as an increase to the size, slope, or cross section of a pipe or channel.

Central Park Watershed
Priority Area 1

PROJECT NO.	PREPARED BY:	DATE:	
60607729	AV	JUL 2020	**Figure E-1**

Path: C:\Users\adam.vidalis\Documents\Projects\60607729 Central Park\CP Figures\Figures\MXD\App Figs Rev 2\Figure E1 Improvement Prioritization.3.mxd



Central Park Watershed
Priority Area 2

PROJECT NO.	PREPARED BY:	DATE:	
60607729	AV	JUL 2020	**Figure E-2**

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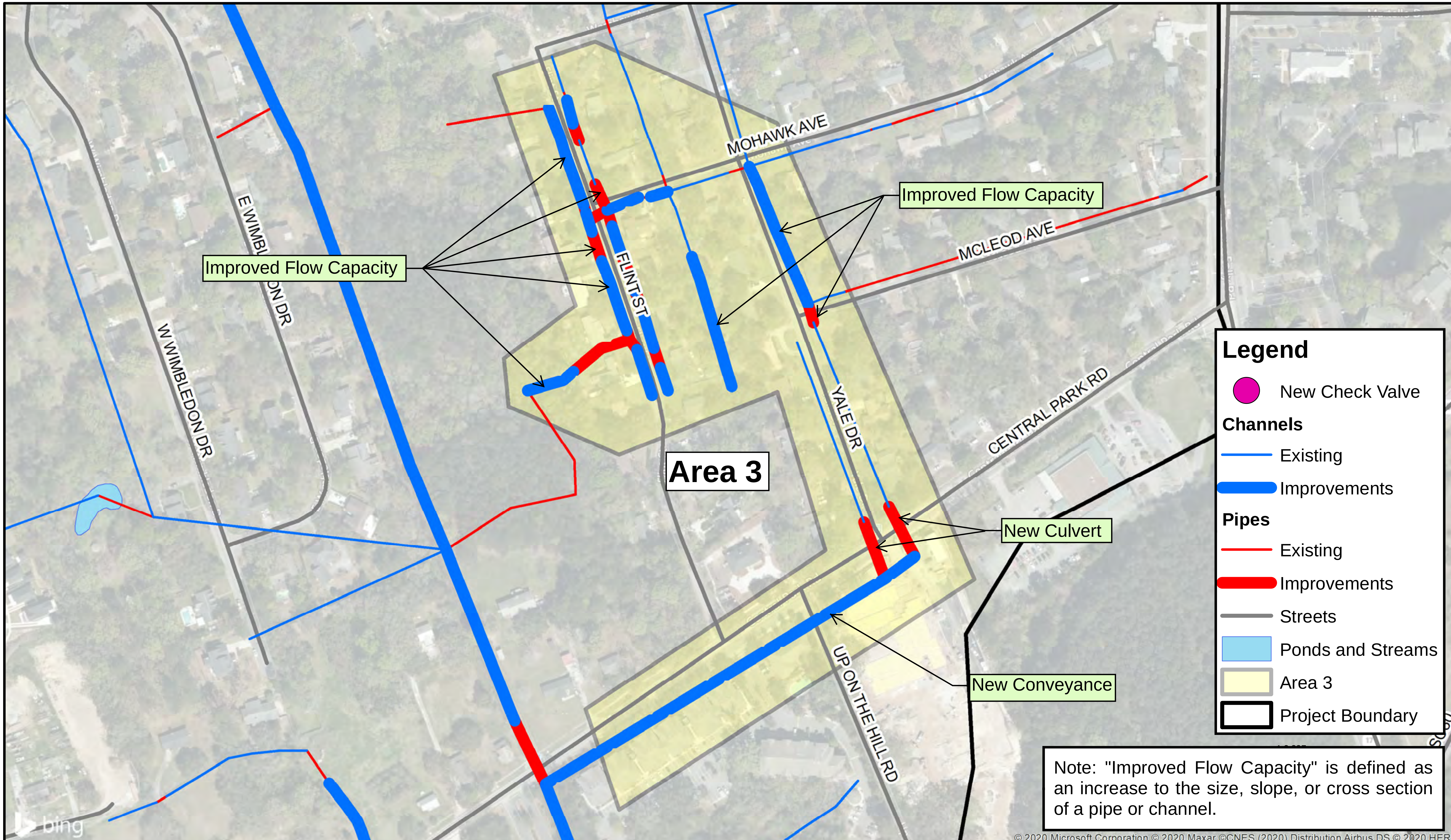
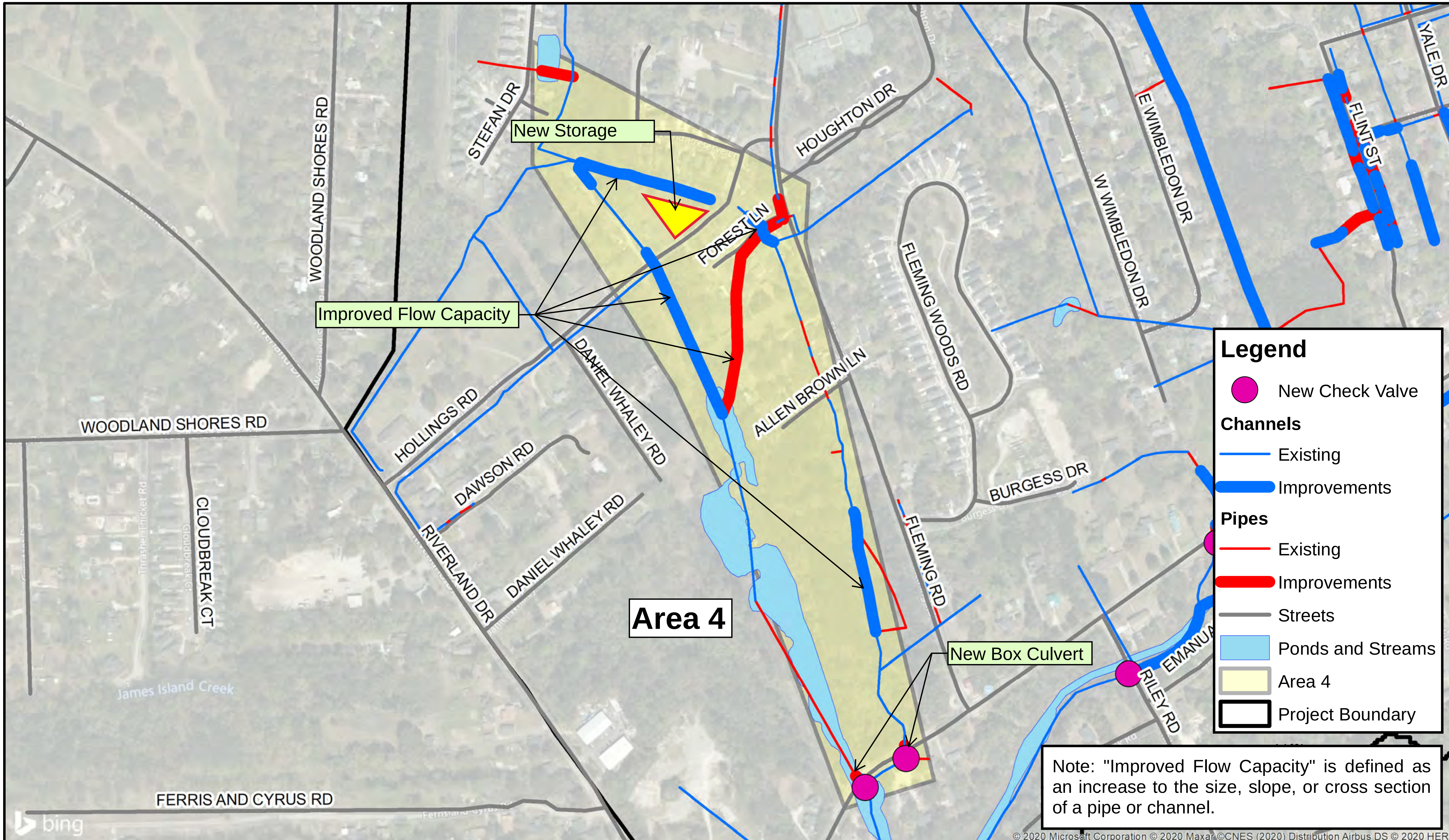


Central Park Watershed
Priority Area 3

PROJECT NO.	PREPARED BY:	DATE:	
60607729	AV	JUL 2020	**Figure E-3**

Path: C:\Users\adam.vidalis\Documents\Projects\60607729 Central Park\CP Figures\Figures\MXD\App Figs Rev 2\Figure E3 Improvement Prioritization.4.mxd



Central Park Watershed
Priority Area 4

PROJECT NO.	PREPARED BY:	DATE:	
60607729	AV	JUL 2020	**Figure E-4**

Path: C:\Users\adam.vidalis\Documents\Projects\60607729 Central Park\CP Figures\Figures\MXD\App Figs Rev 2\Figure E4 Improvement Prioritization.4.mxd