CITY OF CHARLES TOWN

INFRASTRUCTURE COMMITTEE
AGENDA • OCTOBER 1, 2026

Committee Meeting **COUNCIL CHAMBERS** **5:00 PM**
101 E Washington Street, Charles Town, WV 25414

1. CALL TO ORDER

2. UNFINISHED BUSINESS

: **2026-1958:** Expansion of Walkability Grant - Referral from City Council
Staff Recommendation 2026-09-17_-_WIP_Grant_Status_Report.pdf
CT_Walkability_Connectivity_Study (1).pdf
Walkability Improvement Program.pdf

: **2026-1963:** Stormwater Issues and Updates
Greenway Engineering Stormwater Study Charles Town Drainage Study Report Part 1 2026.04.23 (1).pdf

: **2026-1964:** Other Projects Updates from Staff

3. NEW BUSINESS

4. ADJOURNMENT

5. NOTICE: The Public May View the Meeting Live by Clicking on the Event Link at: https://www.charlestownwv.us/government/agendas_minutes.php

Infrastructure Committee
101 East Washington Street
Charles Town, WV 25414

SCHEDULED

Meeting: 10/01/26
Department: Infrastructure Committee
Category: Report
Initiator:

AGENDA ITEM (ID #)

2026-1958: Expansion of Walkability Grant - Referral from City Council

ATTACHMENTS:

- Staff Recommendation 2026-09-17_-_WIP_Grant_Status_Report.pdf
- CT_Walkability_Connectivity_Study (1).pdf
- Walkability Improvement Program.pdf

Date: For the September 17, 2026 Infrastructure Committee meeting
From: James Newman, City Planner, Zoning/Subdivision Administrator

Walkability Improvement Grant – Proposed Changes

1. Walkability Improvement Grant – Current Parameters

This grant is handled administratively by the Zoning Administrator; no public hearings or board/commission/Council meetings or approvals are required. The purpose of the grant is to "*improve and enhance the overall pedestrian experience in Charles Town*", by helping to finance the restoration, repair sidewalks, as well as the creation of new sidewalks for properties with a building(s) but no sidewalk.

A. Eligibility

1. All existing sidewalks in City limits are eligible.
2. Lots with structures but lacking a sidewalk are eligible.
3. Vacant lots without a structure or sidewalk are not eligible.
4. Ineligible projects may be approved at the discretion of City Council at their first June meeting, provided no eligible projects have been received by the deadline application of the end of the first working day in June.

B. Materials

Concrete must be used unless there is an existing brick sidewalk, in which case the applicant can choose brick or concrete. Replacing/repairing existing brick with new brick is also permitted.

C. Process

Complete the application and provide two quotes; if quotes are not available, then a cost sheet of material expenses must be provided. If approved, a building permit must be filed. Grants are awarded after the work is done. Grants are awarded at a 50/50 match up to a maximum $5,000 per grant request. Projects must be completed within 12 months of approval.

D. Proposed Changes

A. Amount of Funds

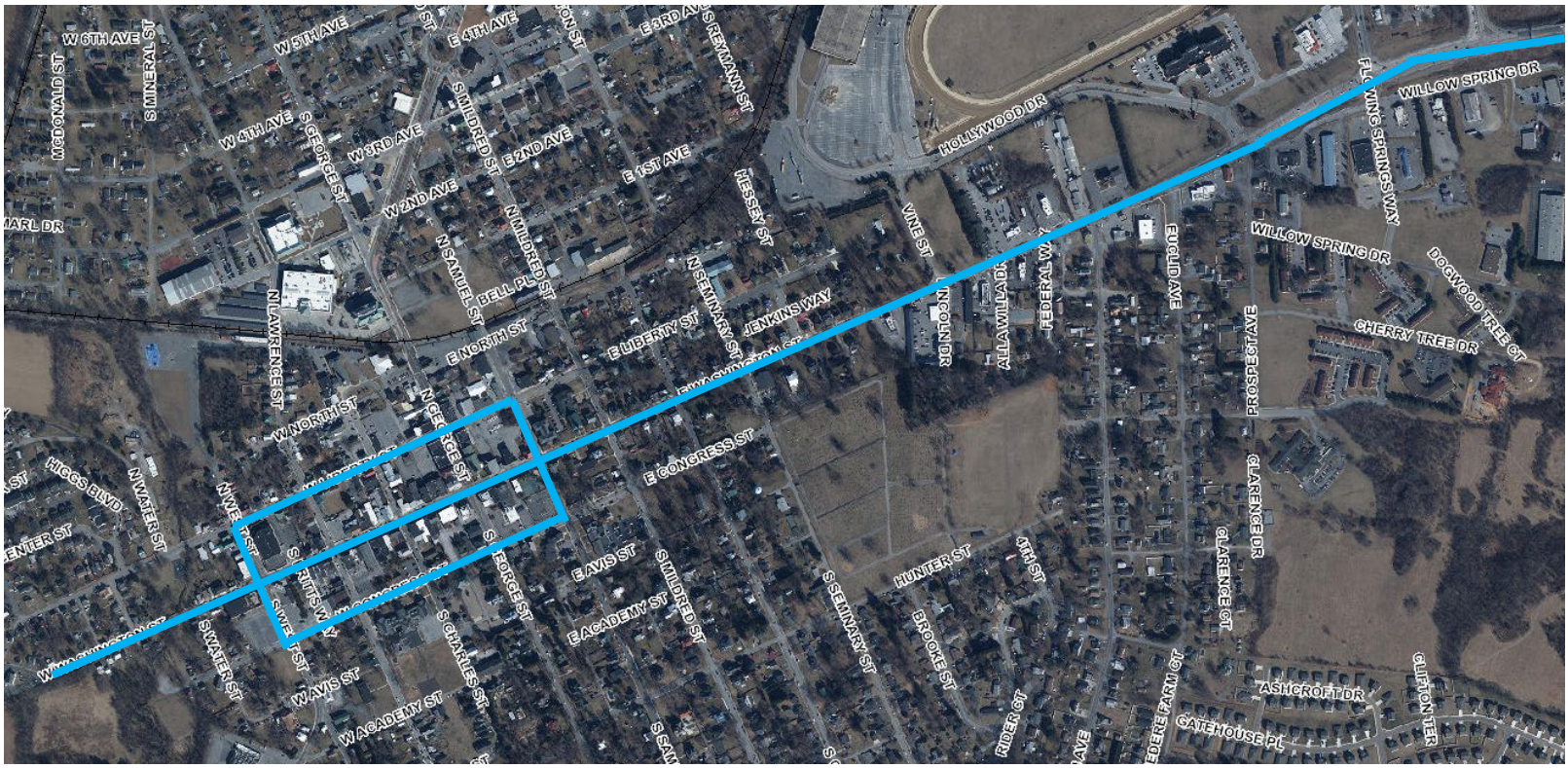
Currently $30,000 is set aside for the fund. Applicants are permitted to receive a 50/50 match of up to $5,000 per application. The Grant dates back to at least 2019. Per the Federal Bureau of Labor Statistics Inflation Calculator, $5,000 in 2019 is now worth $6,656.87.

The average cost of concrete sidewalks, per the quotes we've received, has gone up from $11 a square foot in 2019 to between $20-30 a square foot. Grant funding now covers less material for less coverage than when the Grant program started.

B. Bid Percentages

The City's downtown core sees the most pedestrian sidewalk usage. With a downtown focus on ensuring a safe and enjoyable experience for pedestrians, the match percentage for downtown projects should be increased up to 90% for the City / 10% for the applicant. The area of focus would be all of Washington Street between MLK Jr. Blvd and the Adam Link Bridge, and bound by West Street, Samuel Street, Liberty Street, and Congress Street (see boxes in blue below and on following page):





The City could increase the match for properties outside of the downtown core or Washington Street to a 70% City / 30% applicant match.

The reason for the proposed increased match amount is to ensure that sidewalks are maintained in a safe manner. If a property owner cannot afford their half of the rising costs, they will not fix their sidewalk. If the Grant increases both the amount offered and the amount covered by the City, that gives the property owner more room to financially support their portion of the project.

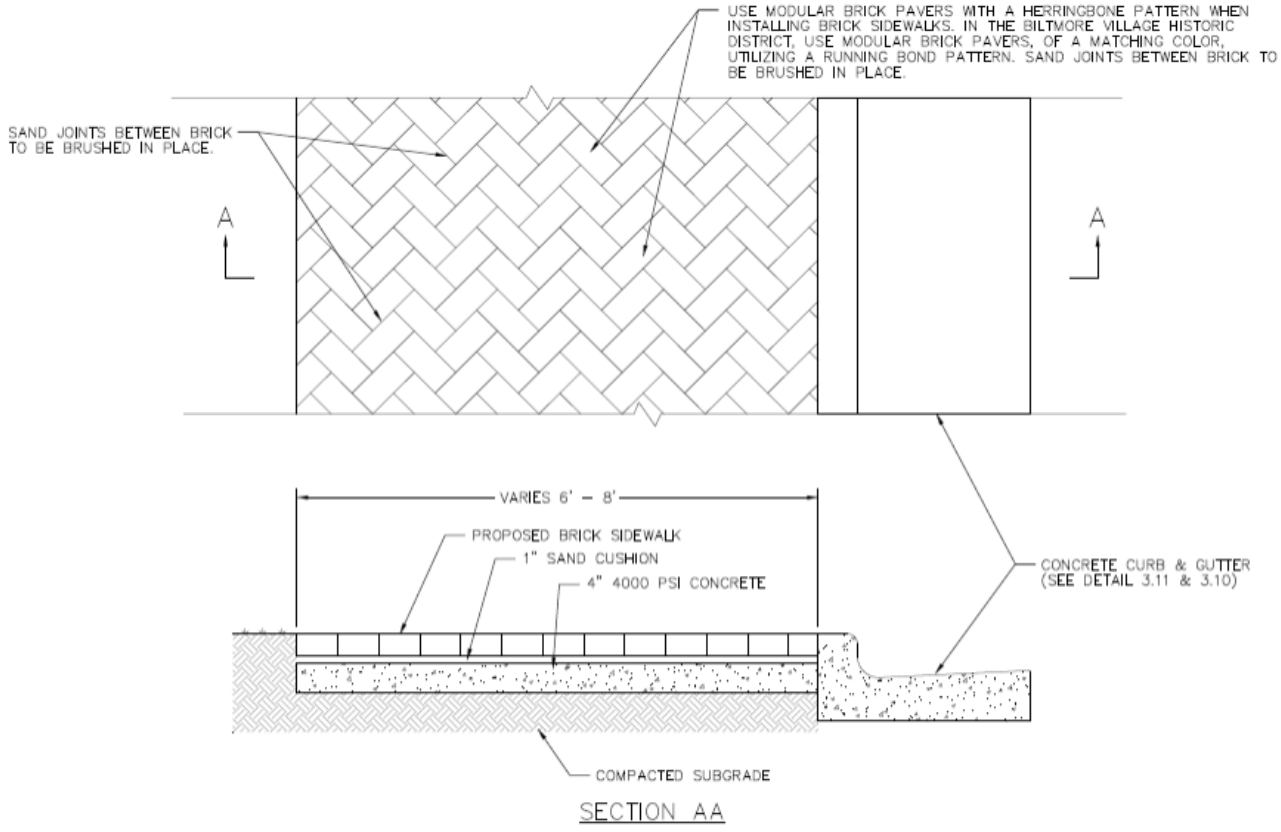
C. Coverage

Currently applicants can apply only once for their property within a 12-month period. For lots that have multiple road frontages and thus multiple sidewalks, they are burdened by that extra maintenance cost but are still capped at the $5,000 maximum.

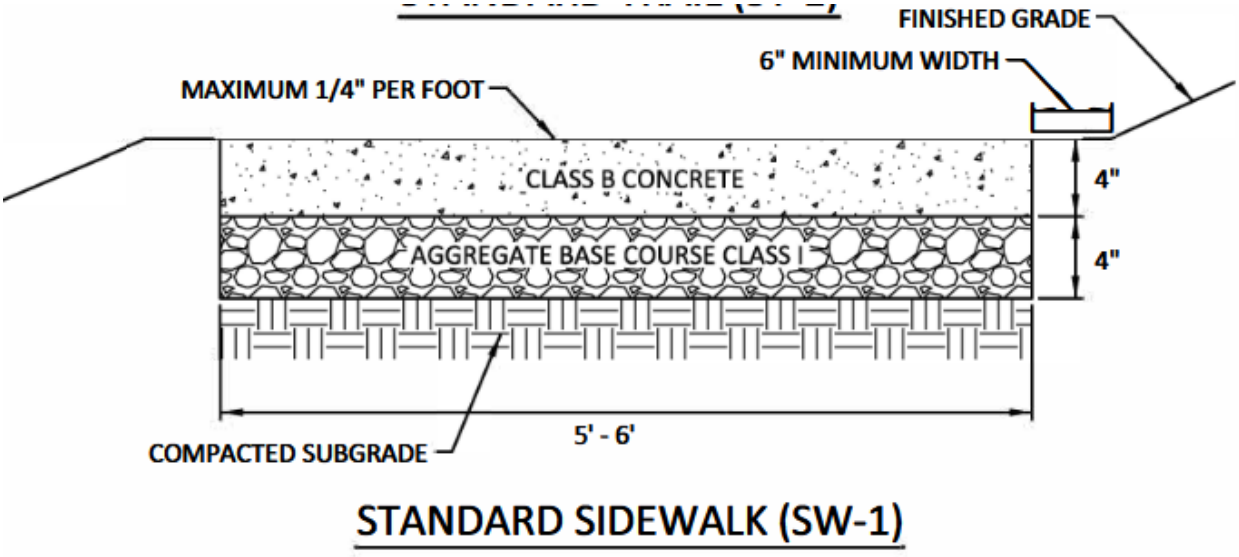
The Grant should be revised to allow owners of properties with two or more road frontages to apply for one grant per road frontage, thereby giving them the financial help needed to maintain their sidewalks.

D. Design Standards and Materials

Under the current requirements, only concrete or brick may be used. Brick is only permitted where there are existing brick sidewalks. There are no specific design standards for a brick sidewalk: no requirement for a concrete base underlay, nor any requirement for any type of pattern or design. The City should consider adopting such design criteria; the example below is from Asheville NC, which has brick in a herringbone pattern over a concrete base:



The City's current Standard Design Detail for sidewalks is based on a concrete sidewalk, with no guidance on installing brick:



E. City Council

Council chose to send this request to the Infrastructure Committee at their July 20, 2026 meeting.

F. Recommendation

Provide direction to staff on:

1. Changing the Grant amount
2. Changing the Grant percentages
3. Providing a specific design standard for brick sidewalk/stamped concrete.



City of Charles Town

Walkability and Connectivity Study

August 2016



Source: Jefferson County Convention & Visitors Bureau

Table of Contents

1. INTRODUCTION

2. SIDEWALK INVENTORY AND ASSESSMENT

3. TRAIL CONNECTIVITY

4. WALKABILITY DESIGN STANDARDS

Standard Design Templates
Maintenance/Construction Roles and Responsibilities

5. WAYFINDING PROGRAM

6. PRIORITIZED IMPLEMENTATION PLAN

Sample Costs
Resources Roadmap/Finance Scheme
Next Steps

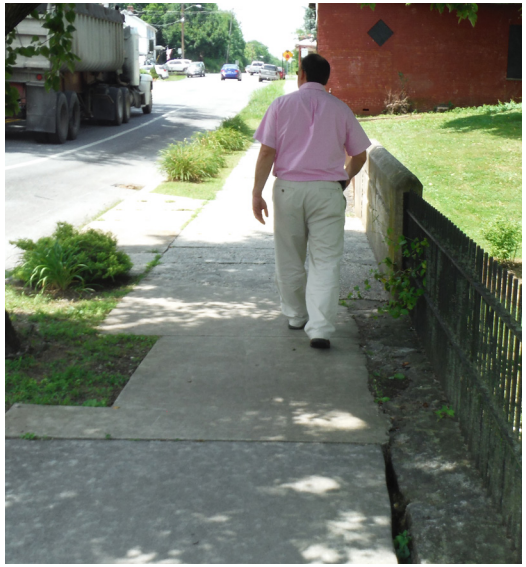
7. APPENDIX

Introduction

Walkable communities are experiencing a resurgence in America, with new generations desiring to live a less auto-focused lifestyle and the baby-boomer generation downsizing, there is demand for affordable urban areas that are walkable. Walkable communities allow residents to complete most daily activities within a convenient walk of their home in a way that is safe, comfortable, and interesting. Walkable communities encourage sidewalks to be used as "outdoor living rooms" with a seamless connection between businesses and the public realm. The ultimate goal for walkable communities is to enable residents to live their lives in the way they choose, and with the option of doing so without a car.

Communities that support walking and other active transportation modes have a measurable positive impact on public health. In one study, men and women age 50–71 who took a brisk walk nearly every day had a 27% reduced death rate compared to non-exercisers.[1] Americans are becoming more sedentary and obese and, consequently, are putting their lives at risk, according to reports prepared by the Center for Disease Control and Prevention. Engaging in light to moderate physical activity reduces the risk of coronary heart disease, stroke, and other chronic and life-threatening illnesses.

The health benefits of walking stretch well beyond physical health improvement. A 2010 University of New Hampshire study found that people living in walkable neighborhoods trust neighbors more, participate in community projects and volunteer more than in non-walkable areas. All of these facts combined present a compelling case to create a walkable community and consistently make improvements to the infrastructure that support walkability. Beyond these quality of life benefits, walkable communities can attract investment and increased economic activity, and boost the property values of neighborhoods.



1 http://www.pedbikeinfo.org/data/factsheet_health.cfm

With these inherent benefits in mind, the C***harles Town Walkability and Connectivity Study*** aims to address two major goals:

Goal 1: Achieve an accurate assessment of the current state of existing sidewalks within downtown Charles Town and identify key corridors and trail connections to connect residents and visitors with downtown.

Goal 2: Provide the City with a resource roadmap and implementation strategy for future walkability improvements, including:

- Prioritization of high-activity sidewalks in need of repair
- Identifying future walking trails or paths
- Identifying priority corridors that connect with downtown
- Templates for compete streets and similar improvements in various areas in the City
- Strategy to ensure all projects connect in a way that will promote pedestrian movement

The Charles Town Walkability and Connectivity Study represents the first step in improving the walkability and livability of Charles Town. Improvements recommended in the plan completed over time will help position Charles Town as a preferred destination within the Eastern Panhandle region.

Project Study Area

For the purpose of the ***Charles Town Walkability and Connectivity Study***, a priority area was identified for detailed analysis. This priority area was established to maximize the effectiveness of the study and was selected as the area including and immediately surrounding downtown Charles Town. This area is the well-established "Old Town" where walkability is critical to success with minimal parking, commercial and retail businesses, and higher-density residential development. Additionally, the downtown can be considered a public asset that bellows to all residents of Charles Town. Instead of choosing individual neighborhoods where improvements may only benefit a few, improvements made within downtown Charles Town will benefit all City residents that patronize businesses, conduct personal or professional business, or participate in civic activities and festivals. The limits of the priority area are illustrated in **Figure 1**.

Integration with Historically Hip Charles Town 2040

The City of Charles Town is currently undergoing an update to the municipal comprehensive plan, an effort dubbed Historically Hip Charles Town 2040. The comprehensive plan is still in the development phase and the outcomes of this study will be integrated into the planning themes addressing mobility, connectivity and accessibility. Specifically, the mobility, accessibility and connectivity theme will address the following key focus areas:

- Connectivity to downtown
- Transportation and circulation
- Pedestrian and bicycle mobility
- Complete streets
- Wayfinding/signage
- Parking

These focus areas are discussed at length through multiple sections of this report, and will be expanded upon more generally to cover all of Charles Town and guide the development of transportation-related projects throughout the UGB to the year 2040.

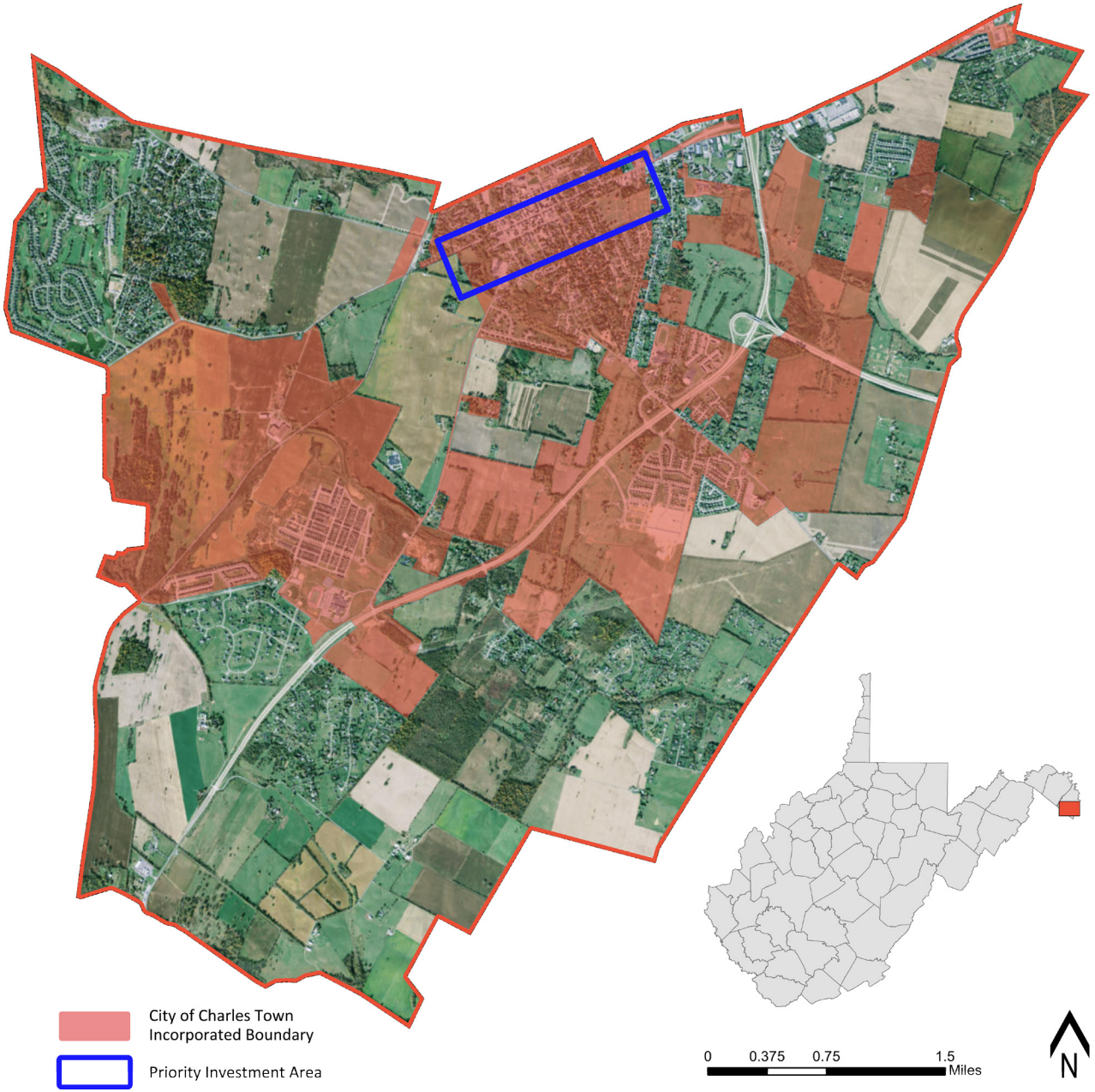


Figure 1: Limits of the Priority Area

Sidewalk Inventory and Assessment

To promote a prosperous downtown, sidewalk infrastructure is vital to allow pedestrians to maneuver easily throughout the City. Charles Town promotes preserving the history of the City as well as modernizing the town to accommodate future mobility goals and visions. Bricks are used in sidewalks to display tradition and provide a visual reminder of Charles Town's history. The most notable segments where bricks are used are located at the intersection of George Street and Washington Street. When designing Charles Town, Charles Washington dedicated the four corners of this block to public buildings. Establishing a walkable community starts with connecting residents to downtown and providing an economical alternative to driving.

Along the downtown district, brick buffers on the sidewalks compliment the historic buildings by adding a separator from street and walkway. Buffers provide an area for utility poles and other sidewalk amenities so that they are not directly positioned in the walking area. Separating street and sidewalk through a brick buffer allows for a safe and walkable sidewalk as well as providing a visually appealing characteristic. Sidewalks near the town center must be kept in excellent condition to allow residents and tourists the ability to connect to other parts of the City. Upon exiting the downtown, sidewalk quality starts to decline and there are noticeable gaps in the sidewalk network. Maintaining equal sidewalk priorities throughout the City boundary is important in sustaining a conducive sidewalk network.

The purpose of the sidewalk inventory and assessment was to evaluate the existing conditions of the selected study area in the City of Charles Town. The study area included the downtown district as well as main corridors exiting Charles Town that connect pedestrians to main points of the City. The selected corridors extend in each direction and serve as potential linking areas for pedestrians to the downtown. Two hundred and four (204) sidewalk segments were inventoried during the sidewalk assessment along the downtown district of Charles Town between Liberty and Congress Streets. This assessment was designed to create a detailed inventory of sidewalks based on existing conditions and width, as well as ADA compliance. The focus was to assess the ramps entering the streets by grading the slope, lip, and if there was an entrance to the road from the sidewalk. Upon completion of the field inventory, the sidewalks were then rated based on criteria designed to display conditions of each sidewalk. Sidewalks that were assessed a poor grade are considered a high priority for future repair and maintenance.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Field Study

A field study was completed to accurately determine the overall condition and quality of each sidewalk in the study area. A total of 6.2 miles of sidewalk were inventoried during this field study that produced a detailed description of each sidewalk segment in downtown Charles Town. To assess the sidewalk segments, devices were used to efficiently document distance, obstructions, ramps, width, and other sidewalk impurities that negatively impacted the pedestrian experience. Using a measuring wheel with a camera mounted on it gave an exact measurement on width and distance of the sidewalk. The camera mounting provided a video of each sidewalk segment to use as a reference upon grading each section. A GPS (Trimble) device was used to pinpoint locations of obstructions along each sidewalk segment. The GPS device was able to document visual photography of defects in the sidewalk, which were then mapped in ESRI ArcMap using the coordinate location.

The two main designs of sidewalks in Charles Town are brick and concrete. Concrete requires less maintenance and preservation compared to brick. However, brick sidewalks provide a traditional feeling that grasps the historical background of Charles Town. Vegetation was a factor when assessing the rating for the sidewalks. Trees, shrubs, and grass reduce the walking area on sidewalks and in some areas restrict walking completely. Bricks must be well maintained to prevent vegetation growing through the cracks and displacement along the sidewalk. Tree roots were found in some areas dislodging bricks and causing a hazard. Removing roots from the sidewalks will alleviate any risk of injury along the sidewalk and will greatly increase the quality of the walkway.



Example of Field Study Video



Example of Obstruction

Condition Assessment: Sidewalk Width

Sidewalks were scored good, fair, or poor on condition of the sidewalk and overall width. Width is a contributing factor in evaluating the overall quality of the sidewalk. Typically wider sidewalks should be found in the downtown area where pedestrian traffic and usage is much greater. In the width assessment, each individual sidewalk segment was broken down further into a first and second portion to display more in-depth details of each section. Two sidewalks stretched for half of the street so they were counted as one total portion instead of being separated in two.

Out of the total 204 sidewalk segments, 143 were classified as good with minimal restrictions and obstructions (shown in **Figure 2** on the following page). Obstructions included utility poles, trees and other vegetation, porches, and any objects that decreased travel area on a sidewalk. The field team determined whether an obstruction constricted the walkway by measuring and documenting where problems occurred. Sidewalk width changes were sporadic so to record them, points were made in the GPS and on paper to cross reference and confirm the location of where changes occurred. The width of the sidewalks were graded as follows:

- **Good:** Sidewalk was over five feet in width
- **Fair:** Sidewalk was between four to five feet in width
- **Poor:** Sidewalk was under four feet in width

Condition Assessment: Sidewalk Condition

To sustain a walkable city, sidewalk conditions must be assessed to ensure a safe sidewalk network that is easy to travel on for all age groups. Fifty-two (52) of the 204 sidewalk segments in the study area were in good condition with most being located around the center of town along Washington and George Streets (shown in **Figure 3** on page 10). Sidewalk segments are in worse condition on the outskirts of the downtown and need to be updated to ensure a walkable environment in Charles Town. Sidewalks along West Liberty at Jenkins Way and Higgs Boulevard have a substantial lip and steep grade making walking challenging. The brick sidewalk at Jenkins Way appeared to be recently redone but was never completed leaving a gap and sharp drop-off from sidewalk to street. The grading criteria for sidewalk condition is as follows:

- **Good:** Segment is in good working condition and does not need to be fixed
- **Fair:** Issues with the sidewalk that is up to the discretion of the City to either fix or not
- **Poor:** Sidewalk should be considered to be replaced

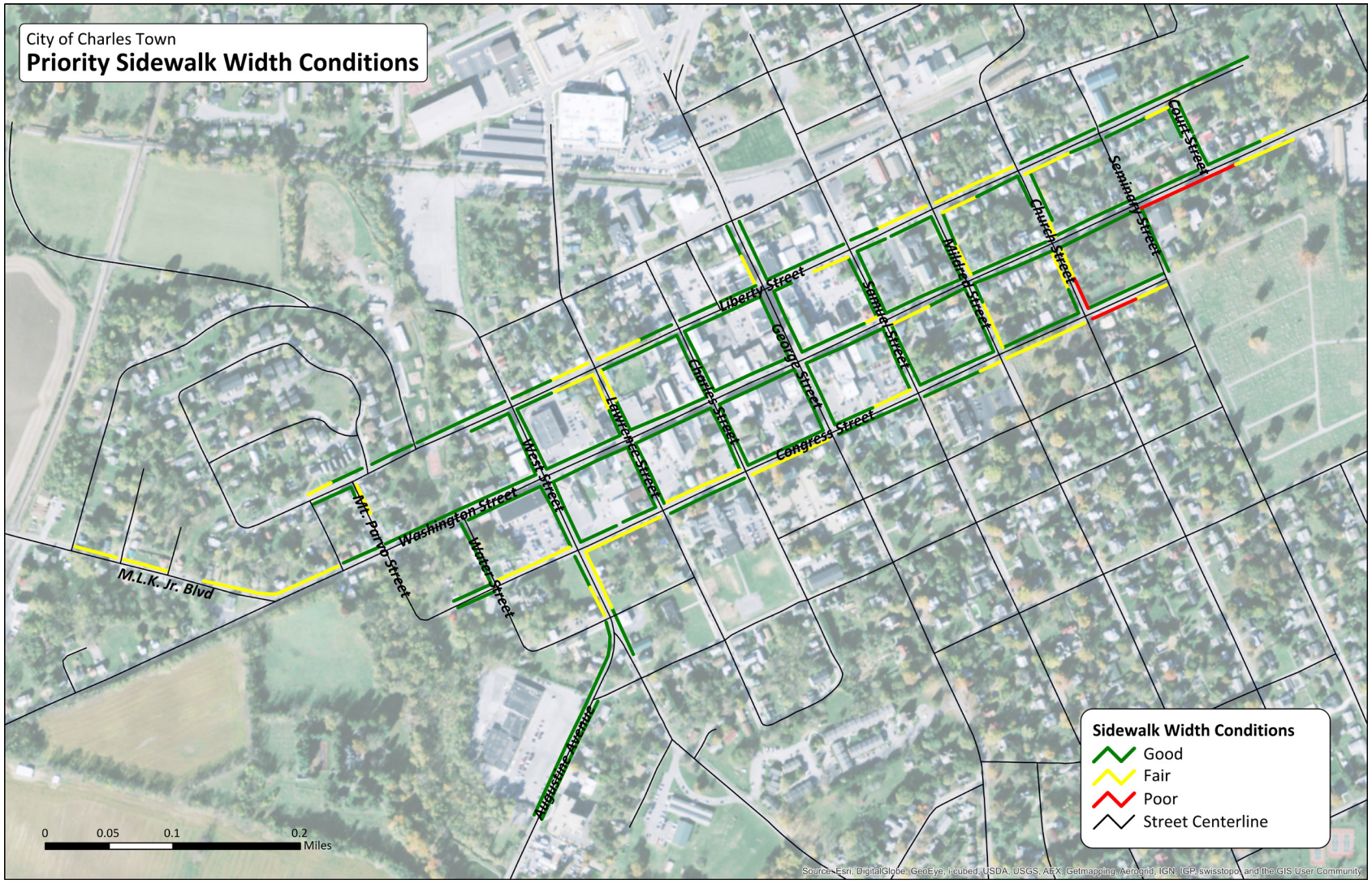


Figure 2: Sidewalk Width Conditions within the Priority Study Area

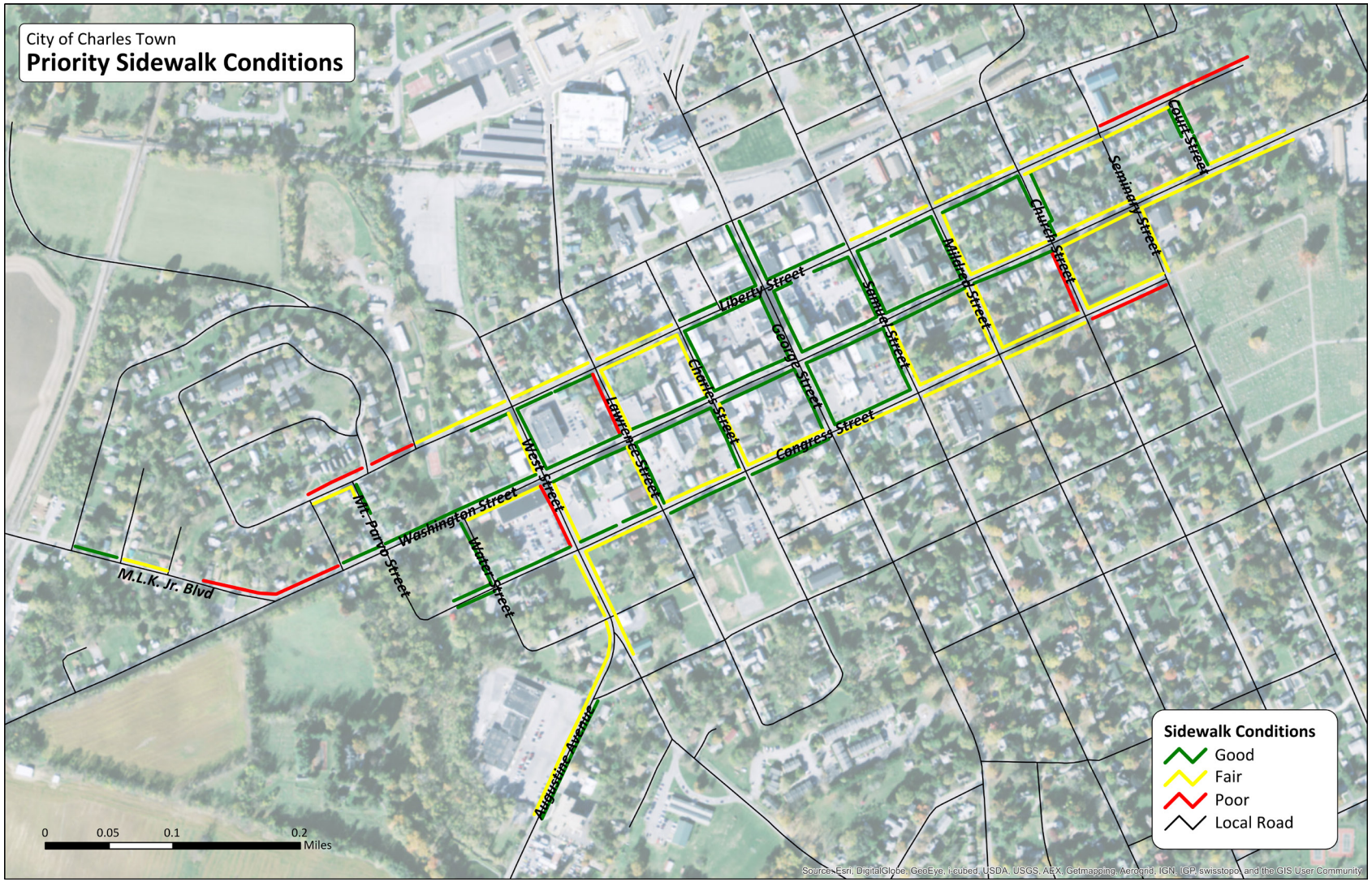


Figure 3: Sidewalk Conditions within the Priority Study Area

Overall Condition Assessment

While both sidewalk width and condition are independently important, overlaying the two assessments provides a better picture of overall condition. Based on the good, fair, poor assessment criteria, there are nine potential combined conditions. Each of these condition assessment combinations has been assigned a relative priority based on the overall condition. Higher priority ratings indicate worse overall condition and more deserving of timely investment. Sidewalk segments that are narrow with poor physical conditions received a higher priority rating, while segments that are in good and fair condition with appropriate width are not rated as highly.

Priority	Width Assessment	Condition Assessment
1	Poor	Poor
2	Fair	Poor
3	Poor	Fair
4	Good	Poor
5	Poor	Good
6	Fair	Fair
7	Good	Fair
8	Fair	Good
9	Good	Good

The majority of the City's sidewalks in the downtown center are in good condition. However, when making sidewalk investments, Charles Town must weigh each of the assessment priorities identified above against areas that have no sidewalks at all. In respect to pedestrian connectivity, the lack of a sidewalk will be more important to address than most of the priority sidewalks based on condition. **Figure 4** depicts sidewalk conditions ratings based on the field assessment and identifies sidewalk gaps in the study area network.

Priority Sidewalk Investment Area

Based on the combined condition ranking, the City of Charles Town should identify priority sidewalk segments for incremental improvements. Probable costs for such improvements, as well as the legal and policy roles and responsibilities are identified in later sections. Using the combined condition rating, there are several specific areas that should be considered for priority investment:

1. **Sidewalk gaps in the immediate downtown area** – filling gaps in sidewalks in a mostly-complete network is the most important improvement that can be made. Sidewalk gaps inhibit mobility and stop pedestrians from travelling further along a path. They can also be unsafe if a pedestrian chooses to continue on and are inherently not ADA compliance.
2. **Repair and/or replace sidewalks with the worst overall condition** – Based on the condition ranking, eight (8) segments have been identified for prioritized improvements. The segments are not identified in any particular order, and should be further prioritized by City officials and local stakeholders.

Figure 5, shown on page 14, displays the priority sidewalk investment area based on the above criteria.

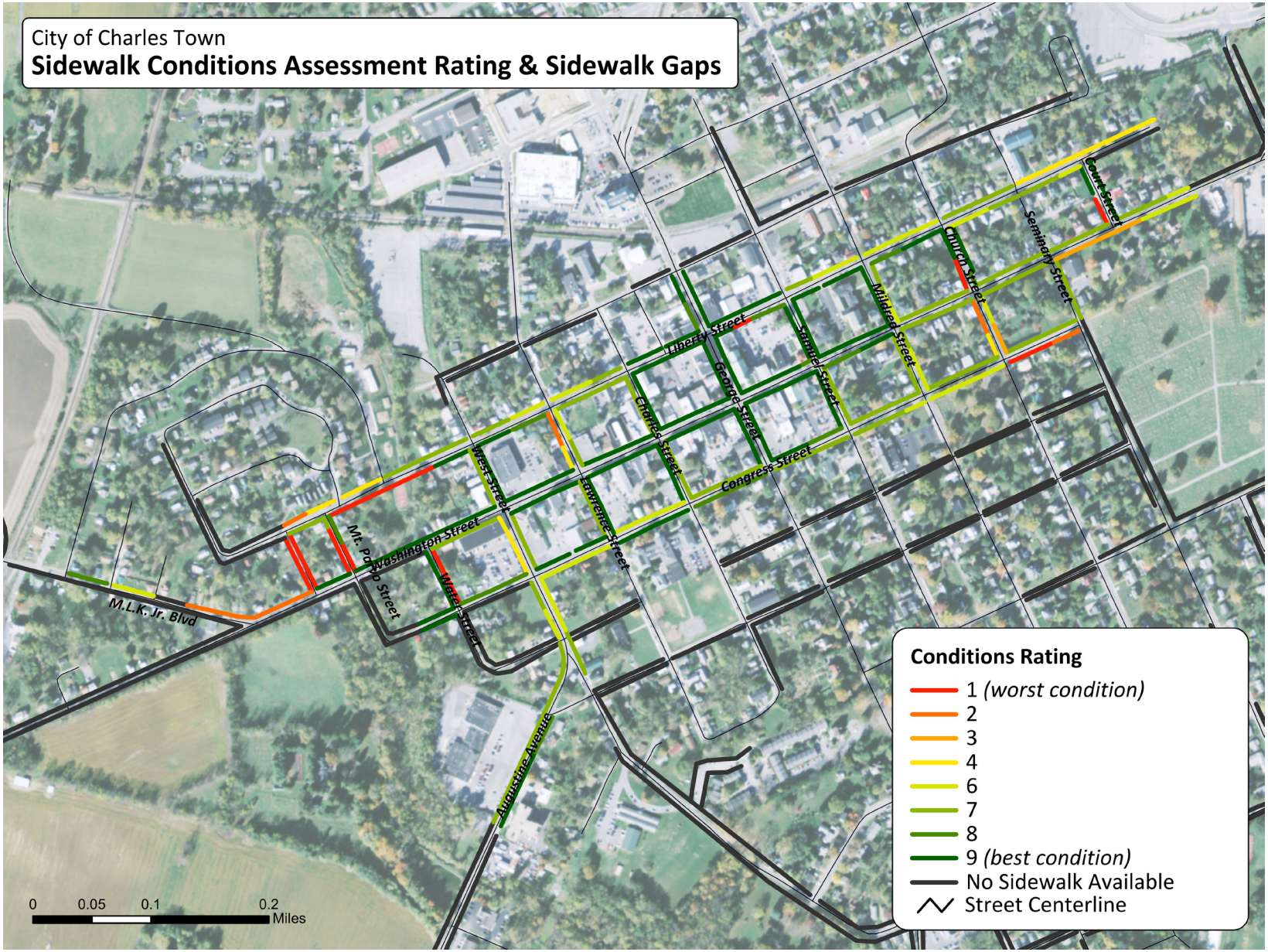


Figure 4: Sidewalk Conditions Assessment Rating & Sidewalk Gaps in Downtown


1
M.L.K. Jr. Blvd & Washington St.

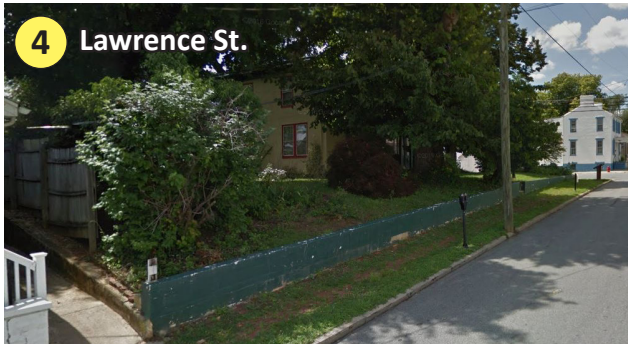

5
Church St.


2
Liberty St.


6
Congress St.


3
West St.
West St


7
Liberty St.


4
Lawrence St.


8
Washington St.



Figure 5: Priority Sidewalk Investment Areas in Downtown Charles Town

Americans with Disabilities Act (ADA) Compliance

ADA compliances takes on a number of forms in the urban walking environment. There are three particular areas of concern related to sidewalks in Charles Town:

- **Sidewalk Width** – sidewalks are required to be at least four feet wide with areas of at least five feet to allow persons using mobility devices (i.e. wheelchairs) to pass one another. For this reason, ADA compliance sidewalks are predominately considered to be at least five feet in width. Charles Town is planning to require all future sidewalks to be 5 feet in width to meet this standard.
- **Sidewalk Condition** – sidewalks should not have excessive gaps in horizontal or vertical surfaces, or obstructions that limit the width of the sidewalk to less than the minimum sidewalk width identified above.
- **Sidewalk Ramps (crosswalks)** – sidewalks approaching intersections should end in ramps of specific dimensions, not to exceed 1/48 cross slope, and should contain a detectable warning surface (dws) to alert pedestrians that they are entering the street.

The field team documented all non-ADA compliant ramps within the study area. **Figure 6** depicts the final ADA ramp assessment. Out of 151 sidewalk ramps, 66 were observed to likely be compliant with ADA standards, leaving 85 ramps that are likely not ADA compliant. All sidewalks must be easily accessible and be built to accommodate ADA requirements. Each sidewalk ramp was marked using the GPS device and a field determination was made on whether it was compliant or not. The videos recorded through the mounted camera were reviewed and used as a reference when determining the compliance of the ramps. ADA compliance must be achieved to ensure a walkable environment for all pedestrians of Charles Town, not just those with disabilities.



Example of Detectable Warning Surface



Example of Sidewalk with No Ramp

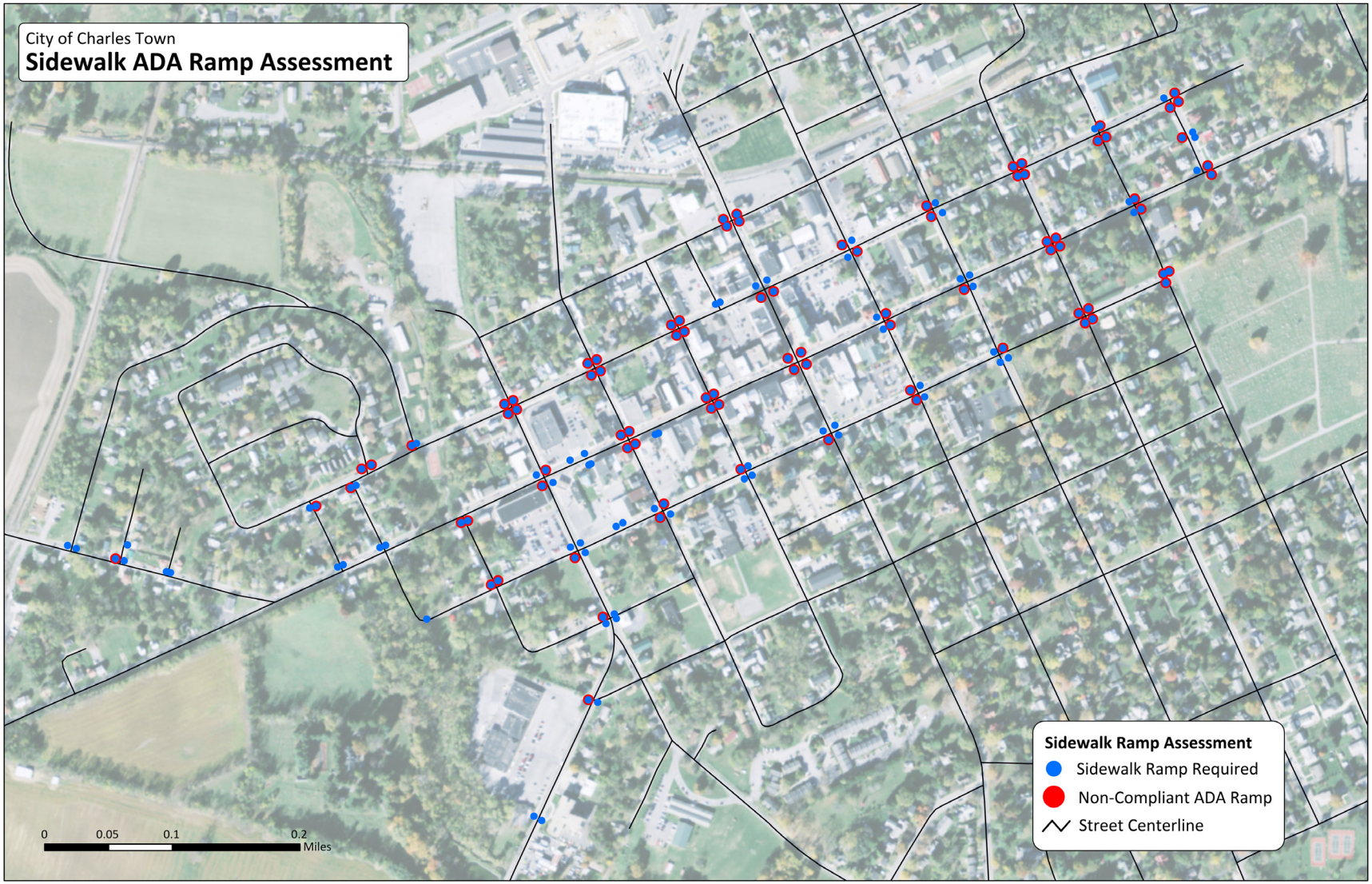


Figure 6: Sidewalk ADA Ramp Assessment in Downtown Charles Town

Trail Connectivity

To create a more complete multimodal network, trail systems must also be considered. The City of Charles Town currently lacks a comprehensive trail network and connections to downtown are nonexistent. However, mutiple agencies, including the City, the Hagerstown-Eastern Panhandle Metropolitan Planning Organization (HEPMPO), and the Jefferson County Parks & Recreation Commission, have proposed bicycle and trail improvements as priorities in their long range plans and each has a key focus in the central hub of downtown Charles Town. Most of the proposed improvements connect with existing sidewalks and will make non-motorized forms of transportation more prevalent in the downtown. **Figure 7** depicts propsed and existing trails in Charles Town.

Agency	Planning Document(s)	Proposed Project Description
City of Charles Town Parks & Recreation	West End Master Plan	**Evitts Run Trail**:The Park Master Plan identifies a number of pedestrian improvements within the park and to the Ranson Civic Center, as well as a future trail connection.
1) City of Ranson 2) HEPMPO	1) Comprehensive Plan 2012 & Fairfax Boulevard and George Street Complete/ Green Street Plan 2) Long Range Transportation Plan 2014	**George Street Bicycle Lanes**: There is an interest in connecting the Route 9 Bike Path to Charles Town and Ranson. The City of Ranson has studied the corridor for "complete street" opportunities, including dedicated bicycle lanes along George Street. HEPMPO included bicycle lanes along the George Street corridor as a proposed project in Jefferson County and referenced the City's Comprehensive Plan as a source.
HEPMPO	Regional Bicycle Plan	**Augustine Avenue Trail:** The Regional Bicycle Plan proposes a 1.9 mile multi-use path along Augustine Avenue, connecting the Huntfield residential development in southwestern Charles Town to the downtown core.
		Harpers Ferry - Charles Town Mult-iuse Trail: Improving bicycle facilities between Harpers Ferry and Charles Town/Ranson was identified as a priority in the Regional Bicycle Plan and a proposed shared-use path is recommended.
		Cattail Run Trail: Potential stream corridor trail identified through the City's comprehensive Urban Growth Boundary to the Shenandoah River.

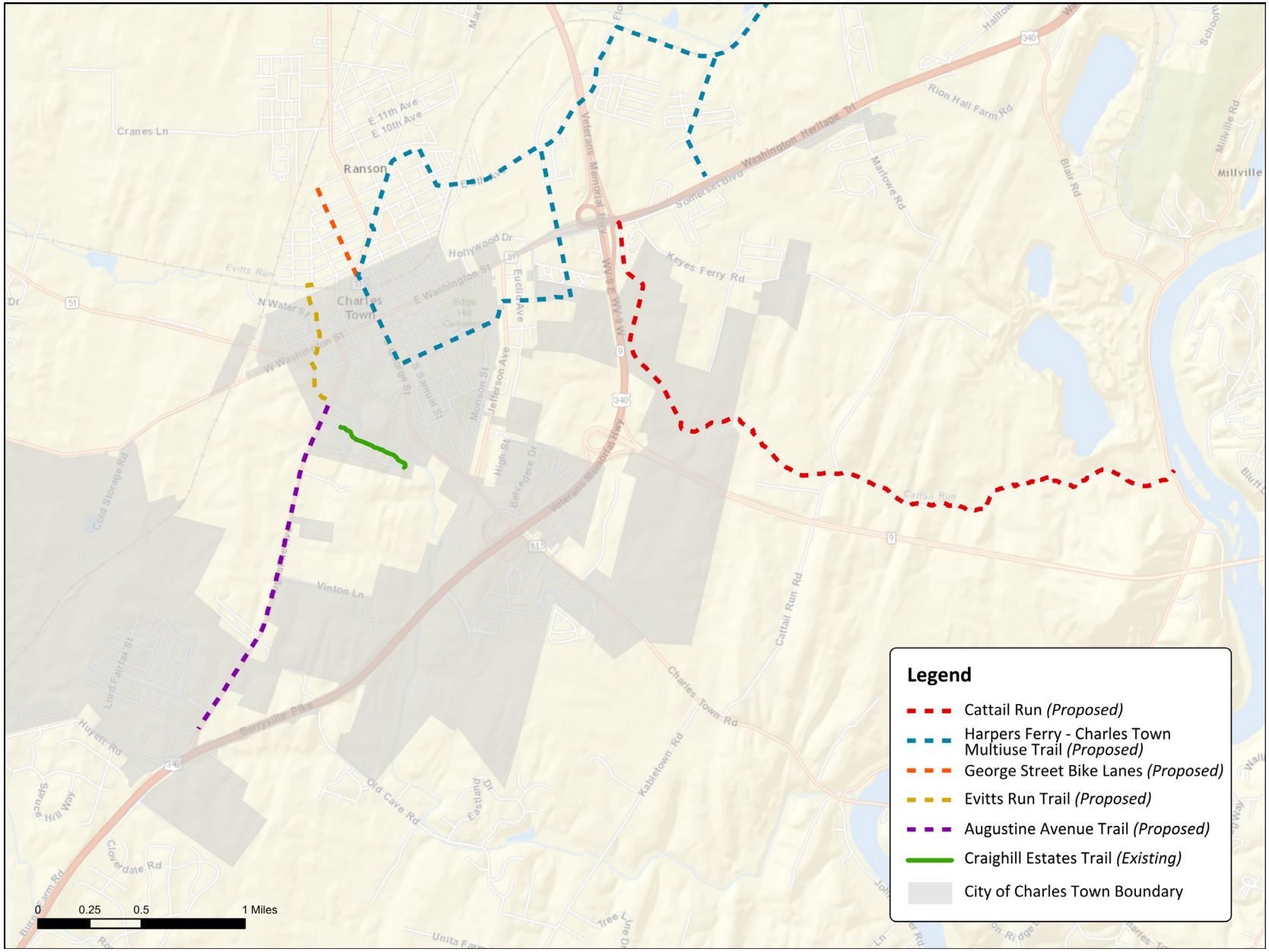


Figure 7: Trail Connectivity in Downtown Charles Town

This study identifies priority pedestrian-bicycle trail projects that could be pursued to connect the central downtown to key Charles Town neighborhoods, other regional hubs and assets, and a broader regional trail network. Among these priorities, there are three that have been widely discussed among community members and leaders, considered in preliminary concept plans, and identified as high priorities for Charles Town:

1.) Evitts Run Park Trail: The City of Charles Town has identified opportunities to reclaim the eastern shore of the Evitts Run Creek as a community park, recreational, and ecological asset. The West End Revitalization Plan calls for the removal of brownfields, blighted areas, and overgrown and inaccessible segments of the Evitts Run Creek, and the installation of parks, recreational amenities, green infrastructure, and walking-biking trails. There are already several segments of trail along with Evitts Run Creek, at the existing Evitts Run Park north of W. Washington Street, and along the creek in Charles Washington Park in the Craighill Estates area, which could be expanded and connected to form a continuous pedestrian-bicycle trail connecting the Ranson Civic Center and Jefferson County Boys & Girls Club at one end, with the Happy Retreat Community Center at the other. Also note that there is a rough trail cleared in the rear of Happy Retreat north of the Evitts Run Creek along an existing municipal utility easement.

With improvements and connections, a future Evitts Run Trail system could run as follows:

Along the eastern side of the Evitts Run Creek – from the Ranson Civic Center on the north end of the Evitts Run Creek; past the Boys & Girls Club; past and through the planned "Lake Rutherford" restoration of the old water reservoir, public works yard, and Dixie-Narco parking lot area; through the existing Evitts Run Park (with an existing trail segment completed); through the Supertane brownfields revitalization area (with a trail segment construction planned for 2016); around the back of Hilldale Shopping Center to the Perry Pond; and across Augustine Avenue onto the south-western side of the Evitts Run Creek through the Charles Washington Park (with an existing trail segment); with a trail spur crossing from near the Charles Washington Grave site to the northern side of Evitts Run Creek leading to the backyard of Happy Retreat. A continuous Evitts Run Trail would also need effective crosswalks over West Washington Street and Augustine Avenue.

2.) Augustine Trail: A second high priority for trail connectivity in Charles Town is the "Augustine Trail", which would be a 1.9 mile pedestrian/bicycle trail from the intersection of Augustine Avenue/Old Route 340 and the US 340 Bypass at its southern terminus, and connect at the northern terminus to the City's existing sidewalk grid just past Evitts Run Creek at Creamery Place in the West End of Charles Town's downtown. The Augustine Avenue Trail is expected to be widely used for health and recreation, as well as basic access to neighborhoods, schools, downtown, job centers, parks and recreational areas and other key nodes by a mix of citizens including 1,200 students and teachers at Washington High School, the 434 teachers and students at Page-Jackson Elementary School, the ~1,200 citizens living in the Huntfield mixed-use community at the southern end of the proposed Trail, the senior citizens and low-income residents of the Charles Tower Apartment complex at the northern terminus of the proposed Trail, and the 1,000+ residents of the West End neighborhood. This 1.9 mile corridor of "Old Route 340 has no sidewalks, no trail, barely even road shoulders, and overall unsafe conditions for walking, biking, or other non-motorized transportation choices.

3.) Connecting Southern Neighborhoods to Old Town – The neighborhoods of Crosswinds, Norbourne Glebe, Greenfield, Hillside, and the Saint James Church area are located on the eastern side of the Route 340 Bypass, generally arrayed around Route 115 south. The residents of these neighborhoods do not have good or safe options for walking or biking into the core "Old Town" area along Route 115 or any other route. Charles Town could consider roadway improvements that would foster better connectivity for pedestrians and bicyclists from those neighborhoods, beginning at the intersection of Fairleigh Drive at Route 115, down to the area around the 7-Eleven store between Jefferson Avenue and Samuel Street, and then further down Route 115 north as it becomes George Street, to George's intersection with Blakely Place, which is where the City's sidewalk grid commences on George – a total distance of approximately 1.3 miles.

The West Virginia Division of Highways plans to create a roundabout feature at the current 4-way stop at the intersection of Route 115 and Citizens Way just west of the 340 Bypass which, if properly designed, could incorporate features for optimum pedestrian/bicycle access and crossing at that area. Further, a shoulder on Route 115 could be dedicated for pedestrian and bicycling usage, improved with signage, painting and striping, barrier separations that could include fencing or other materials, enhanced crosswalk facilities, and other techniques. With these methods, Charles Town could create a "Southern Neighborhood Connector" pedestrian-biking facility build links between Charles Town's older and newer neighborhoods.

Walkability Design Standards

To achieve greater walkability in the City of Charles Town, a coordinated effort is needed for all future pedestrian-related infrastructure projects within the City. While the City's Subdivision and Land Development Ordinance (Part 13, Articles 1331 – 1336, of the Charles Town Code) provides some specifications for sidewalks, streets, and walking trails, more could be done to unify future construction projects with regards to walkability.

To achieve unification, this Section outlines the City's current policies and regulations pertaining sidewalk, streets and walking trail construction and maintenance requirements. It also introduces a Standard Design Template to achieve uniformity in future construction projects whether completed by the City and/or a private entity.

Role of Municipal & Property Owners in Sidewalk and Trail Improvements

Given the significant costs associated with sidewalk construction and improvements for just the highest priority segments, it is unlikely that the City of Charles Town will be able to conduct these sidewalk projects on a rapid basis, or conduct them with only municipal funds. Further, although this report finds that these high priority segments are the areas most in need of improvement in the central core of the city, there could be legitimate concerns about fairness raised if the City uses general taxpayer funding for improvements in these few areas, without identifying, paying for, or conducting improvements in other areas of the city that may also have significant problems with sidewalk gaps, conditions, widths or handicapped accessibility.

The City should therefore consider the proper role of municipal funding of priority sidewalk improvements, versus funding by the private landowners whose properties abut the priority targeted areas.

First, the City may decide that some priority sidewalk improvement areas, even if abutting private landowners' property, are worthy of public investment because they provide common public benefits to the entire community. For instance, this report calls for prioritization of sidewalk improvements on MLK Boulevard & West Washington Street (#1) and East Washington Street (#8). The City could decide that, because these are gateway entrances on the City's main street with major sidewalk gaps yet heavy pedestrian usage, and a compelling justification to keep these gateways in top condition to be able to maintain the quality of life and economic competitiveness of the core downtown – that these could be improved and paid as a general public works project.

Second, the City should confirm its long-standing law and policy that, for most cases of poor sidewalk condition, the responsibility for paying for and conducting the sidewalk construction and improvements rests with the property owner whose land abuts the specific segment.

The design and construction of trails within the City of Charles Town is regulated by Section 1333.18 of the City's Subdivision and Land Development Ordinance. Trails constructed by and within a common interest community – as defined by West Virginia Code Section 36B-1-103, et seq. – are owned and maintained as part of the development's Homeowners Association (HOA). Trail facilities designed and constructed by the City are typically associated with general public improvements for the benefit and use by all City residents and are maintained by the Public Works Department under the auspices of the City's Parks and Recreation Commission.

The design and construction of sidewalks within the City of Charles Town is regulated by Section 1333.18 of the City's Subdivision and Land Development Ordinance and the enforcement for sidewalk construction, maintenance and repair thereof is regulated through the City's Codified Ordinance, Section 909.05. This approach to the construction, maintenance and repair of sidewalks is consistant with the way that sidewalks are installed and maintained throughout the United States. The following sections address both in further detail as they relate specifically to the City of Charles Town.

1. Municipal Subdivision and Land Development: Sidewalk installation traditionally occurs during the land development process, whereby a landowner and/or developer includes sidewalks as part of the overall development project. The requirements and standards by which sidewalks are thereby installed is typically stipulated in a municipality's subdivision and land development ordinance or other pertinent sections of a codified ordinance. Section 1333.09 of the City of Charles Town's Subdivision and Land Development Ordinance outlines the City's requirements for the location and design of sidewalks; the maintenance and repair of which are ultimately the responsibility of the property owner. Under this scenario, the costs of installing the sidewalks are typically included as part of the overall land development project and are financed as part of the overall project costs (e.g., construction loan, mortgage, etc.).

However, the City of Charles Town's Subdivision and Land Development Ordinance was just recently enacted and made effective in July and September 2012, respectively. Previously, the requirements and standards for sidewalks were based on the general requirements specified under Chapter 8A of the West Virginia Code. Prior to the state code requirements, little or no standards existed for sidewalks and in many cases sidewalks constructed in the Old Town Residential Zoning District areas vary in their design and placement, or are non-existent along some stretches of Avis, Academy, Hunter, and Mason Streets, as well as Eagle Ave., Park and Center Streets.

2. Sidewalk Construction and Repair Policy: Municipal sidewalk construction and repair policies typically apply to the ongoing maintenance and repair of existing sidewalks, but also may be administered to require the construction of new sidewalks where development currently exists. Section 909.05 of the City's Codified Ordinance outlines the regulations for the construction, maintenance and repair of sidewalks and specifically stipulates that "Sidewalks shall be maintained by the owner and the occupier of the adjoining real estate. All sidewalks shall be kept in a proper state of repair and maintained free from hazardous conditions.....Every owner of property in the City of Charles Town shall, on ninety days' notice from the City of Charles Town Code Official, construct or reconstruct either a sidewalk or curb, or both...." [3] The section further stipulates the requirements and penalties that are enforceable by the City upon property owners that fail to comply with regulations. Therefore, these regulations are enforceable where sidewalks currently exist as well as areas that are void of sidewalks including locations where gaps may exist in the existing sidewalk network. In all cases, the property owner is ultimately responsible for the financial costs associated with the engineering, design, construction and ongoing maintenance and repair of sidewalk improvements.

Such sidewalk regulations can be challenging for municipalities such as Charles Town to enforce and administer due to several issues:

- **Costs** – According to this study (Prioritized Implementation Plan), the average construction cost per linear foot is approximately $50- $75 per linear feet for a typical five foot wide concrete sidewalk, which coupled with permitting, design and labor costs could ultimately cost a typical property owner well over $3,500 to reconstruct a typical 50 foot section of sidewalk. As such, most homeowners lack the means to upfront the costs to either proactively make the appropriate sidewalk repairs or effectively respond to a code enforcement notice issued by the City.

3 Codified Ordinances of the City of Charles Town, WV. Accessed online August 26, 2016 at http://whdrane.conwaygreene.com/NXT/gateway.dll?f=-templates&fn=default.htm&vid=whdrane:WVCharlestown

•**Time** – The City Code requires property owners to construct or reconstruct sidewalk and/or associated curbing within 90 days of receiving notice from the City. As discussed, most property owners are unable to finance the necessary construction costs and therefore, may ultimately be in violation of the Code requirements. In turn, the City then is responsible for making the necessary repairs and incurring the costs, but the City needs a more robust capital plan and budgeting process to finance these improvements. As a result, the City's sidewalk repair and maintenance program lacks a sustainable funding source to maintain a viable, City-wide sidewalk repair and maintenance program.

•**Responsibility of Ownership** – Most property owners often view the sidewalk area as the City's property and ultimately its responsibility for repair and maintenance. This viewpoint may be well-founded based on the definition of sidewalk specified in the West Virginia State Code, which defines "Sidewalk" as "…that portion of a street between the curb lines, or the lateral lines of a roadway, and the adjacent property lines, intended for the use of pedestrians."[4] This definition implies that the sidewalk is part of the public street and not part of the adjacent property. This, in turn, further complicates the City's ability to successfully enforce and administer the Code requirements for the construction, maintenance and repair of sidewalks and this ultimately contributes to code violations as described above.

The Prioritized Implementation Plan, further addresses these challenges by identifying several opportunities that the City may consider to improve its pedestrian design standards and achieve its overall walkability objectives.

Given these challenges, Charles Town could consider taking three steps to encourage property owners to fulfill their responsibilities for sidewalk maintenance:

1.) **Public Outreach and Communication:** Certainly property owners will not want to be surprised with a major sidewalk enforcement campaign that could impose significant and costly responsibilities, without having the opportunity to engage and discuss these priorities with the City first. City officials should consider conducting significant public outreach and communication, particularly with the owners and residents who own and/or live, or conduct business operations at these priority sidewalk segments. The City should put this completed report on its web site. The City could draft a short flier explaining the new initiative to identify and fix sidewalks, and describing the long-standing regulation that places responsibility for sidewalk maintenance on abutting property

4 West Virginia Code, §17C-1-38.

owners. This flier, including a web link to (or hard copy of) this report, could be delivered or mailed to the potentially affected landowners. The City could hold a public workshop, inviting all citizens, but with special effort to engage potentially affected landowners at priority improvement areas.

2.) Foster the Use of Sidewalk Templates: In some cases, property owners may seek to replace or repair their sidewalks on their own, without being triggered by any enforcement requirements or orders. The City will want to make sure that it has easily-accessible and easily-understood information about the sidewalk design templates that the City will require for all facilities. These materials should be made available to all property owners seeking a permit to replace or repair a sidewalk. Further, the City could consider stuffing a flier or postcard within water bills mailed to property owners, letting them know that the City has adopted a revised sidewalk policy that includes design templates providing detailed instructions on how all facilities should be constructed.

3.) Sidewalk Incentive Program: The City could also consider establishing a program to provide financial and technical incentives to property owners who wish to upgrade their sidewalks, either on their own or as part of the Section 909.05 requirements process. The City could establish the "Sidewalk Team Encouragement Program" or "STEP", which would bring a team of municipal and contractor personnel together with financial incentives for those property owners who step up to address sidewalk deficiencies. These STEP incentives could include:

- The City could establish a relationship with one or more qualified sidewalk construction vendors who understand Charles Town's design templates, and who would be willing to provide a cost discount to Charles Town homeowners who take advantage of the STEP program.
- The City could offer to provide in-kind public works services from City work crews, such as existing sidewalk demolition or ground excavation, or tree planting services. These could be provided at discounted costs to the customer, saving even further money.
- The City could provide matching grants to a specific number of owners who take advantage of the program. For instance, the City could provide $500 grants to the first 10 landowners who take advantage of the program each year.
- The City could also consider setting up a loan fund which, for a zero or very low interest fee, could provide a loan to a property owner for the cost of installing a new sidewalk or repairing existing sidewalks. These loans could be paid back through payments on the customer's water bill over a period of time, further lessening the burden on the property owner.

In these ways – discounted services from preferred vendors, in-kind contributions from City work crews, grants, and/or loan services, the burden of sidewalk upgrades can be lessened for those property owners who "STEP" forward to take advantage of these incentives."

Standard Design Template

The purpose of the Standard Design Template is to allow the City or private entity to bid complete street, sidewalk, and walking trail improvements to conform to the City's standards specified in its Subdivision and Land Development Ordinance. The template includes performance-based specifications, standard construction details, and construction specifications that aim to provide a high quality and consistent walking experience as construction projects are completed throughout the City. As such, the City should amend its Subdivision and Land Development Ordinance to incorporate the template's design standards therein.

As stated above, a unified approach for all future construction projects is crucial to building consistent walking areas throughout Charles Town. This will be accomplished utilizing the following items:

- **General Standards**
  These standards will be common throughout all construction projects involving roadways, sidewalks, or walking trails in Charles Town.
- **Specifications**
  Construction specifications will be used to create continuity among all future projects. These include detailed dimensions and material types.
- **Standard Details**
  Standard drawing details of common construction items that may be found within Charles Town. These items will be conducive to walkability through the City.
- **Typical Sections**
  These roadway sections are created for each major roadway throughout the City. They include typical widths, materials, and other information that might be common along specific roadway corridors.

All of these items have been selected based on coordination with the City's Public Works and Planning Departments. They have been determined to be the best standards to achieve a uniform appearance for future projects, and will blend well with the existing infrastructure.

General Design Standards

These design standards should be maintained by The City's Planning Department and any revisions to these standards will be coordinated between the City and any other private entities.

Sidewalks

General design standards for sidewalks for the City of Charles Town will be as follows:

A) Sidewalks will be provided in accordance with the requirements specified in table.
B) Sidewalk will be constructed either with concrete or brick with concrete subbase. See Appendix A, Details D-2 and D-3.
C) All utility poles, traffic posts, water hydrants, fire hydrants, sign posts, and any other object positions within the sidewalk must be separated with a one-half inch expansion joint providing a clearance of six (6) inches.
D) Sidewalks will be constructed according to the typical materials section shown in
Appendix A, Details D-2 and D-3.
E) Sidewalks will not be constructed with a curb as a single integral unit.
F) Where sidewalks are part of a driveway or access drive, the sidewalk will maintain grade, with no depression, except where necessary to tie into the entrance.
G) Handicap Accessible (ADA) Ramps will be provided on the sidewalks at all street intersections and pedestrian crossings. See See Appendix A WV DOH Standard Sheet PVT7.
H) When brick/clay is used in a sidewalk, and the sidewalk crosses a driveway, stamped concrete will be used across the driveway instead of brick/clay. See Appendix A, Detail D-4.

Sidewalk Requirements			
Land Use	Average Lot Size	Density	Sidewalk Requirement Street Frontage
	Sq ft	Du/acre	
Residential	> 30,000	1.46 or more	None
Residential	15,001 – 30,000	2.90 – 1.45	One Side of Street
Residential	12,001 – 15,000	3.00 – 5.50	Both Sides of Street
Residential	< 12,000	> 5.51	Both Sides of Street

Source: Charles Town Subdivision and Land Development Ordinance

Streets

General design standards for complete streets for the City of Charles Town should be as follows:

A) The use of shared use lane markings (sharrows) is recommended on streets through the City. See Appendix A, Detail D-6.
B) Where possible, construct raised crosswalks across roadways for pedestrian use. See Appendix A, Detail D-5.
C) All signs designated for traffic use that are within sidewalk limits will be a minimum of eight (8) feet high.

Walking Trails

General design standards for walking trails for the City of Charles Town will be as follows:

A) Walking trails will be constructed in accordance with Detail D-1.
B) Appropriate lighting and signage, landscaping, buffering, and drainage measures, along with considerations for security will be incorporated in the design of walking trails.
C) A private access easement will be provided for all trails outside of City of Charles Town right-of-way and will include a minimum of three (3) feet of width on both sides of the trail.

Washington and Charles Street Design Standards

While current sidewalks along Washington and North Charles Streets provide for safe and easy movement of pedestrians, these streets are still predominantly car oriented with wide travel lanes. Reducing the width of the travel lanes will allow for the streets to become more pedestrian oriented with wider sidewalks. Increasing sidewalk widths will activate public spaces resulting in an increase in commerce for businesses. In addition, wider sidewalks create safer places for pedestrians to walk, allow for storefronts to expand on to the sidewalk, and increase outdoor seating options.

Washington Street

Currently, Washington Street is car oriented with 16 feet wide travel lanes in both directions. In order to create a more pedestrian oriented street, the travel lanes should be narrowed to 12 feet allowing for an increase in sidewalk widths for additional seating or expansion of storefronts. While the ideal travel lane width would be 10 feet in order to reduce speed, Washington Street serves as a main thoroughfare that currently conveys a significant number of commercial vehicles on a daily basis. See Appendix C for current cross section, Appendix B for proposed cross sections, and Appendix D for proposed renderings.

Charles Street

Similar to Washington Street, North Charles Street currently has a 16ft wide travel lane. The travel lane would be narrowed to 10 feet to reduce vehicular speeds and sidewalks widened to allow for additional seating or expansion of storefronts. In addition, the roadway should be raised to the same height as the sidewalks to create a continuous surface commonly known as a "shared street". A Continuous surface would allow for the road to be completely turned into a pedestrian street when the road was closed to traffic. Pedestrian areas, parking lanes and travel lanes would be denoted with changes in material. See Appendix C for current cross section, Appendix B for proposed cross sections, and Appendix D for proposed renderings.

Specifications

This section details specifications for individual walkability items. These are shown pictorially within Appendix A: Standard Details below, and are combined with the general standards above to show overall roadway cross sections in Appendix B.

Sidewalks

Specifications for sidewalks for the City of Charles Town should be as follows:

A) Sidewalks will have a minimum width of five (5) feet.
B) Sidewalks will have weakened plane traverse joints at four (4) foot intervals, and no more than forty (40) feet between expansion joints.
C) Sidewalk concrete will be no less than four (4) inches deep.
D) Concrete material will have a minimum PSI of 3,500.
E) Sidewalk cross slope will be a maximum ¼ in per foot.
F) A four (4) inch subbase of Aggregate Base Course Class 1 will be used under the concrete.
G) Stamped concrete across driveways will have a minimum PSI of 4,000.

Streets

Specifications for complete streets for the City of Charles Town should be as follows:

A) Spacing between sharrows will be no less than 150 lane feet.

Walking Trails

Specifications for walking trails for the City of Charles Town should be as follows:

A) Pedestrian trails will have a minimum width of six (6) feet.
B) The maximum grade for all pedestrian trails will be ten (10) percent.
C) Trail cross slope will be a maximum ¼ in per foot.
D) Trail will be constructed using hot mix asphalt concrete, at 1 ½ in to 2 in depth.
E) A four (4) inch subbase of Aggregate Base Course Class 1 will be used under the concrete.

Other Combined Improvements

While the improvements described above are primarily concerned with walkability through the City, additional improvements are also available that can be included during construction of these walkability improvements. A "dig once" mentality is in view here. Rather than construct the walkability improvements by themselves, and then construct any additional improvements later, it would be much more cost efficient to propose and construct all improvements at the same time. The following items are proposed to include with walkability construction.

Street Trees

Street trees are native trees purposefully planted within sidewalks along roadways. They offer many benefits, from beautifying neighborhoods to providing storm water reductions through root absorption. There is even some evidence that shows street trees encourage reduced vehicle speeds along roadways. Because these trees are often placed within sidewalk limits (when placed along city roadways), it is essential that these plants are included in sidewalk walkability improvement plans. Otherwise, new sidewalk would need to be removed to plant the new trees later.

Flow-Through Planters

Flow-through planters are stormwater management facilities that do not allow for storm water infiltration back into the water table, utilizing trees and other plants to pre-treat and reduce storm water runoff before entering a traditional drainage system. These are used mostly in infiltration-preclusive or high-density urban areas, and are constructed alongside the roadway within the sidewalk limits.

It is recommended here that the street trees proposed above be used in conjunction with these flow-through planters. Rainwater would enter the planter from the roadway and sidewalk and be absorbed by the tree roots in the soil.

Similar to the street tree improvements, any planters that might house the trees would also need to be included in walkability improvement plans.

City of Charles Town Preliminary Wayfinding Signage Location Analysis

The ability to navigate a city is critically important to its economic prosperity. Residents and visitors must be able to confidently orient themselves within the community as they find local services and points of interest. Proper wayfinding infrastructure has the ability to inform people of their nearby surroundings in an unfamiliar environment and display information at strategic points to guide them in the right direction. Even with the proliferation of smart-phones and other mobile technologies, physical wayfinding elements – such as directional signs, interpretive boards, monuments, and directories – can enhance pedestrian experiences within the community. Further, local wayfinding systems can serve as an educational tool for visitors on the boundaries, destinations, and key cultural or historical features of the community.

Project Overview

The City of Charles Town Preliminary Wayfinding Signage Location Analysis (Preliminary Wayfinding Analysis) serves as an initial framework for implementing an effective and appealing signage system that directs pedestrians, bicyclists, and automobile drivers to key destinations within the City and its vicinity. Because planning and designing a comprehensive wayfinding signage program is a significant undertaking, the purpose of this Preliminary Wayfinding Analysis is to identify potential locations for wayfinding signs to serve as a base for future implementation efforts. Various plans and studies related to walkability, community development, and economic revitalization have been initiated within the City of Charles Town in recent years and findings from these resources will be used to inform the Preliminary Wayfinding Analysis:

- Existing Sidewalk Inventory & Conditions Assessment tasks of the City of Charles Town Walkability and Connectivity Study
- Charles Town Parking Study
- C*Town Arts and Cultural District
- City of Charles Town Comprehensive Plan
- Jefferson County Convention & Visitors Bureau's "Walking Tour of Charles Washington's Town" brochure

The study area for this Preliminary Wayfinding Analysis includes all areas within the City of Charles Town Urban Growth Boundary, with a key focus on priority sidewalks located in the downtown. **Figure 8** shows the extent of the study area.

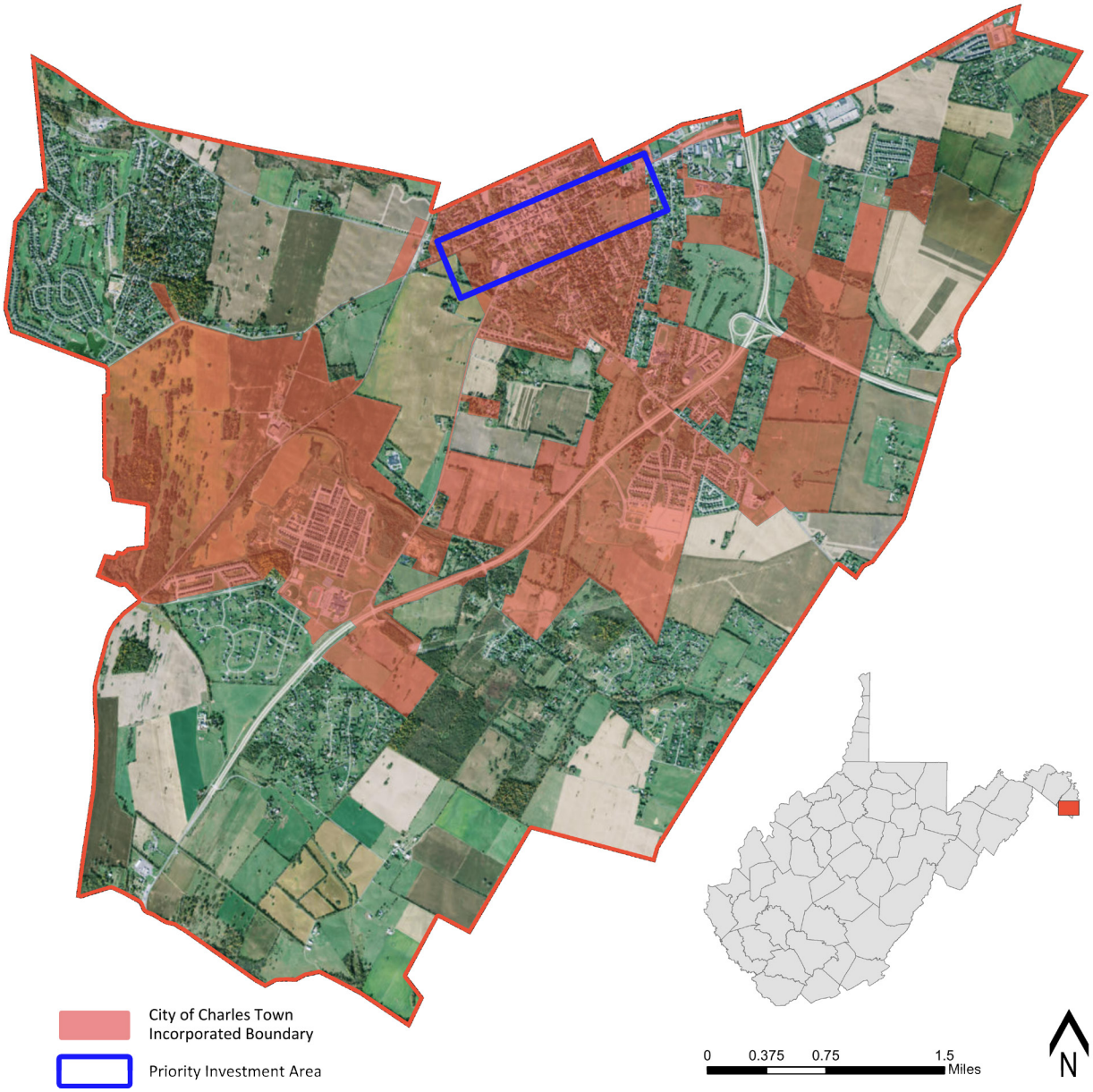


Figure 8: City of Charles Town Preliminary Wayfinding Analysis Study Area

Hierarchy of Wayfinding Signage

An effective wayfinding system should connect people to the unique destinations and attractions located within a city and its region. Signage and mapping elements can create a hierarchy of destinations and simplify the city's layout to allow for ease of navigation. The City of Charles Town has many historic downtown attractions, which lends itself well to a pedestrian-scale signage system (especially along the Washington Street corridor). However, getting to the historic attractions often means traveling via automobile along highway routes. Identifying districts based on the number of and types of destinations available can be beneficial in outlining a wayfinding signage system at the local and regional scale.

City of Charles Town Signage Districts

Like many historic small towns, the City of Charles Town has a large concentration of noteworthy attractions within its downtown. As the "hub" of the region, the downtown historic district composed of Washington Street, Liberty Street, and East Congress Street (shown in **Figure 9**) should have the greatest number of pedestrian-oriented signage. Additionally, there are three public parking lots in downtown Charles Town that should be clearly marked for vehicular traffic and have locational signage for individuals transitioning from vehicular to pedestrian travel mode to allow them to orient themselves to their immediate environment.

Just outside of the downtown district, there are fewer attractions that are more widely dispersed. These attractions are still accessible to pedestrians and should be identified in any wayfinding mapping products, particularly those of regional significance (e.g. the Charles Washington Grave Site and the Gibson-Todd House, where John Brown was executed). However, locational signage within the secondary signage district will not be as frequent or as prominent as it is within the downtown.

The City of Charles Town is within close proximity to two regional roadways (U.S. Route 340 and WV Route 9) and can use these higher-volume, through corridors to alert drivers of the nearby historic downtown. Specifically, the City can work with West Virginia Division of Highways (WVDOH) to add signage along the WV Route 9 bypass, prior to the exit ramp, that notifies drivers of the upcoming historic district. Once the driver has exited the highway, the City should have prominent gateway signage to welcome residents and visitors to the town.

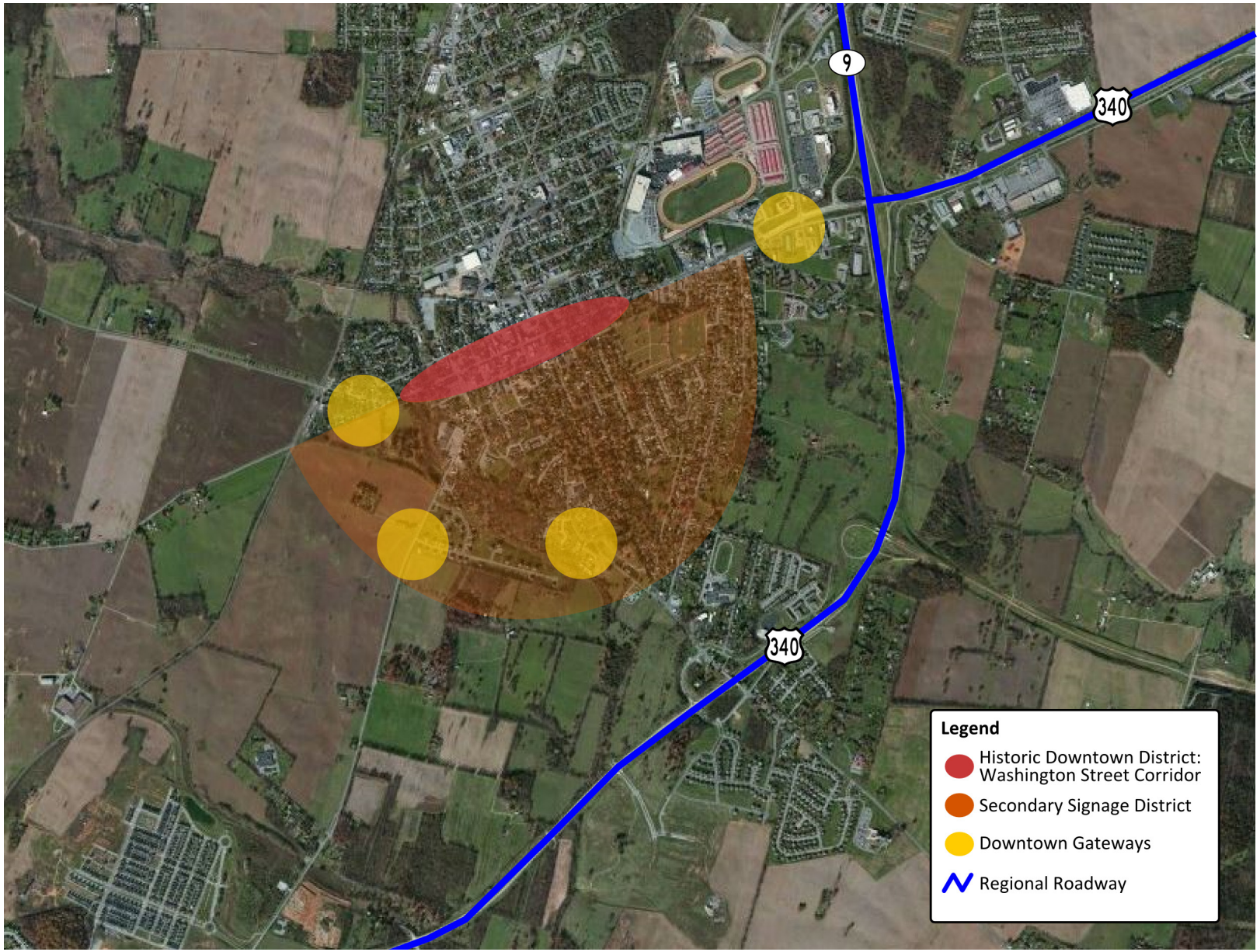


Figure 9: Downtown Charles Town Wayfinding Signage Districts

Signage Requirements by Transportation Mode

The U.S. Federal Highway Administration (FHWA) has established requirements for roadway and community wayfinding signage, which is outlined in their Manual on Uniform Traffic Control Devices (MUTCD). The intent of the MUTCD is to provide national standards for all traffic control devices on all public streets, highways, private roads, and bikeways that are open to public traffic. Design details for these signs are generally not included in the MUTCD; however, FHWA provides design guidance through the Standard Highway Signs and Markings (SHSM) book. Examples of signs regulated by the MUTDC and SHSM include street signs, stop signs, and "destination guide signs" often found along the highway.

Vehicular Signage

Vehicular signs are intended to move vehicles from freeways leading into Charles Town to major destinations and to parking areas along those travel routes. These signs should contain limited information so as to not distract or confuse drivers. Vehicular signage should focus on tourists and individuals who are new to the area. They should be located at key intersections and appear frequently enough to assure the driver that they are headed in the right direction. Once the driver has parked, the pedestrian signage system should take over. **Figure 10** provides examples of vehicular signage.

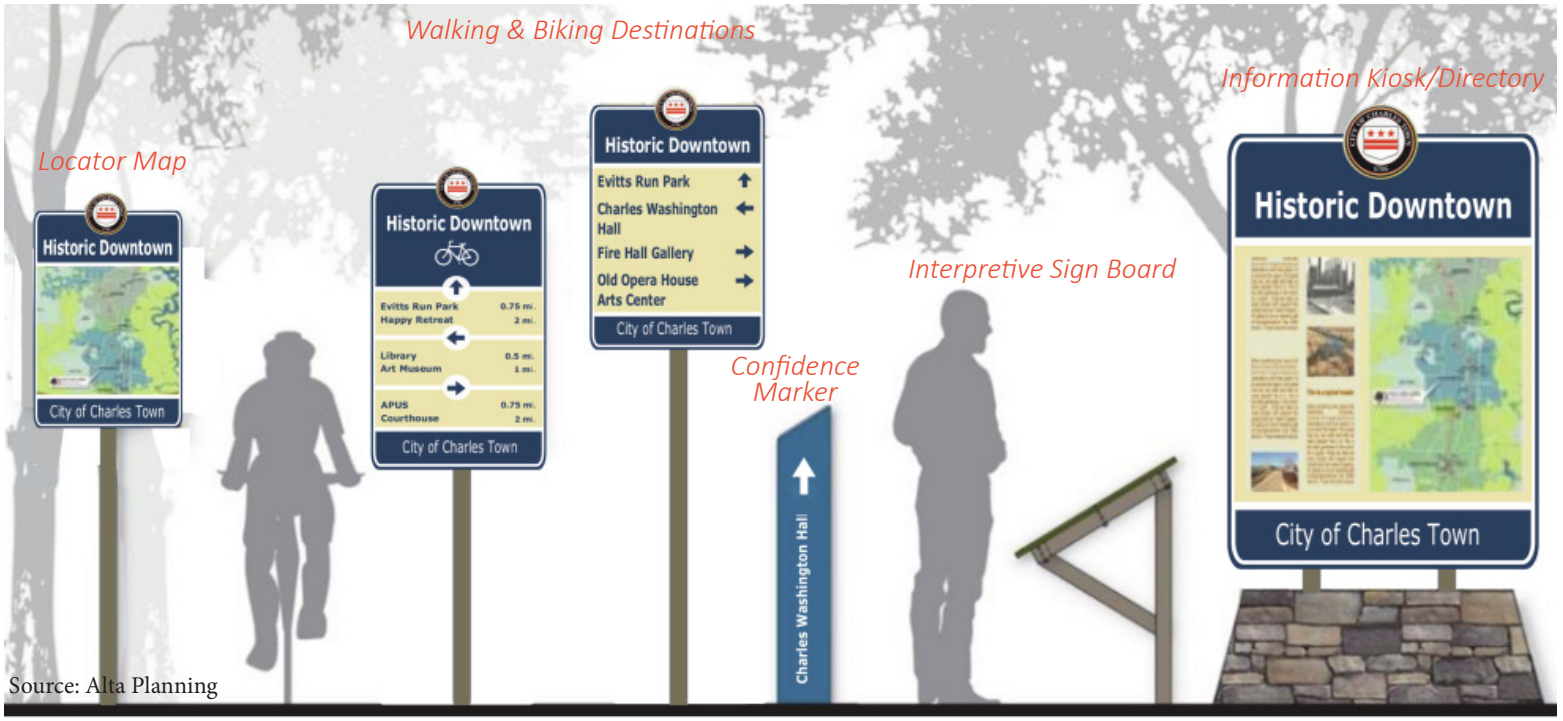


Figure 10: Vehicular Signage Examples

Pedestrian & Bicyclist Signage

Once the visitor is no longer navigating by vehicle, the next level of wayfinding signage should contain more information about specific destinations that are within walking distance, as well as maps to help orient the visitor to their surroundings. The signs should be located near parking and areas of high activity to reinforce predetermined routes so the visitor never feels unsafe or lost. Pedestrian signage includes directional signs, interpretive signs, trail markers, and information kiosks/directories with locator maps. The pedestrian signage network should focus on streets that provide activities that attract visitors and residents (e.g. shopping, dining, parks, museums, historic landmarks, and art galleries).

In addition to directional signage, the City of Charles Town could benefit from additional interpretive signage. Interpretive signage is designed to draw attention to historic landmarks and other sites of interest and should present relevant information in a concise and convenient manner. The location of interpretive signage should fall within high pedestrian activity areas to make the pathways interesting to residents and visitors. **Figure 11** shows examples of pedestrian wayfinding signage, including interpretive sign boards.



Source: Alta Planning

Figure 11: Pedestrian Signage Examples

Defining the City of Charles Town

In summer 2016, the City of Charles Town, along with partnering organizations, launched a new **C*Town Arts & Culture District** with the intent of boosting arts, heritage, and tourism in the downtown. The new district is the result of a two-year planning process sponsored by the National Endowment for the Arts through a creative placemaking grant. The C*Town Arts & Culture District Plan (**Figure 12**) outlines a future vision that celebrates arts, culture, and history and provides an implementation schedule for creating a district with a strong sense of place. The plan places a large emphasis on walkability and connectivity, going as far as suggesting that within the next five years, the City should deploy complete streets principles to Washington Street, encourage tactical urbanism throughout the district, and initiate traffic calming techniques to make the streets more pedestrian friendly.

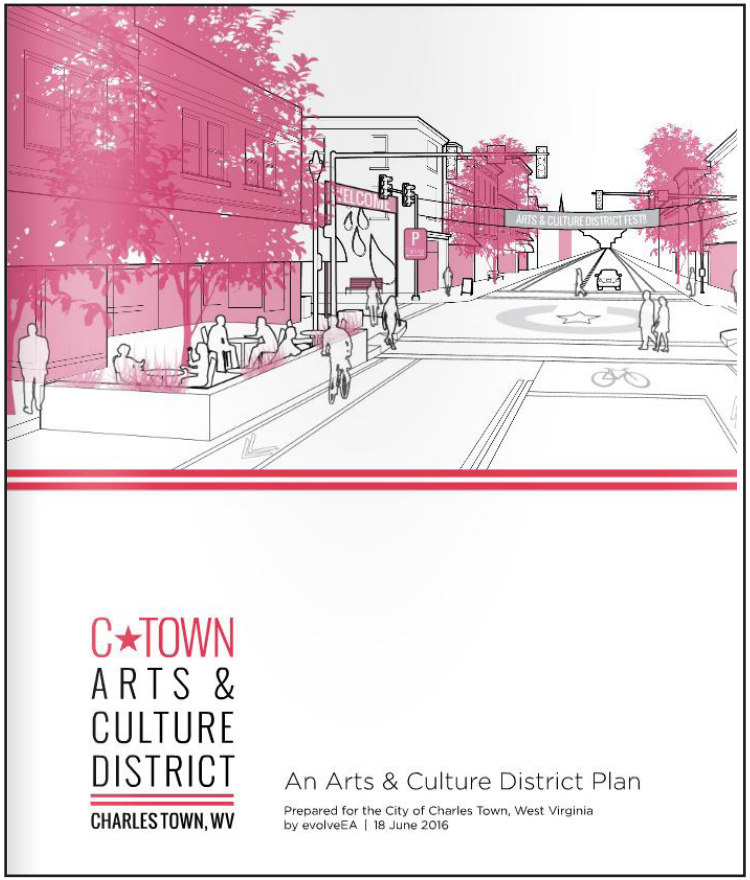


Figure 12: City of Charles Town Arts & Culture District

As part of the Arts and Culture District Plan, the City identified potential branding and marketing materials to bolster its public identity. **Figure 13** demonstrates potential signage designs that were one outcome of the Plan and can be used as an example of a unified sign theme during future discussions about wayfinding and community image. A key next step of this study will be a more detailed signage design project that will include local stakeholders, specifically the Design Committee of Charles Town Now and the C*Town Creative Council.

The signage design project will focus on the aesthetic and functional elements of signage, specifically color standards, font and typography standards, symbology, and branding.



Figure 13: Example Wayfinding and District Branding Signage Designs

Opportunities for Wayfinding Signage

A wayfinding signage system for the City of Charles Town should be organized to direct visitors and residents to major attractions and destinations, regardless of their transportation mode. Signage should be strategically located along priority routes that connect to areas of high activity. In addition to navigation, the signs can alert newcomers to the presence of these attractions and encourage "pedestrian propulsion", or some element of the street that entices one to walk further than originally intended. Fortunately, the City has many points of interest located in its downtown and within walking distance of downtown.

Attractions

To begin identifying potential wayfinding signage locations, the project team compiled a list of 77 attractions, including cultural and historic destinations, community facilities, shopping plazas, and schools. Many of the attractions are clustered around downtown Charles Town and are within walking distance of one another, specifically along Washington Street (shown in **Figure 14**). Most of the identified attractions were included in the "Walking Tour of Charles Washington's Town" brochure, published by the Jefferson County Convention & Visitors Bureau. The following section provides recommendations for potential signage locations based on the City's points of interest.



Source: Jefferson County Convention & Visitors Bureau



Figure 14: Attractions in Downtown Charles Town

Preliminary Signage Location Plan

As a starting point for the City, a set of proposed wayfinding signage locations has been identified based on the regional significance of nearby attractions. For each location, a type of sign has been suggested, as well as potential locations to be included on the sign. **FIgure 15** shows potential wayfinding sign locations.

Signage Locations

Map ID	Signage Type	Signage Location	Details
1	Gateway Sign	W. Washington St. & MLK Jr. Blvd.	Branded City of Charles Town Welcome Sign
2	Gateway Sign	Augustine Ave.	Branded City of Charles Town Welcome Sign
3	Gateway Sign	S. George St.	Branded City of Charles Town Welcome Sign
4	Pedestrian Sign	W. Washington St. & West St	Directs visitors to "Fisherman's Hall", "Charles Washington's Grave Site", "Charles Washington Park" and "Evitts Run Park"
5	Parking Sign	W. Washington St. & S. Lawrence St.	Directs visitors to parking on N. & S. Lawrence St.
6	Pedestrian Sign	W. Washington St. & N. Charles St.	Directs visitors to "Tiffin House", "Episcopal Reading Room Site", and "Charles Washington's Office"
7	Information Kiosk	Washington St. & George St.	Provides visitors with more specific information about nearby destinations and a map for orientation. Additional vehicular directional signs directing visitors to "Chares Washington Hall Visitors Center", "Fine Hall Art Gallery", "Historic Jefferson County Courthouse", and "Happy Retreat"
8	Parking Sign	W. Washington St. & N. Samuel St.	Directs visitors to parking on N. & S. Samuel Street
9	Pedestrian Sign	E. Washington & S. Samuel St.	Directs visitors to "John Brown Hanging Site", "Jefferson County Museum" and "Blessing-Webb Historic Houses"
10	Pedestrian Sign	E. Washington & S. Seminary St.	Directs visitors to "Carriage Inn" and "Historic Civil War Battlefield"
11	Vehicular Sign	Hollywood Casino Entrance, south on Rt. 51	Branded using "C*Town Arts, Culture & Historic District"Directs visitors to the casino, "John Brown Hanging Site", "African American Historical Sites" and "Happy Retreat"
12	Gateway Sign	Rt. 51, east of Hollywood Casino entrance	Branded City of Charles Town Welcome Sign
13	Vehicular Sign	0.5 miles south of the Rt. 340/Rt. 51 interchange	Highway directional sign directs visitors to "C*Town Arts, Culture & Historic District", and "Visitor Center"
14	Vehicular Sign	0.5 miles north of the Rt. 340/Rt. 51 interchange	Highway directional sign directs visitors to "C*Town Arts, Culture & Historic District" and "Visitor Center"

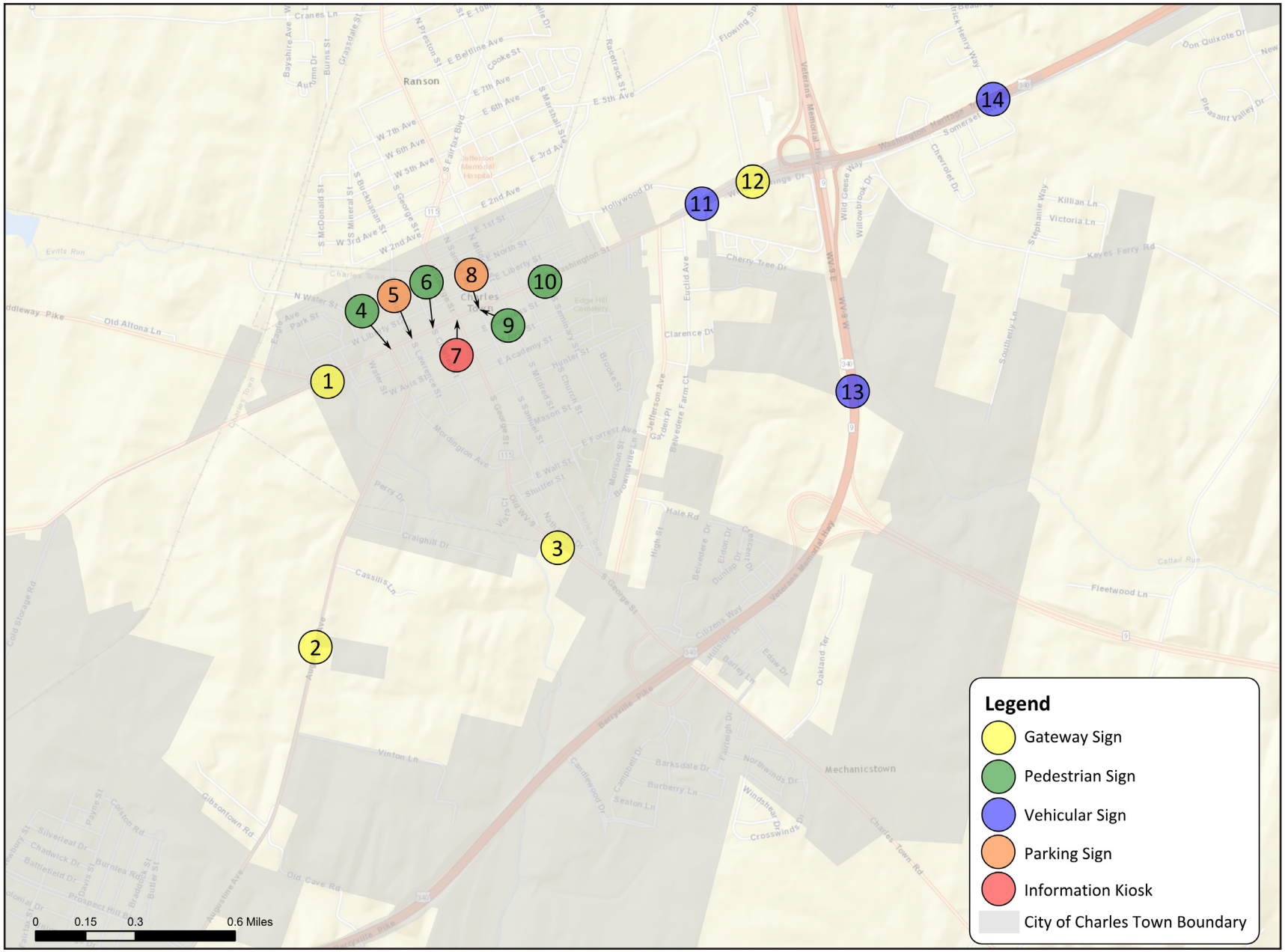


Figure 15: Potential Wayfinding Signage Locations

Wayfinding Study Next Steps

Often times, the most difficult part of a planning study is determing what must be done to implement the study recommendations. This Preliminary Wayfinding Analysis is an early product of what could be a more robust wayfinding signage and city placemaking effort. The following key next steps have been identified as necessary actions for

- **Signage Design Project** - The City should convene local stakeholder groups, including the Design Committee of Charles Town Now and the C*Town Creative Council, for a signage design project to confirm a final style for the wayfinding sign types identified in this study.
- **Confirm Signage Locations**- Similarly, the City should work with local groups to confirm the best locations for signage using the previous section as a foundation for further analysis. The local group could include representatives from the Design Committee of Charles Town Now and other historic society organizations, specifically the City of Charles Town Historic Landmarks Commission. In addition to preferred signage locations, the local stakeholder group could be charged with drafting location content for the individual signs.
- **Coordinate with WVDOH** - Because a few of the proposed sign locations exist on state-owned roads, the City will need to coordinate with the WVDOH to confirm the parameters for the different types of signage in terms of style, materials, and approval process to ensure all signage is compliant with state regulations.
- **Signage Cost Estimates** - As part of a broader walkability study, the City will estimate the cost of proposed signage and identify potential sources of funding for the implementation of the final signage plan and the deployment of signs.



Source: Jefferson County Convention & Visitors Bureau

Prioritized Implementation Plan

Many barriers to pedestrian mobility were identified in previous sections, ranging from gaps in the existing sidewalk network to inadequate pavement conditions. Using information gathered from the completed sidewalk conditions assessment and initial sidewalk and trail connectivity plan, this section seeks to outline anticipated costs of sidewalk improvement and trail connection projects identified along selected priority corridors in downtown Charles Town. Additionally, a resources roadmap has been developed that identifies potential sources of funding to support City consideration of implementation actions. The final component of the ***City of Charles Town Walkability and Connectivity Study*** is an outline of recommended "Next Steps" for the City to consider as it continues to prioritize walkability and connectivity improvements in the downtown core.

Opinion of Probable Construction Cost Assumptions

In producing the Charles Town Walkability Opinion of Probable Construction Cost (OPCC), various assumptions were made to create the costs. The following items were assumed as part of the proposed improvements:

- Assume a 1' excavation depth wherever excavation is needed
- Sidewalk widening widths were averaged where there were varying existing sidewalk widths
- Proposed curb was assumed to be a combination concrete curb and gutter, with the total width of curb being 2.5'. For excavation purposes, total curb excavation width was assumed to be 3.5' to give a 1' wide buffer into the existing roadway.
- For the Route 115 Trail, assume warning signs at the major highway intersection, and new Bicycle Route Signs every quarter mile of roadway.
- For the Route 115 Trail, assume a 3' shoulder widening where needed, and 2' shoulder repair where needed.
- For Evitts Run Park and Augustine Trails, assume 10' wide trails.

Washington, George, and Charles Streets

The OPCC provides a range of cost for the typical section recommended for Washington and George Streets including both sidewalk and curb replacement. Since these streets typical sections recommend a "Road Diet" they will require the replacement of the curb along their entire length. The cost are shown in both a linear foot replacement cost and a total OPCC based on the entire study area being updated.

Other Charles Town Streets

The OPCC for Other Charles Town Streets is further broken sown to show the cost difference in replacing sidewalk only versus replacing sidewalk and curb. These OPCC again provide a range of cost for the recommended typical section. The cost are shown in both a linear foot replacement cost and a total OPCC based on the entire study area being updated.

ADA Compliance

In addition the OPCC provides a cost for the replacement of the ADA ramps within the study area that are not ADA compliant in a per ramp bases and the total study area bases to meet current ADA standards.

Grand Total OPCC

Two separate grand totals ranges are shown for the study area. The first assumes that all curb is replaced on the "Other Charlestown Streets" in the study area and the second assumes that no curb is replaced on the "Other Charlestown Streets" in the study area.

CHARLES TOWN WALKABILITY STUDY OPINION OF PROBABLE CONSTRUCTION COST							
CROSS SECTION (SEE TYPICAL SECTION SHEETS)	**TOTAL PER FOOT COST***			**SEGMENT LENGTH**	**TOTAL SEGMENT COST***		
SIDEWALK IMPROVEMENT SECTIONS							
EB Washington St 1 Sidewalk	$136	-	$163	1380	$187,578	-	$225,093
EB Washington St 1 Curb	$36	-	$44		$50,344	-	$60,413
EB Washington St 2 Sidewalk	$168	-	$202	1388	$233,390	-	$280,068
EB Washington St 2 Curb	$36	-	$44		$50,636	-	$60,764
George St Sidewalk	$104	-	$124	1680	$174,222	-	$209,067
George St Curb	$36	-	$44		$61,289	-	$73,547
Charles St Sidewalk	$104	-	$124	1120	$116,148	-	$139,378
Charles St Roadway and Curb	$134	-	$161		$150,018	-	$180,021
Other Charles Town Streets Sidewalk	$62	-	$74	26476	$1,641,512	-	$1,969,814
Other Charles Town Streets Curb	$36	-	$44		$947,605	-	$1,164,944
ADA RAMPS							
All Intersections (85 ramps)	N/A			N/A	$102,000	-	$122,400
TRAIL PROJECTS							
Evitts Run Park Trail	N/A			N/A	$440,000	-	$528,000
Augustine Trail	$118	-	$142	10032	$1,187,500	-	$1,425,000
Southern Neighborhood Connnector Trail	$34	-	$41	6864	$233,440	-	$280,128
				GRAND TOTAL =	**$5,425,665**	**-**	**$6,538,615**

* Cost ranges for each item are the base cost to base cost plus 20% contingency

Next Steps

The probable construction cost assumptions outlined in the previous section, totaling between $5.425 million and $6.538 million, are large for a community of Charles Town's size and budgetary capacity. Implementing these improvements will require careful long-term capital planning, policy determinations on what is expected of private landowners and developers, proactive efforts to secure grant funding, and a willingness to finance these capital projects through bonding that is backed by municipal taxes or fees. Charles Town can begin to address the funding goals for these priority walkability projects using the following suggested approach and key next steps:

1. Rank and Confirm Priorities: Charles Town's elected leaders and staff management should review the priority sidewalk improvement, ADA compliance, and trail connection projects in this report, giving them priority ranking for funding and implementation.

2. Capital Planning and Budgeting: The planning, engineering, design and construction costs for the sidewalk, trail connectivity and wayfinding initiatives will require the City of Charles Town to undergo a robust capital planning and budgeting process to identify and program the revenue resources required the achieve these multi-year improvements. This will enable to the City to identify the appropriate phasing strategy that is often necessary to meet desired capital improvement goals of the City.

3. Engage the Public and Property Owners: The City should to take specific steps to build public understanding and support for its walkability initiatives, because such backing will boost the success of longer-term capital planning. Further, as mentioned earlier in this report, Charles Town should engage property owners abutting priority sidewalk improvement areas about the approach the City will use to require improvements by those landowners. Public engagement can involve the straightforward methods of making this report available on the City's web site and through any future citizen internet notice systems established by the city; summarizing this report in a simple 2-page flier that can be distributed city-wide; reaching out directly to specific property owners; holding one or more public workshops; and working with the local newspapers to explain the Charles Town walkability initiative.

4. Policy Approach on Sidewalk Responsibilities of Private Property Owners: As discussed in detail earlier in this report, the City has a standing legal approach that makes abutting property owners responsible for sidewalk improvements. The City should determine whether and how it wishes to exercise this policy with respect to priority sidewalk improvement areas now, including whether the City wishes to set up a “Sidewalk Team Encouragement Program" (STEP) incentive program to provide support and lower costs to property owners who step forward to undertake improvements.

The City may also wish to take action now to consider ordinance or policy changes that would allow the City’s Planning Commission to require any development of land in areas that are planned for trails, to contribute to the construction of such a trail at the time of development (for instance, on Old Route 340).

5. Connect with WVDOH: Ultimately, the WVDOH will need to be involved in Charles Town’s sidewalk and trail projects, whether from a planning and permitting perspective, and/or from a grant funding role. Once Charles Town has confirmed its sidewalk and trail connection priorities, it would be valuable for City leadership to seek meetings with the District 5 Engineer, the Planning team in the WVDOH headquarters, the designated Bike-Ped Program coordinator at WVDOH, and WV Department of Highway senior leadership. These meetings can help gain DOH’s support for these projects, identify key planning and permitting issues, and set up these projects to be more competitive for funding applications. One key reason for this DOH coordination is to ensure that the roundabout planned for the intersection of Route 115 and Citizens Way can be designed and constructed by DOH in a manner that supports an eventual walkability connection between the Southern neighborhoods and the core community.

6. Coordinate with Hagerstown-Eastern Panhandle Metropolitan Planning Organization (HEPMPO): HEPMPO is the local/regional planning unit responsible for identifying and planning transportation priorities for this region, and a key ally and potential conduit for grant funding. Charles Town should coordinate with HEPMPO leadership and its Interstate Council and Technical Advisory Committee decision-making bodies, to ensure that these priority Walkability projects are included in HEPMPO’s Transportation Improvement Plan (TIP), which establishes priority transportation projects that will be pursued over the succeeding four-year period. Charles Town can also seek HEPMPO technical assistance, potential planning funding, and other support for pursuing your priority projects.

7. Conduct Planning / Engineering Projects: The trail connectivity and wayfinding signage projects will require additional planning, design, engineering, possible permitting, and construction bid documentation work before the projects are "shovel ready" and before they are highly competitive for grant funding. Charles Town should identify the costs for such pre-construction planning and make such consulting work a priority for project implementation.

8. Consider Role of Public Work Crews: Charles Town should consider City's Public Works Department's certain capabilities to provide demolition and construction management of sidewalk improvements.

9. Consider Establishment of Municipal Service Fee & Other Capital Revenue Strategies: The cost of these Charles Town Walkability projects cannot be handled with grant funding alone, particularly as the federal transportation funding system was drastically changed in 2011-2012 in ways that has substantially reduced funding to local government projects. Even with success in grant funding, Charles Town will need to produce significant matches for such grants. Thus, to accomplish these projects, the City of Charles Town will need to consider a tax levy dedicated to key walkability projects, or a municipal service fee that charges households a monthly charge on the property or water bill to cover capital costs or to service the municipal bonds supporting those costs. For instance, Charles Town could add to its existing service fee that covers road maintenance and paving, to add funding for sidewalk/trail maintenance and construction. To move forward on consideration of such an approach, Charles Town should clearly identify project costs that will not be covered by private property owners (#2 above), identify what portion of these costs can be handled through normal capital planning using existing revenue streams, and thus identify the gap in funding needed to conduct these projects. City officials could consider covering such gap with a municipal service fee or municipal tax levy.

10. Grant Funding: It is always worthwhile to identify and pursue any state or federal grant funding that could be used to supplement local funding and lower the local costs of a project. After a drastic reduction in these kinds of transportation grants to locals in the 2012 and 2015 federal transportation authorization statues, and with the demise of the congressional earmarking system in 2011, there are few opportunities left for such transportation grant funding. Note that the likely incoming 2017-2020 U.S. President has indicated that one of her highest priorities will be to create major investments in infrastructure, including infrastructure, which may provide new opportunities.

It is also unlikely that Charles Town would be competitive for grant funding for normal sidewalk maintenance and replacement projects, even if they are high priorities, unless they are on central roadways that have commercial, tourism, or other substantial public benefits. For example, "gateway" sidewalk projects on Washington Street and MLK Boulevard may be fundable with grants, but sidewalk replacements off the main corridor into the neighborhoods, likely would not be.

Major trail connections and community wayfinding signage projects are the kinds of projects that can attract grant funding, and thus the Evitts Run Creek / Happy Retreat pathways, the Augustine Trail, and the Southern Connector are the kinds of projects that can be packaged for grant applications and advocacy.

Following are some of the grants that Charles Town could pursue for trail, wayfinding, and gateway sidewalk projects:

Agency	**West Virginia Department of Transportation**
Grant Program	**Transportation Alternatives Program (TAP)**
Description	• TAP projects focused on creating safe, accessible, attractive, and environmentally-sensitive communities where people want to live, work, and recreate. • Eligible TAP activities include: • **Pedestrian and Bicycle Facilities** including funding for the planning, design and construction of new or reconstructed sidewalks, walkways, curb ramps, bike-lane striping, pedestrian and biking signals, traffic calming techniques, lighting and other safety-related infrastructure, wide paved shoulders, bike parking, bus racks, off-road trails, bike and pedestrian bridges, and underpasses. • **Safe Routes to Schools** projects including off- and on-street bicycle and pedestrian facilities, pedestrian and bicycle improvements, sidewalk improvements, and traffic calming improvements which directly support increased safety and convenience for elementary and middle school children in grades K-8 to bicycle and/or walk to school. Projects may indirectly benefit high school age youth or the general public, however these constituencies cannot be the sole or primary beneficiaries. This category would support the Augustine Trail project, as it would serve Page-Jackson Elementary and Washington High Schools. • **The Stormwater Mitigation** category provides funding to address stormwater management control and water pollution prevention or abatement related to highway construction or due to highway runoff, including activities for runoff pollution studies, soil erosion controls, detention and sediment basins, and river cleanups. See more at: www.transportation.wv.gov/highways/programplanning/planning/grant_administration/transportationalternativesprogram/Pages/default.aspx and www.fhwa.dot.gov/map21/guidance/guidetap.cfm
Timing	Call for applications expected to open in the first quarter of 2017.
Amount	Up to $500,000, but with the most competitive applications under $200,000
Match	At least 20% of total project cost

Agency	**W.V. Division of Highways**
Grant Program	**Surface Transportation Projects (STP) and State Discretionary Funds**
Description	• The WV Division of Highways annually receives Federal Highway Administration pass-through funding which, together with funding authorized by the West Virginia legislature, can be provided to support local projects. WV DOT tends to hold these funds for its own projects, or for local projects with high political backing, which means that Charles Town will need to work closely with both WV DOH and its legislative delegation to boost the support for your walkability projects and their chances of obtaining these funds. These funds can include the State's annual allocations of federal Surface Transportation Project funding.
Timing	Rolling
Amount	Depends on project, and ability to secure DOH support
Match	Typically 20%

Agency	**U.S. Department of Transportation**
Grant Program	**Transportation Invest Generating Economic Recovery (TIGER) Discretionary Grants Program**
Description	• Provides capital investments in surface transportation infrastructure, including for trail connectivity projects • Highly competitive, requiring highly compelling project and strong political backing to be successful • Successful TIGER projects leverage resources, encourage partnership catalyze investment and growth, and fill a critical void in the transportation system • Potential that Evitts Run Trail, Augustine Avenue Streetscape, and Augustine Trail combined into one project could be competitive • Will need to be "shovel-ready" with at least near-complete project design, engineering and permitting completed See more at: https://www.transportation.gov/tiger
Timing	Expected announcement for TIGER each Spring
Amount	$1 million- $20 million, with average grants for smaller communities ~$5 million
Match	Between 30-50% to be competitive

Agency	**West Virginia Department of Commerce**
Grant Program	**Land & Water Conservation Fund (LWCF)**
Description	•As Charles Town knows from successfully securing these funds in past years, the WV Department of Commerce provides annual LWCF grants to local governments and municipal parks & recreational authorities for a wide range of planning and construction projects for publicly-accessible parks and recreational facilities. These can include public recreational trails. The trail component of the Evitts Run Park project t could utilize LWCF grant resources. •Projects must be listed in, or compatible with, the WV Statewide Comprehensive Outdoor Recreation Plan (SCORP) See more at: www.wvcommerce.org/people/communityresources/infrastructure/landandwater-conservationfund/default.aspx
Timing	Typically requires a letter of intent in January and an application in March each year.
Amount	Up to $250,000, with typical grant awards averaging ~$75,000
Match	50/50 reimbursable grant

Agency	**National Recreation & Parks Association (NRPA)**
Grant Program	**Great Urban Parks Initiative**
Description	• In 2016 NRPA launched a “Great Urban Parks Campaign”, and gave grants to three winners in the nation, in a partnership with the American Planning Association and the Low Impact Development Center. If NRPA conducts the project again, Charles Town should re-apply for Evitts Run Park, including the trail component. Charles Town applied in 2016 but was not selected; the City can and should obtain a debrief from NRPA to determine how it can become more competitive for the next round of funding. • Provides funding for projects that provide outstanding urban park and recreation construction which have a green infrastructure component to reduce stormwater pollution, particularly projects in distressed minority neighborhoods. See more at: www.nrpa.org/greeninfrastructure/
Timing	Spring 2017
Amount	Up to $550,000
Match	No match required, but leverage important

11. Effective Grants Advocacy: Charles Town should consider using certain effective tactics for boosting your grants advocacy:

a.) Create project briefing sheets: It is valuable to put together a compelling briefing sheet that can be used to succinctly convey to the public, key stakeholders, and funders the scope, objectives, benefits, status, progress, supporters, funding secured, challenges, and outstanding needs of the walkability project. When drafting a project briefing sheet, keep in mind the following tips:

- Keep it short: no more than two pages (one sheet, front and back).
- Liven up the sheet with graphics or pictures, and the organization/sponsor logo. Remember the adage that "a picture is worth a thousand words" . . . and maybe a million dollars. Consider creating an artist's rendering of the project.
- Include specific funding requests or opportunities currently being sought.
- Include the lead point of contact for inquiries about the project.
- Continuously update the briefing sheet as goals are achieved, funding secured, new partnerships are formed, or as project objectives change.

Distribute and email these briefing sheets widely and often. The briefing sheets can help create a buzz about the project and build support for funding efforts. They are much more effective business cards alone. It is surprising how the briefing sheets can circulate and give a boost to a project

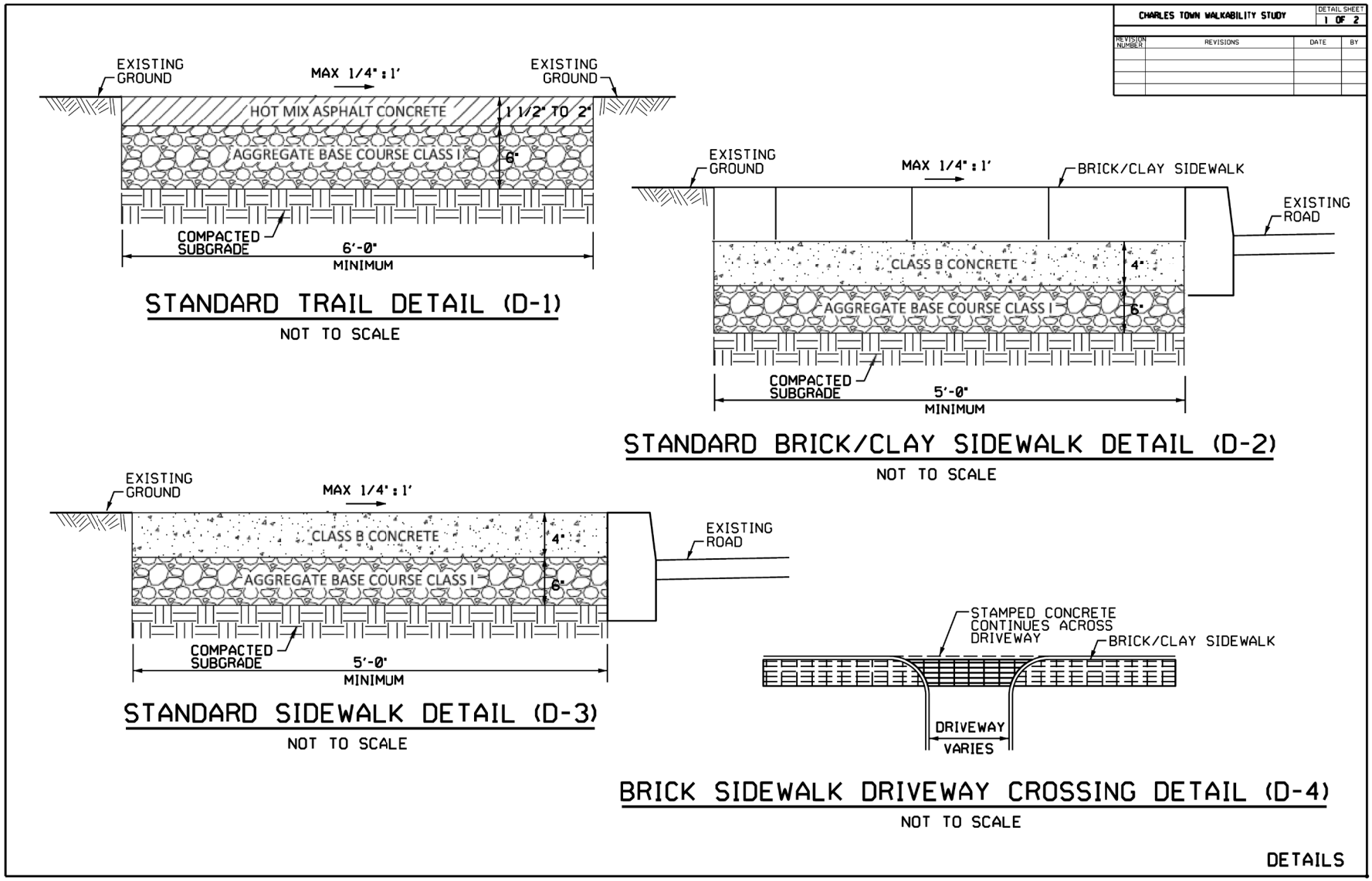
b.) Visit Agency Program Managers & Senior Officials: It is important to build understanding and support among both the program managers and senior leadership of key agencies which, in the case of these walkability projects, would be the WVDOH, the West Virginia office of the Federal Highway Administration, and the West Virginia Department of Commerce. Plan visits to their Charleston offices, and invite these officials to tour your community projects in Charles Town

c.) Collaborate with Elected Leaders: It is likewise important to brief Charles Town's state and federal elected representatives early in the planning process for these walkability projects, invite them to tour your projects and reviews planning materials, to seek their help when grants are submitted, and to make them part of groundbreakings and ribbon cutting events for these projects.

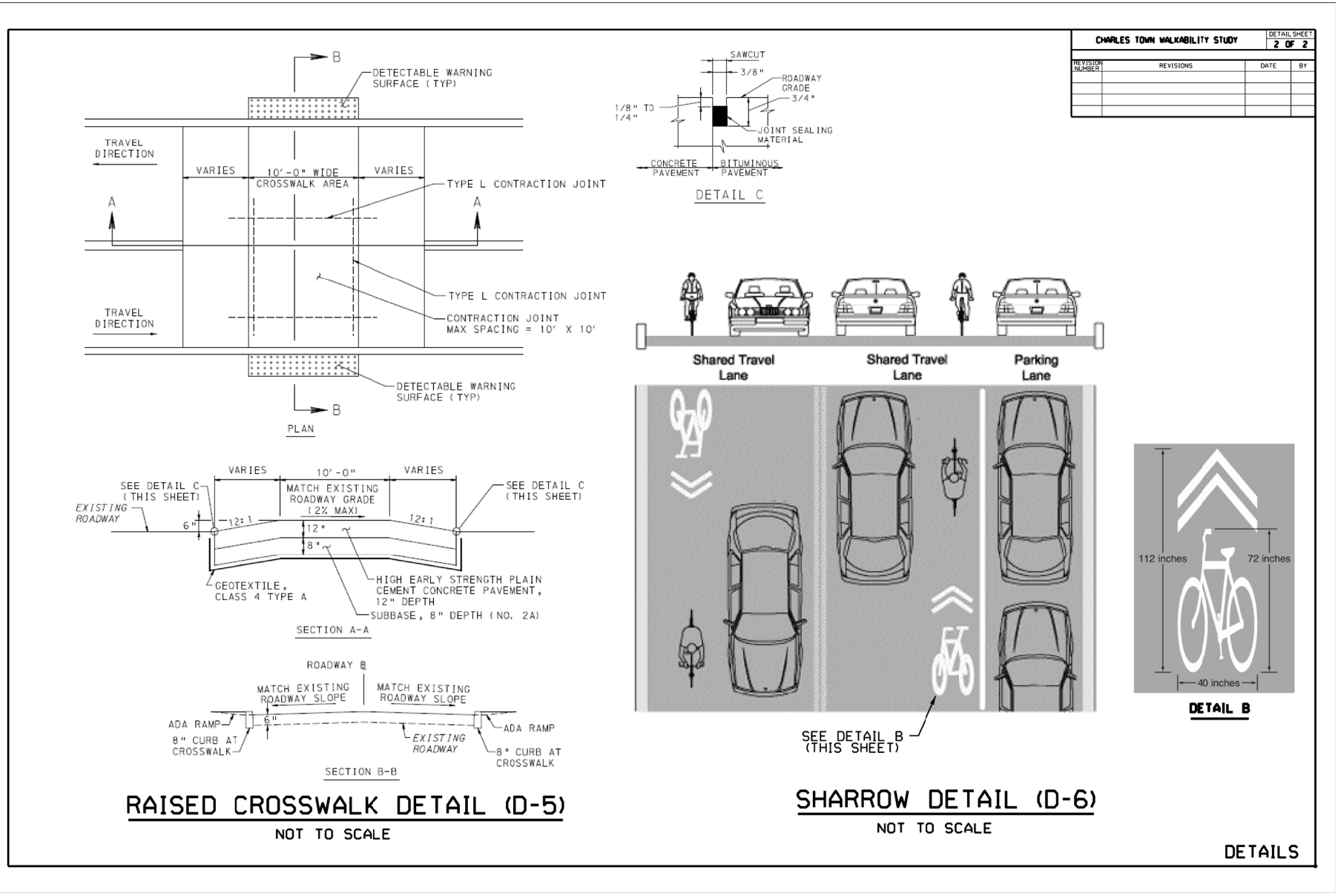
12. Renew Priorities Periodically: Over time, other priority projects will emerge – and other areas of existing sidewalks will deteriorate in condition. Make sure that Charles Town reviews and renews this Walkability & Connectivity study every five years or so, to ensure that the City stays on top of these challenges and opportunities for enhancing community walkability.

Appendix A -Proposed Template for Sidewalk and ADA Ramp Design

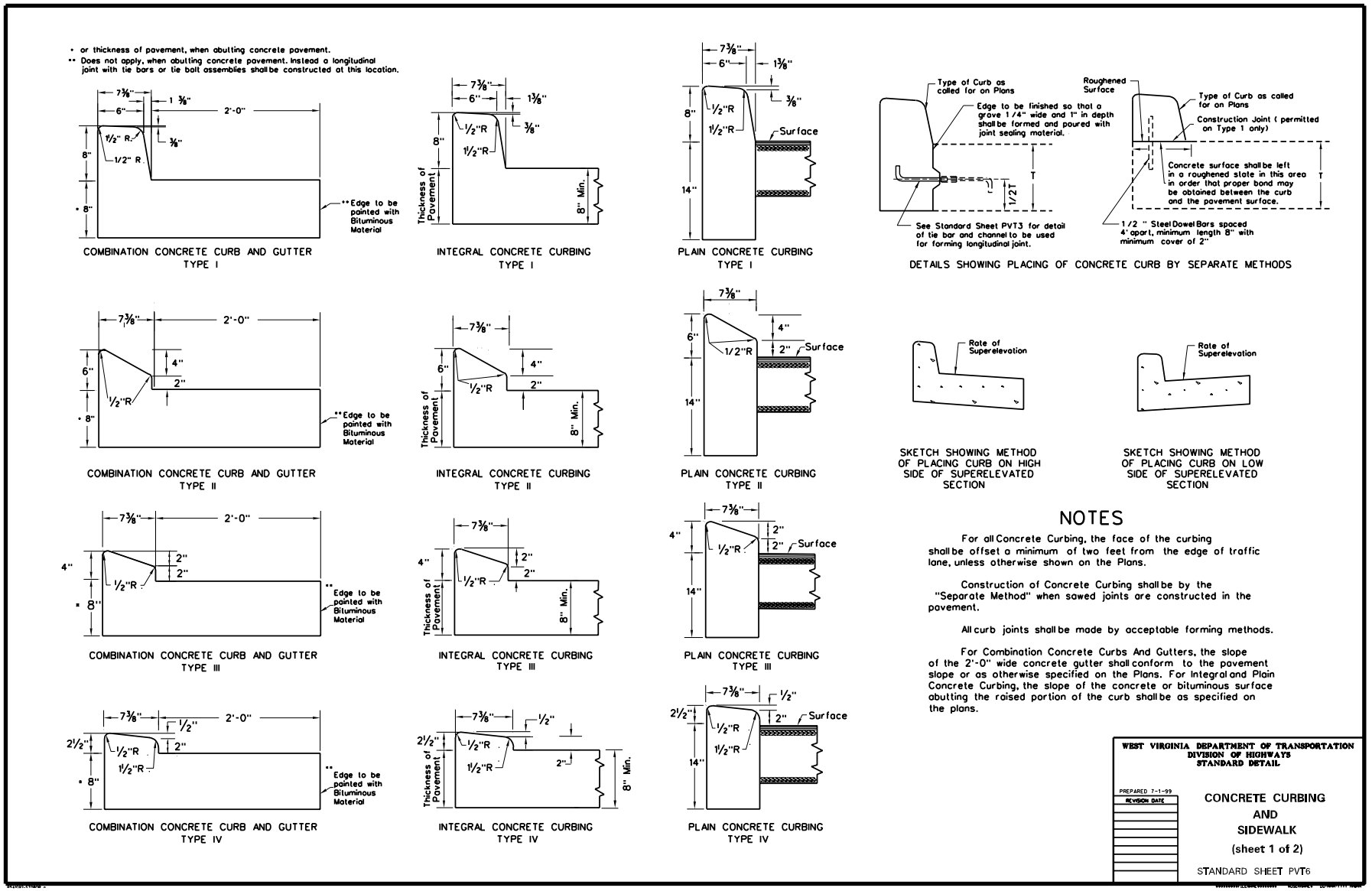
Standard Details



Standard Details



WV DOH Standard Details



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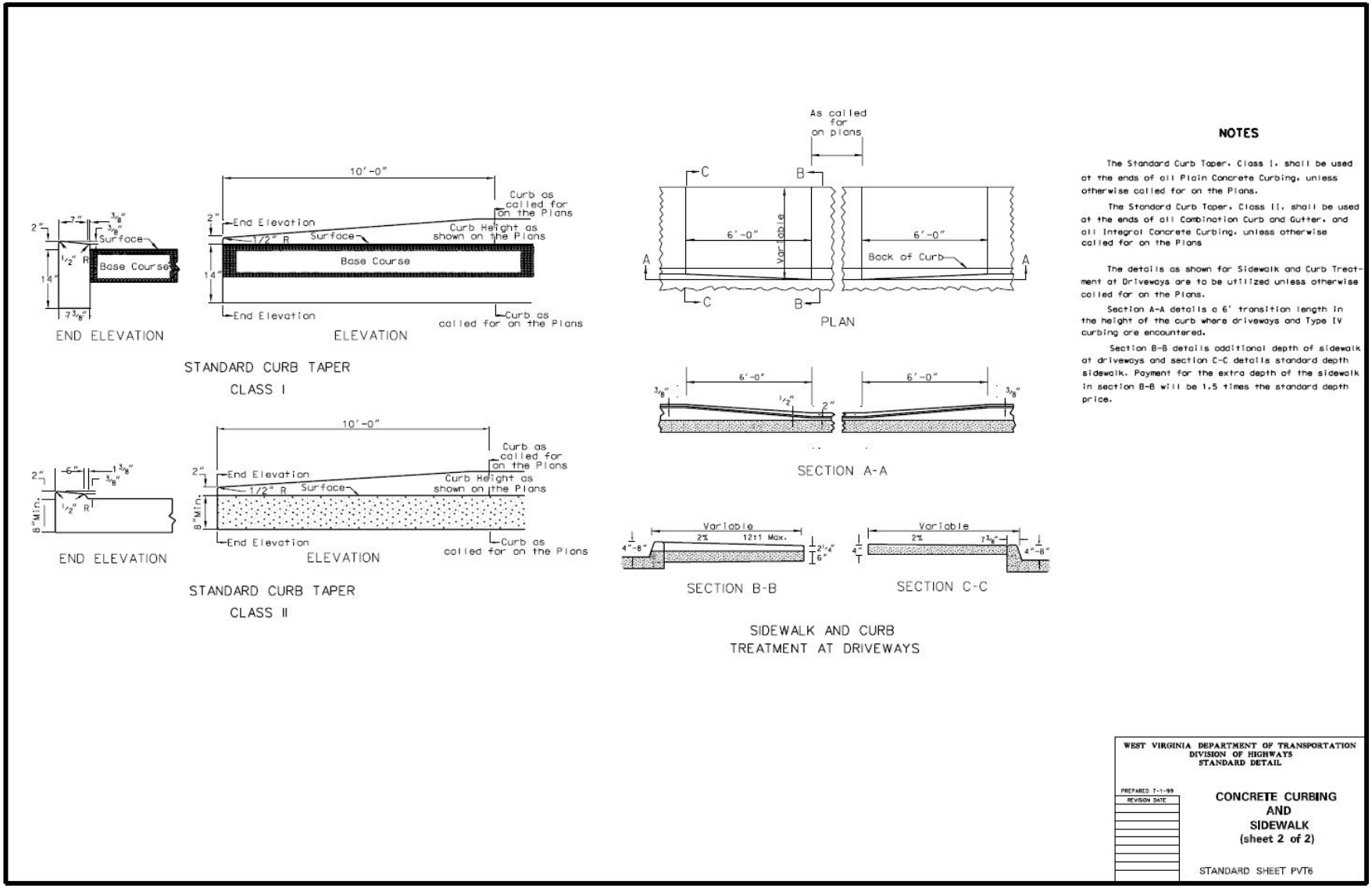

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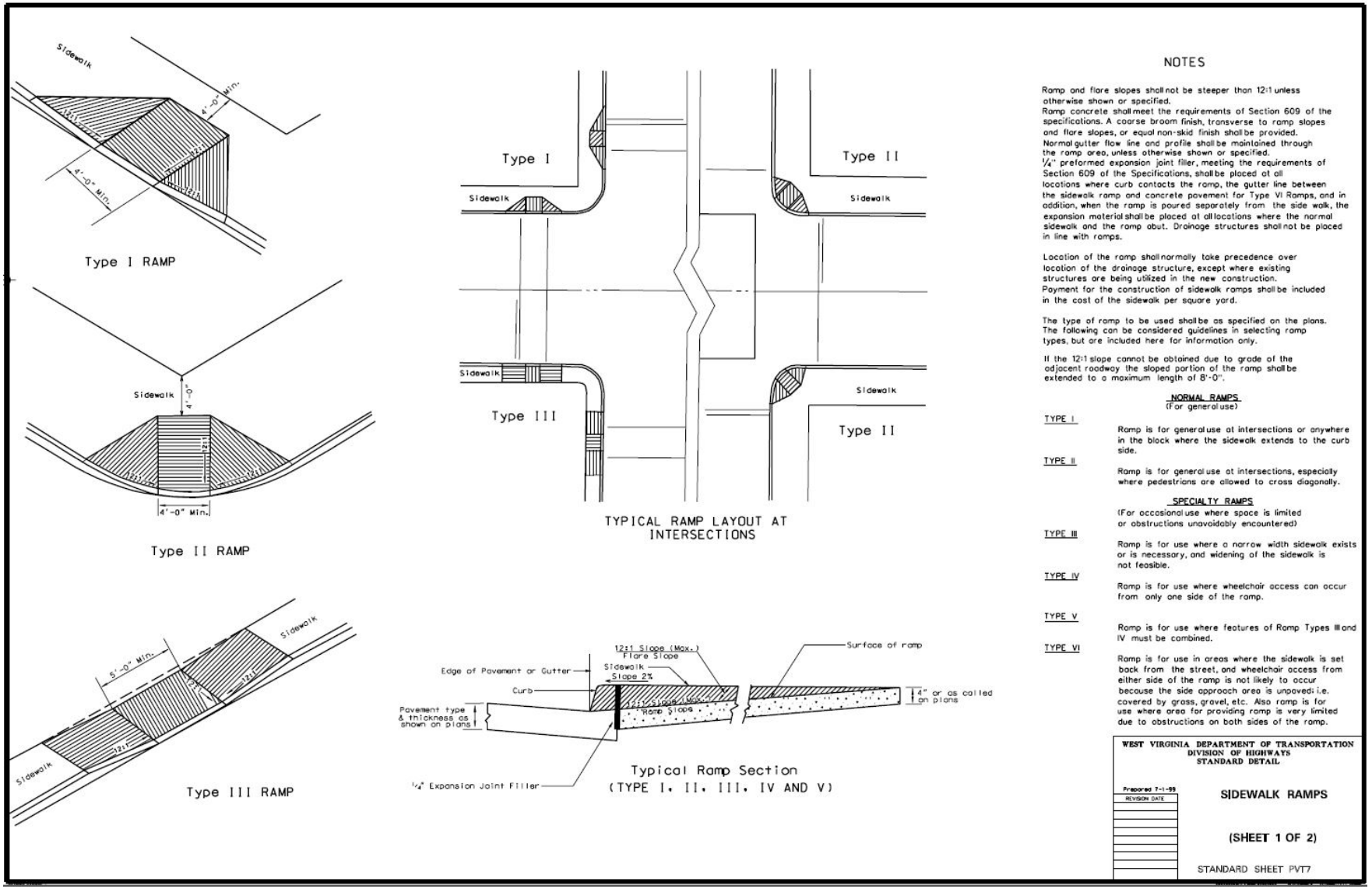

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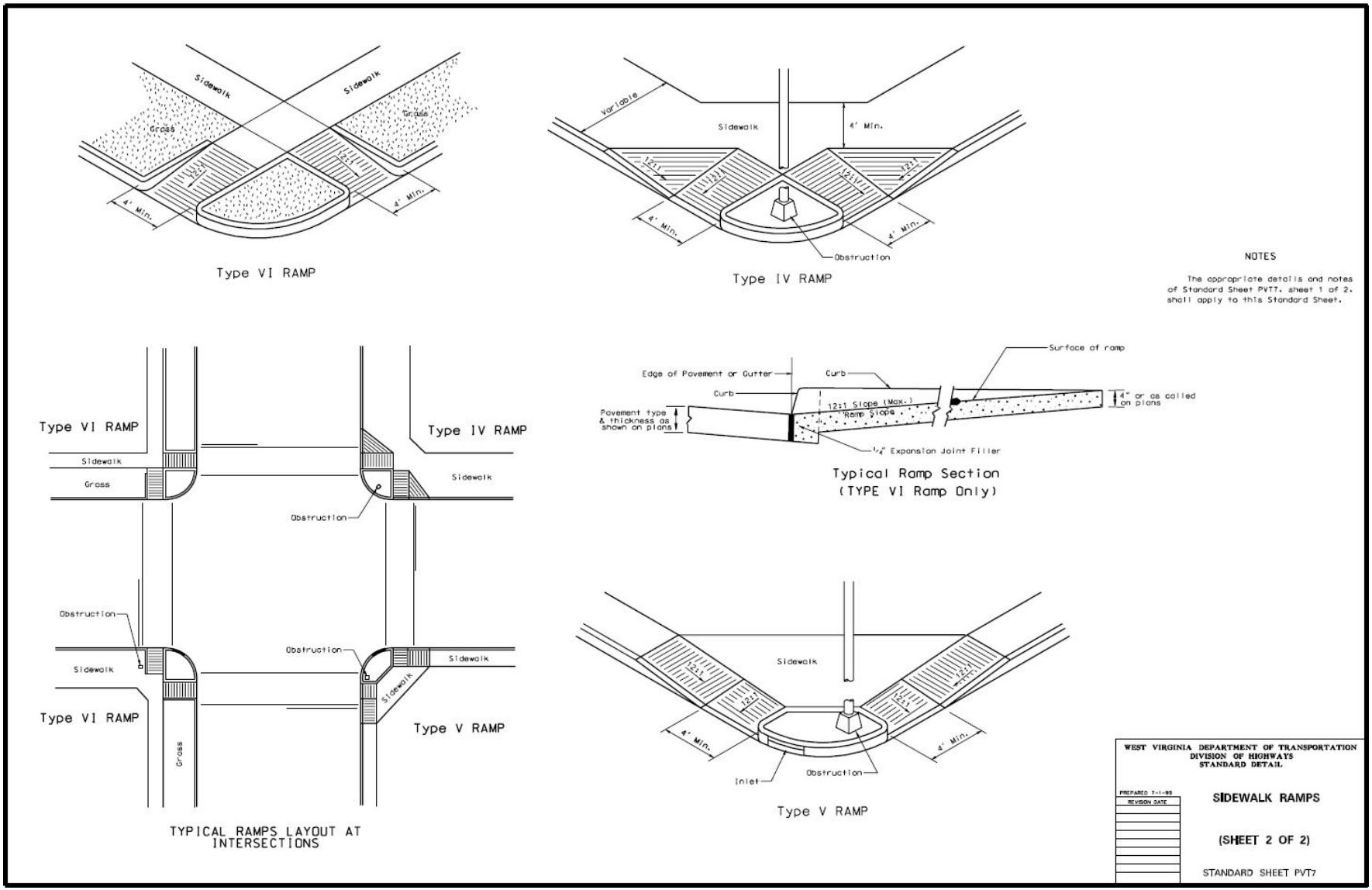
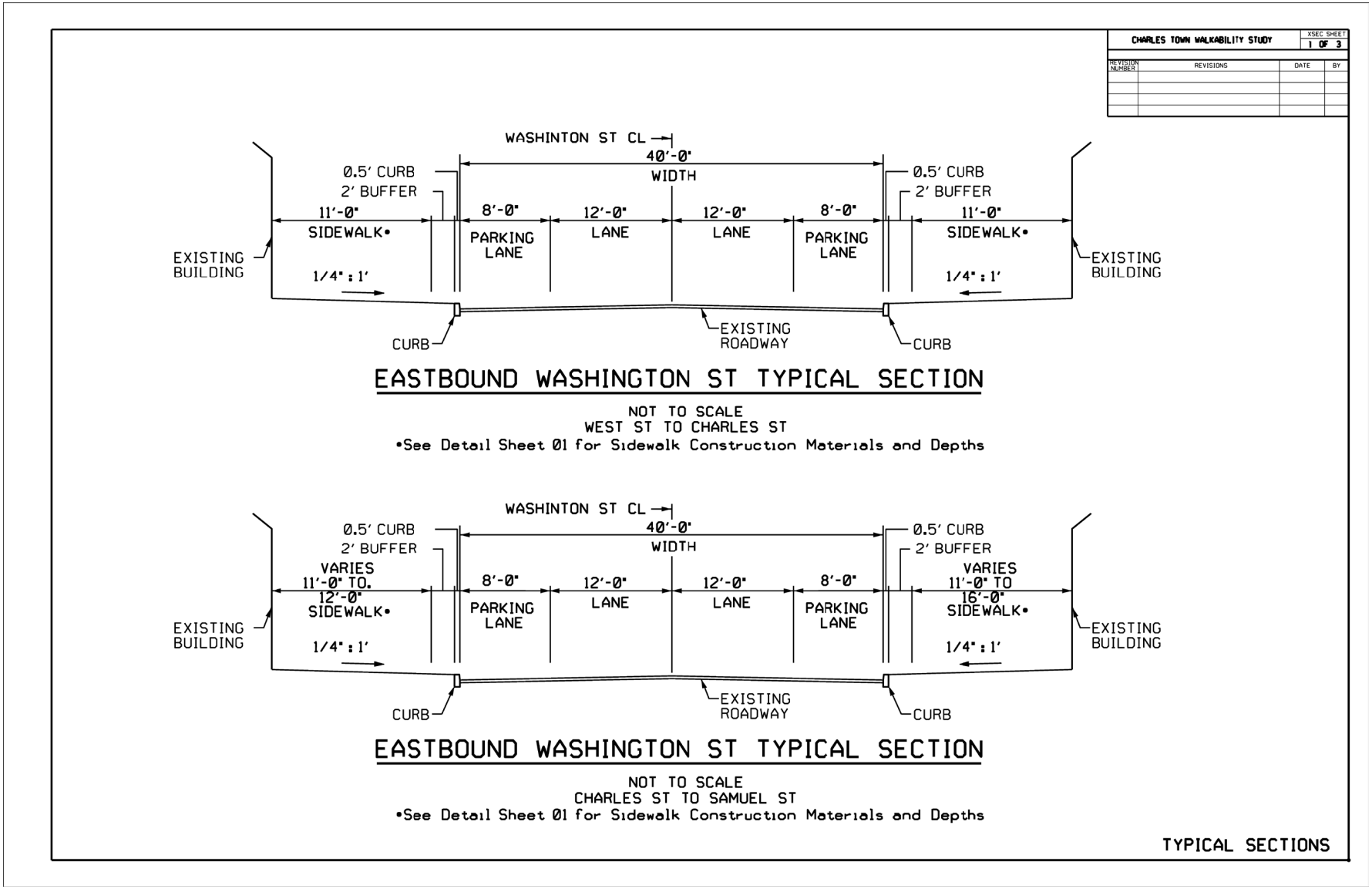
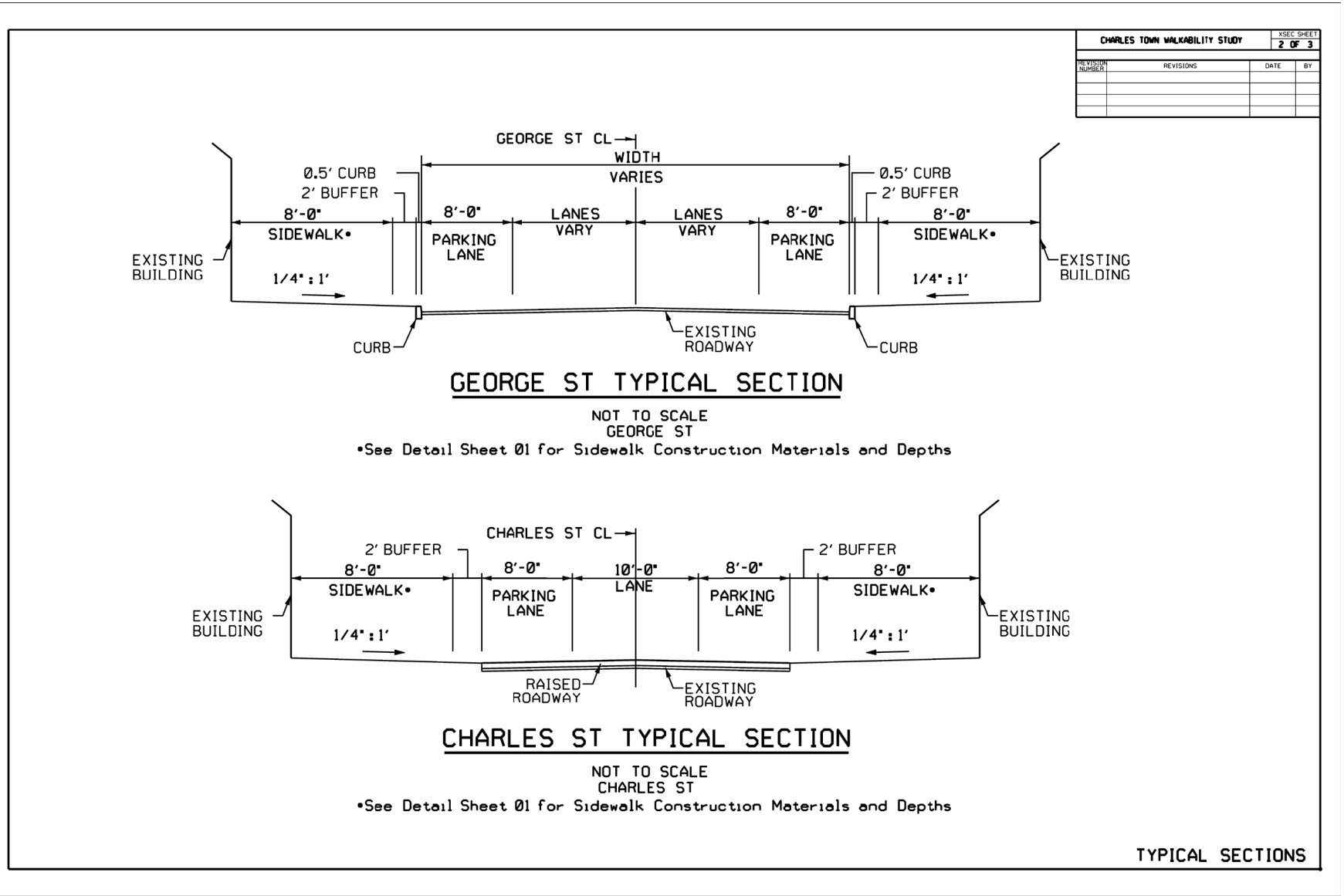


Appendix B -Street & Sidewalk Design Templates for Washington, George and N. Charles Streets

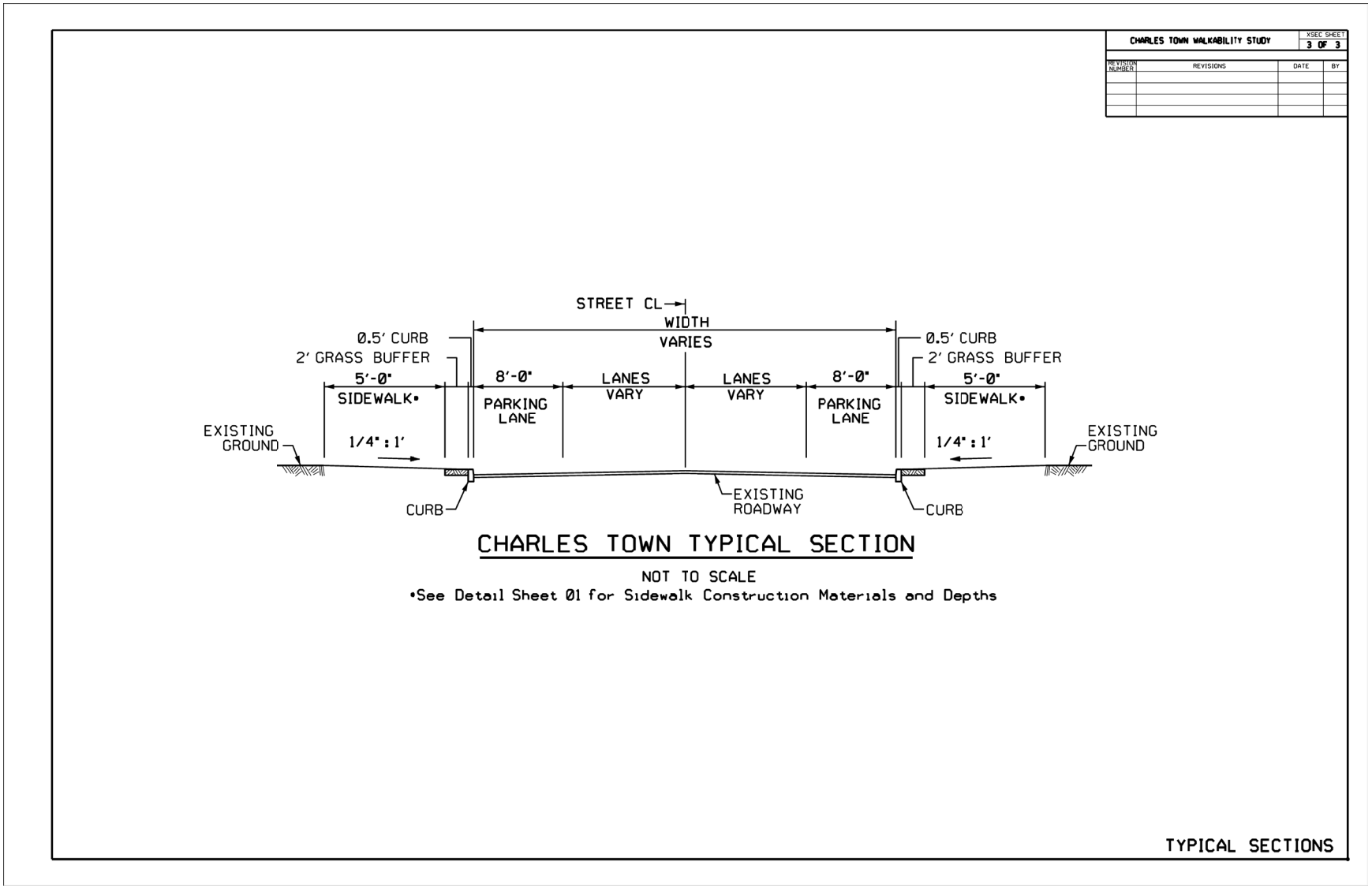
Typical Roadway Sections



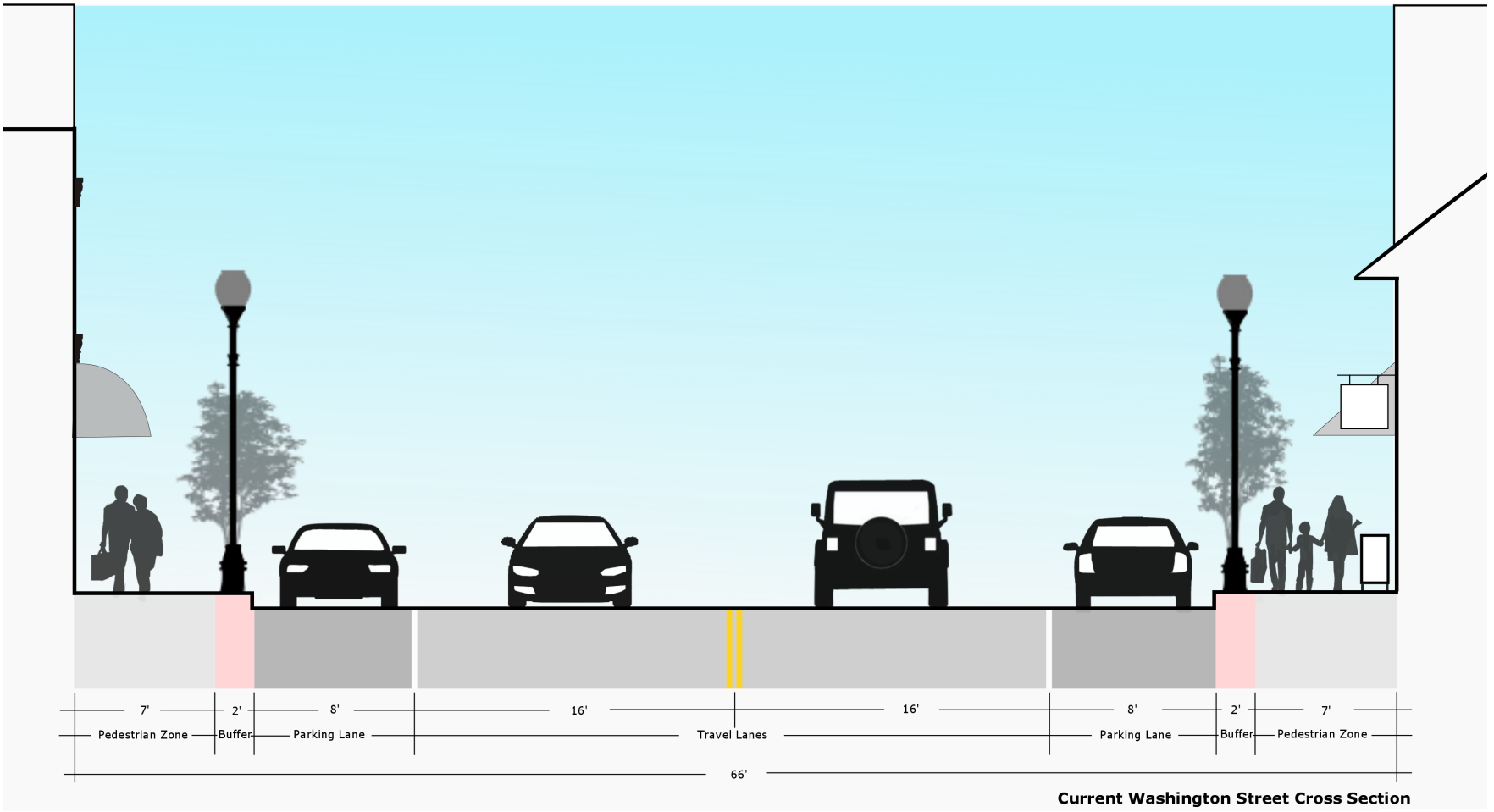
Typical Roadway Sections



Typical Roadway Sections

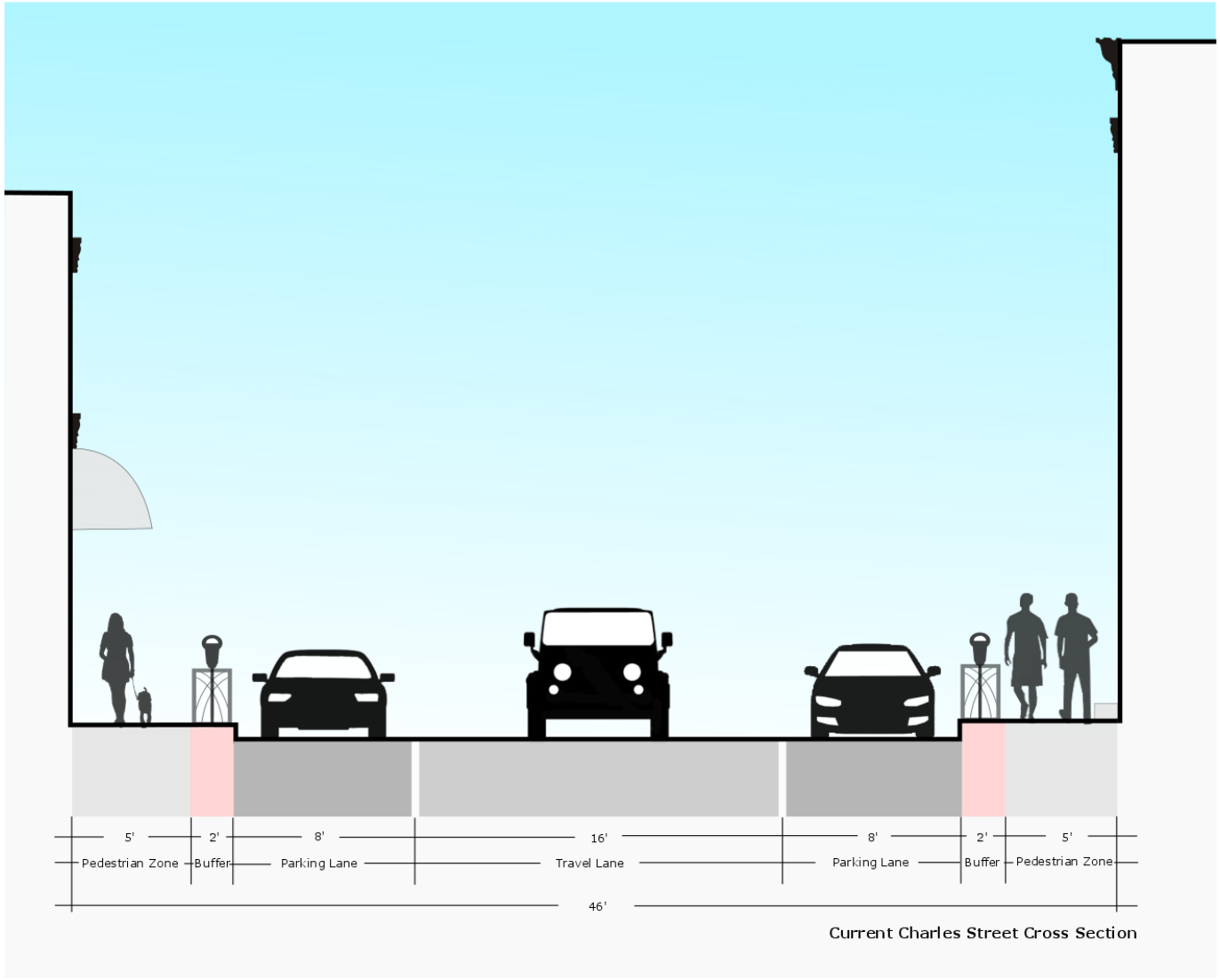


Current Cross Section



Current Washington Street Cross Section

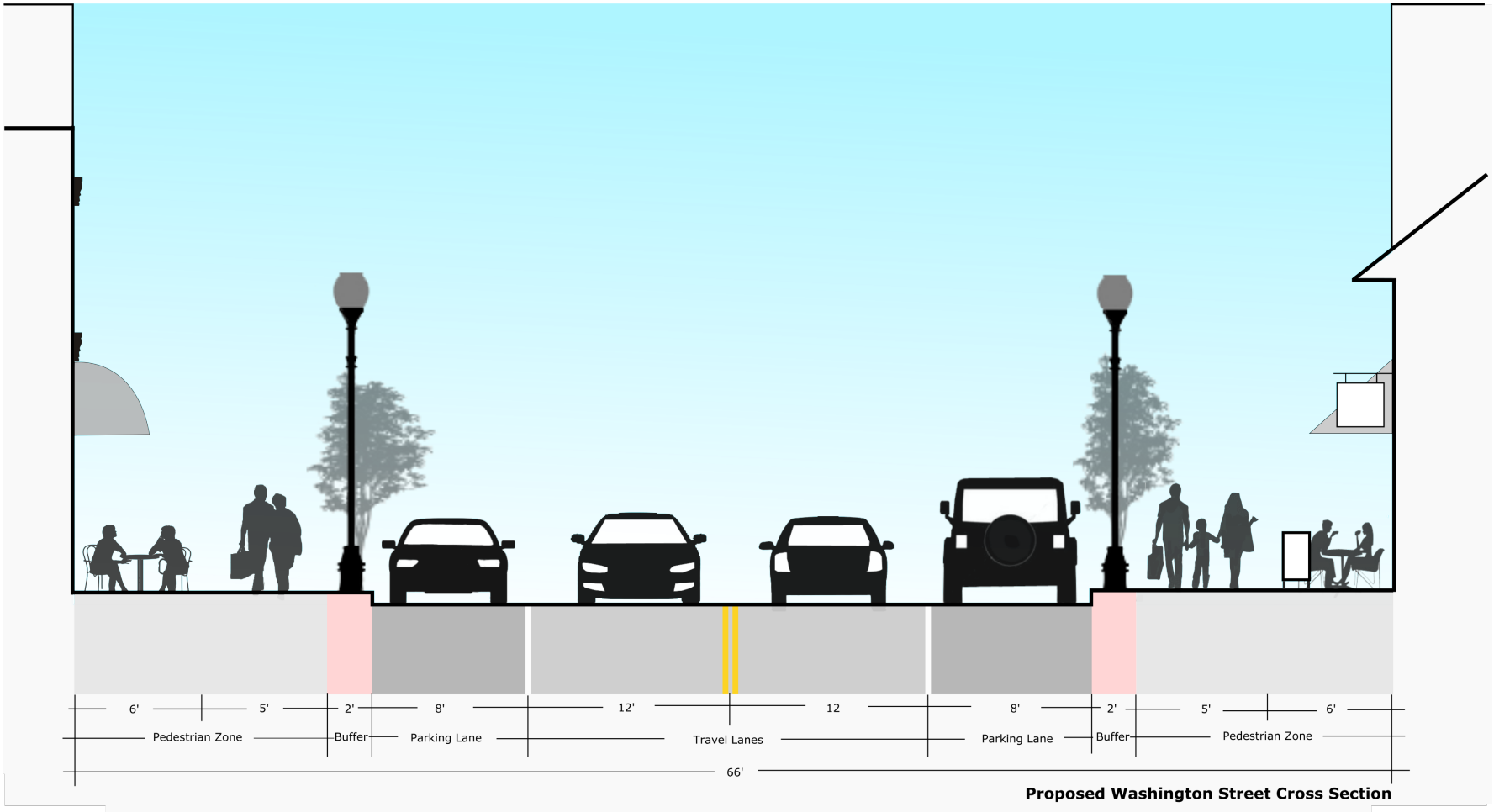
Current Cross Section



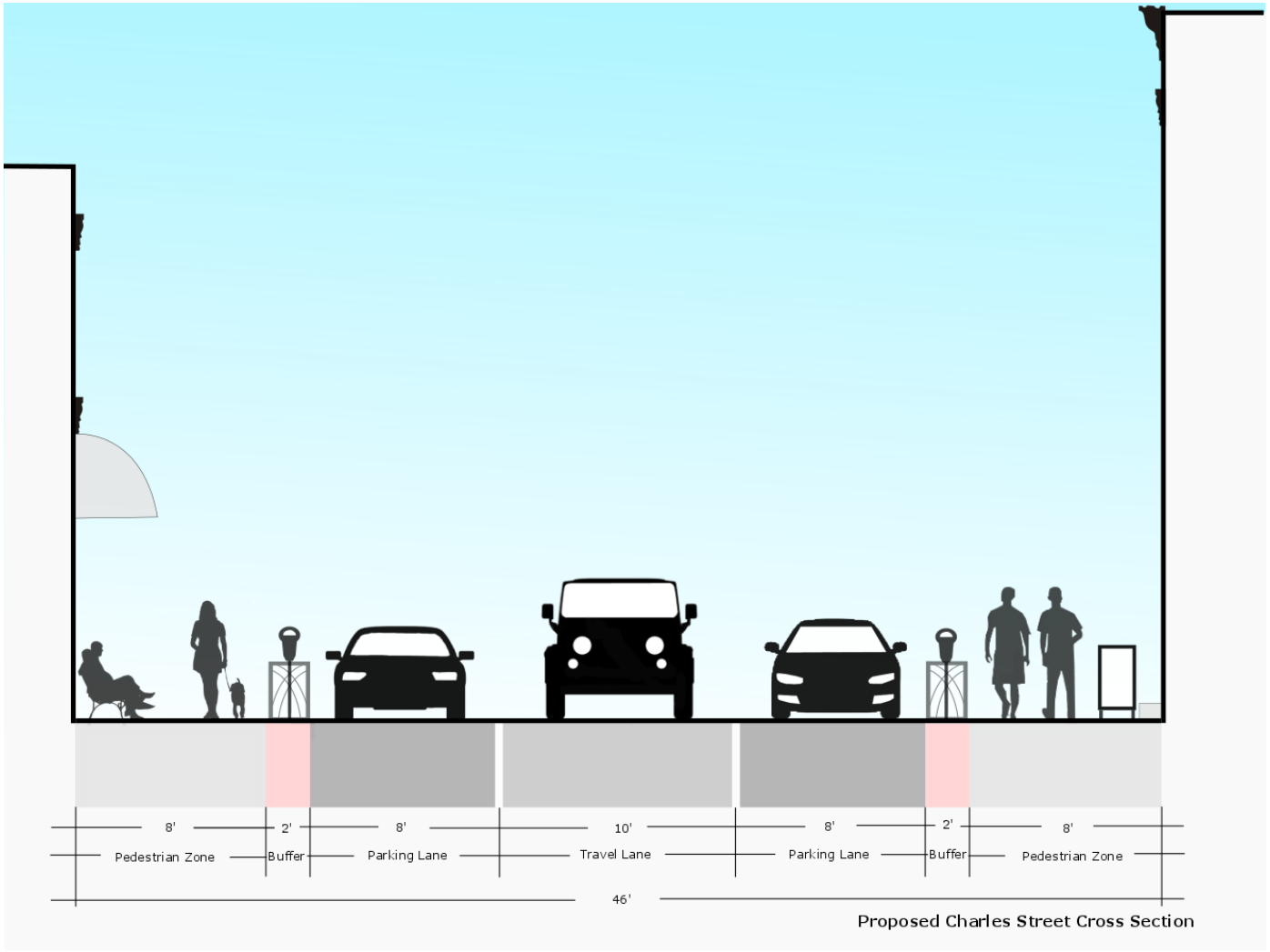
Current Charles Street Cross Section

Appendix C - Street & Sidwalk Cross Sections for Washington and Charles Streets, Showing Wider Sidwalks

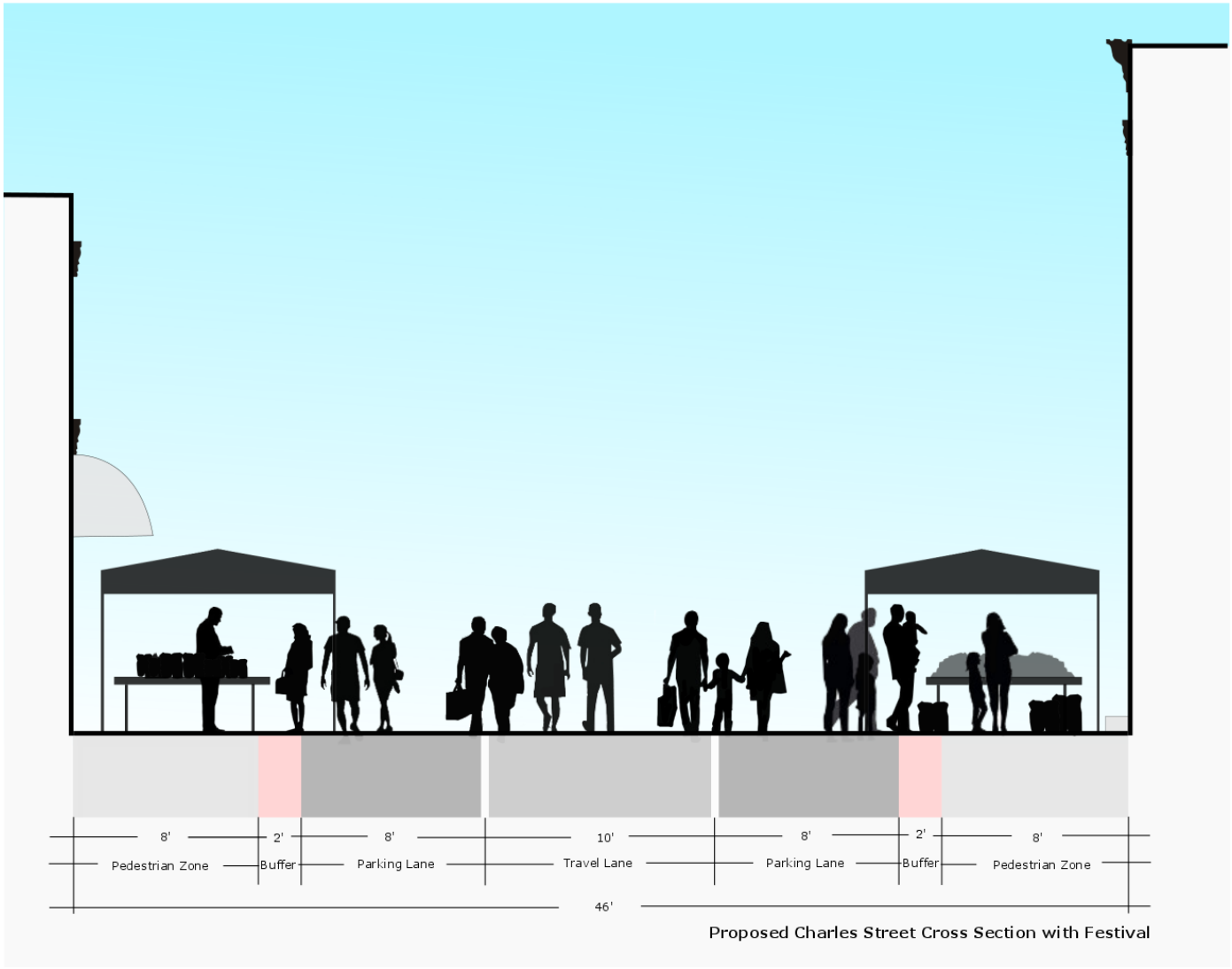
Proposed Cross Section



Proposed Cross Section



Proposed Cross Section



Proposed Charles Street Cross Section with Festival

Appendix D - Renderings of Washington and Charles Streets, Showing Wider Sidwalks

Washington Street



North Charles Street



North Charles Street



CITY OF CHARLES TOWN
WALKABILITY IMPROVEMENT PROGRAM







City of Charles Town
101 East Washington Street
Charles Town, WV 25414

Phone: 304-724-3248
Website: www.charlestownwv.us

Investing in the Future of Charles Town

Charles Town's Walkability Improvement Program was designed as an effort to improve and enhance the overall pedestrian experience in Charles Town. The program is intended to assist applicants in improving the quality of the sidewalks along their property. Improved sidewalks provide safe, accessible streets for all residents, and promote walkability. These benefits contribute to the goals within the comprehensive plan to improve pedestrian experience and quality of life. Approved applicants in this program are eligible to receive financial assistance of **50/50 matching funds** for sidewalk repairs or installation, of up to $5,000.00. The program is managed by the City Staff. The program components may be amended periodically to accommodate new or modified City policies and procedures.

Policy for Two Bids:

1. **Two Bids** will be required for any application submission.
2. If the work is to be completed by the property owner, verification of expenses by a bid or a website such as homewyse.com will be required.

Policy for Walkability Improvement Program Expiration Date:

1. After an award of a Walkability Improvement Program Grant, the awardee will have one year from the time of the award to complete the improvements.

PROGRAM ELIGIBILITY

All sidewalks in the City of Charles Town are eligible in the program. Highest priority to properties with gaps. Sidewalks that are in poorest condition will be given higher priority. Existing buildings without sidewalks are also eligible. The following matrix which is from the Charles Town Walkability and Connectivity Study will be used to identify sidewalks that need the most improvement.

For an application in which the sidewalks are not identified in the Walkability and Connectivity study, the evaluation of the application will be by the same standards by which the Walkability and Connectivity study was created.

Priority	Wide Assessment	Condition Assessment
1	Poor	Poor
2	Fair	Poor
3	Poor	Fair
4	Good	Poor
5	Poor	Good
6	Fair	Fair
7	Good	Fair
8	Fair	Good
9	Good	Good

CITY OF CHARLES TOWN
WALKABILITY IMPROVEMENT PROGRAM

ELIGIBLE PROJECTS

The only permissible material approved for the Walkability Improvement Program is concrete or brick. Brick is only permitted where there are existing brick sidewalks. Existing buildings with no sidewalk are eligible for the grant as well.

INELIGIBLE PROJECTS

New construction projects, government properties, and national franchise properties are not eligible to participate in the Walkability Improvement Program. Private walks extending from the street curb to the main sidewalk and private service walks extending from the main sidewalks to the home or business are the sole responsibility of the owner.

Ineligible projects may be considered for approval at the discretion of City Council at their first meeting in June, provided no eligible project applications have been received by close of business on the first working day of June.

SIDEWALK WIDTH

All sidewalks shall be a minimum of 5 feet wide, unless constraints on the property do not permit this width. Most sidewalks in the City are not 5 feet wide. This program will require those sidewalks to be widened. It is known that there are a few limited locations in the City, that this cannot be achieved. City staff will examine each request and make a determination regarding the ability to install the 5-foot-wide sidewalk.

SURVEY

Where sidewalks do not exist, a survey will be required to ensure that sidewalks are located along the edge of the right-of-way. Survey will be an eligible reimbursement.

APPLICATION PROCESS

Each applicant will be eligible to apply up to $5,000.00 each fiscal year. The applicant shall complete and submit the Walkability Improvement Program Application to include the following:

- Proposal, estimates, sketches/photographs, and a written, detailed description of the project to be considered for the matching grant;
- Applicants are expected to complete the 50% matching portion of the estimated project cost and submit proposed/estimated cost in the application. A **minimum of two bids** must be provided; and
- Grant Approval Agreement will be signed by the property owner.

CONDITIONS OF APPROVAL

In addition to previously listed requirements:

- all properties must be current to date on all municipal taxes;
- each property will be eligible for one application per twelve (12) month period
- grants may be limited based on availability; and
- Applicant are encouraged to have read the Charles Town Walkability and Connectivity Study.

APPROVAL PROCEDURES

Each application will be reviewed, and the property will be deemed eligible or ineligible for grant funding by staff. If deemed eligible, staff will make a decision based on compliance of the project with the Charles Town Walkability and Connectivity Study and the Ordinances of the City of Charles Town. If the application is denied, the applicant will receive notification and an explanation of the denial. The City may also provide recommendations for modifications that could be made for the project to receive consideration for approval at a future funding cycle.

APPROVED PROJECT

The City will contact the applicant and the following shall occur:

- applicant may begin his/her matching portion of the project.
- apply for and obtain all necessary permits.
- submit receipts/invoices to the City once the project is complete for reimbursement.

Construction may begin only after the application has been approved and an agreement has been signed. **Any work completed prior to formal written approval will not be eligible for the match funding.**

PROJECT MANAGEMENT

All applicants accepted into the Walkability Improvement Program will be fully responsible for managing construction of projects, including, but not limited to, obtaining bids, selecting contractors, obtaining approvals, permits, and insurance, overseeing construction work, and paying all invoices for work, materials, and supplies. Any contractor or subcontractor must have a valid business license issued by the City of Charles Town. The applicant is responsible for ensuring that all contractors and subcontractors meet these requirements.

The City of Charles Town encourages employment and business opportunities for local residents and businesses. Applicants should seek to solicit bids and proposals, materials, and labor from qualified local residents and businesses whenever possible.

CITY INSPECTION PROCESS

1. Installation of forms
2. Post pour Inspection
3. Back fill

NON-DISCRIMINATION - EQUAL EMPLOYMENT OPPORTUNTY

Applicants shall follow the City's non-discrimination ordinance and equal employment opportunity requirements in the solicitation of contractors, subcontractors, workers, and suppliers.

CITY ACCOUNTABILITY

The City's participation in this program does not make the city liable regarding the quality and/or soundness of construction or other repairs, additions, or removals. Any contractor or subcontractor working on the project must be licensed and insured.

PAYMENT OF MATCHING FUNDS

Upon completion of the project, the Applicant will provide accounting of all project costs and a copy of all paid invoices. Projects must be completed within twelve (12) months after formal approval has been granted. Any time extension must be filed and approved by staff.

Reimbursement will be issued after the property owner's portion of the project has been completed, including site inspections and the City has received receipts detailing the completed work. If the project meets all standards, the City will provide funding for no more than the amount awarded in the grant application.

APPLYING AS A TENANT

Tenants applying for the Walkability Improvement Program shall have the property owner's permission to make any improvements detailed in this application. The property owner of record signature shall be required on all applications and no application will be accepted if the property owner signature is not present.

ADDITIONAL INFORMATION

The City recommends that any applicant(s) interested in applying for acceptance into the Walkability Improvement Program contact City staff prior to submitting an application. Questions about the program may be directed to the City Planner. Applications may be obtained at City Hall and at www.charlestownwv.us.

CITY OF CHARLES TOWN
WALKABILITY IMPROVEMENT PROGRAM

APPLICATION

No application fee applies

1. Applicant's Name: _____ Date: ____/____/____
   Day Month Year

2. Mailing Address: _____

3. Project Address: (if different from mailing) _____

4. E-mail: _____ 5. Phone: _____

6. Contractor Address: _____, _____, _____

7. Company Name: _____ 8. Phone: _____

9. Sidewalk details
   ☐Front yard ☐Side-yard ☐ADA ramps

Projects that answer yes to any of the following questions are not eligible for the program:

10. Has the property in this application been awarded a Sidewalk Improvement Program grant in the past 12 months?

☐ Yes ☐ No

11. Is this property:

New construction?	☐ Yes ☐ No
Government-owned property?	☐ Yes ☐ No
A national franchise?	☐ Yes ☐ No

12. Description of the Walkability Improvement project:

13. Estimated Project Start Date: _____/_____/_____ (Day / Month / Year)
14. Estimated Project Completion Date: _____/_____/_____ (Day / Month / Year)

15. Estimated Total Project Budget: _____

16. Grant Amount Requested: _____

17. The following items are included with this application:

- ❑ Existing condition photographs
- ❑ Detailed proposal and/or contractor estimates
- ❑ Charles Town Walkability and Connectivity study

18. I have reviewed the following documents:

- ❑ Codified Ordinances of the City of Charles Town
- ❑ Construction Details for Sidewalks

Upon approval of the application the following will be required by the applicant:

- obtain all necessary building permits
- pass City inspection of improvements to ensure compliance with the sidewalk construction details and intended outcomes based on the funding application submittal
- submit receipts/invoices to the City upon completion of the project

I agree that the information provided above and within is accurate and correct to the best of my knowledge. I also assure that the property listed is in compliance with all laws, ordinances, rules, and regulations of the State of West Virginia and the City of Charles Town.

Applicant's Printed Name: _____

Signature of Applicant: _____

Signature of Property Owner(s) (if different than applicant): _____

Date of Application: _____/_____/_____ (Day / Month / Year)

FOR CITY USE ONLY

Application Number:_____ Date Application Received:_____

Approved:_____ Date:_____

Comments:_____

_____

Grant Approval Agreement

1. **I agree to follow the plan submitted with the application and I understand that failure to do so may disqualify the project for grant funding.**

2. **I agree to complete all improvements within one year of approval from the approval of the grant. Any time extension must be filed and approved by Staff.**

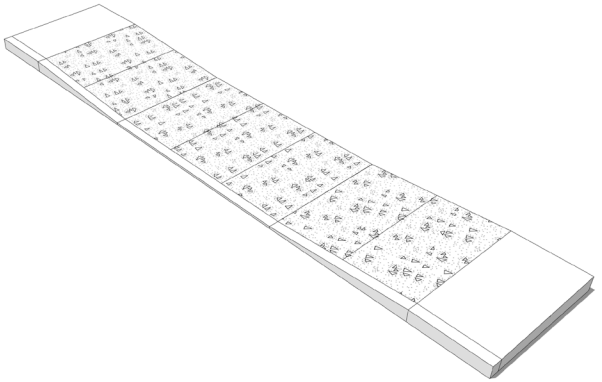
3. **I agree to all of the attached "Conditions of Approval", if any.**

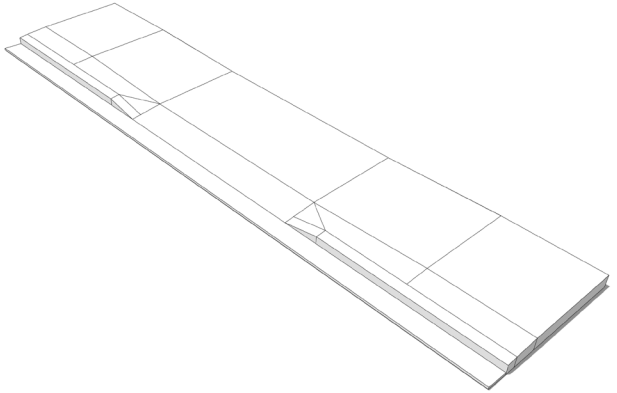
4. **I understand that I have to provide receipts related to the project. If a contractor was used, a written invoice must be provided to the City before funds will be granted. For projects that involve a contractor, receipts and invoices must be accompanied by proof of payment (i.e. cancelled checks). If a contractor was not used, receipts must be provided to the City Staff before a reimbursement will be issued. Only materials may be reimbursed for projects that do not use a contractor. Receipts and invoices must be accompanied by proof of payment.**

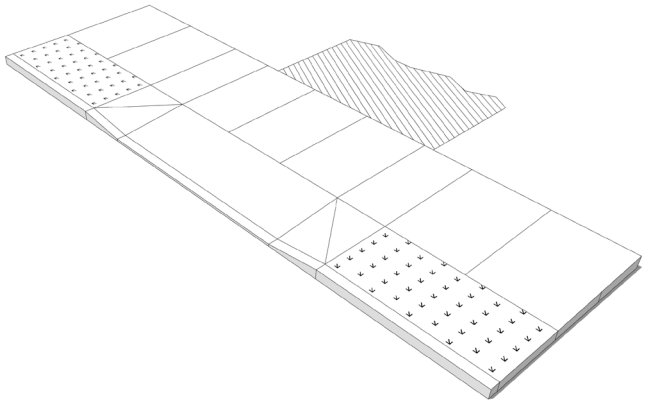
5. **I understand that grant monies shall not be distributed until all proposed work is completed and has passed inspected.**

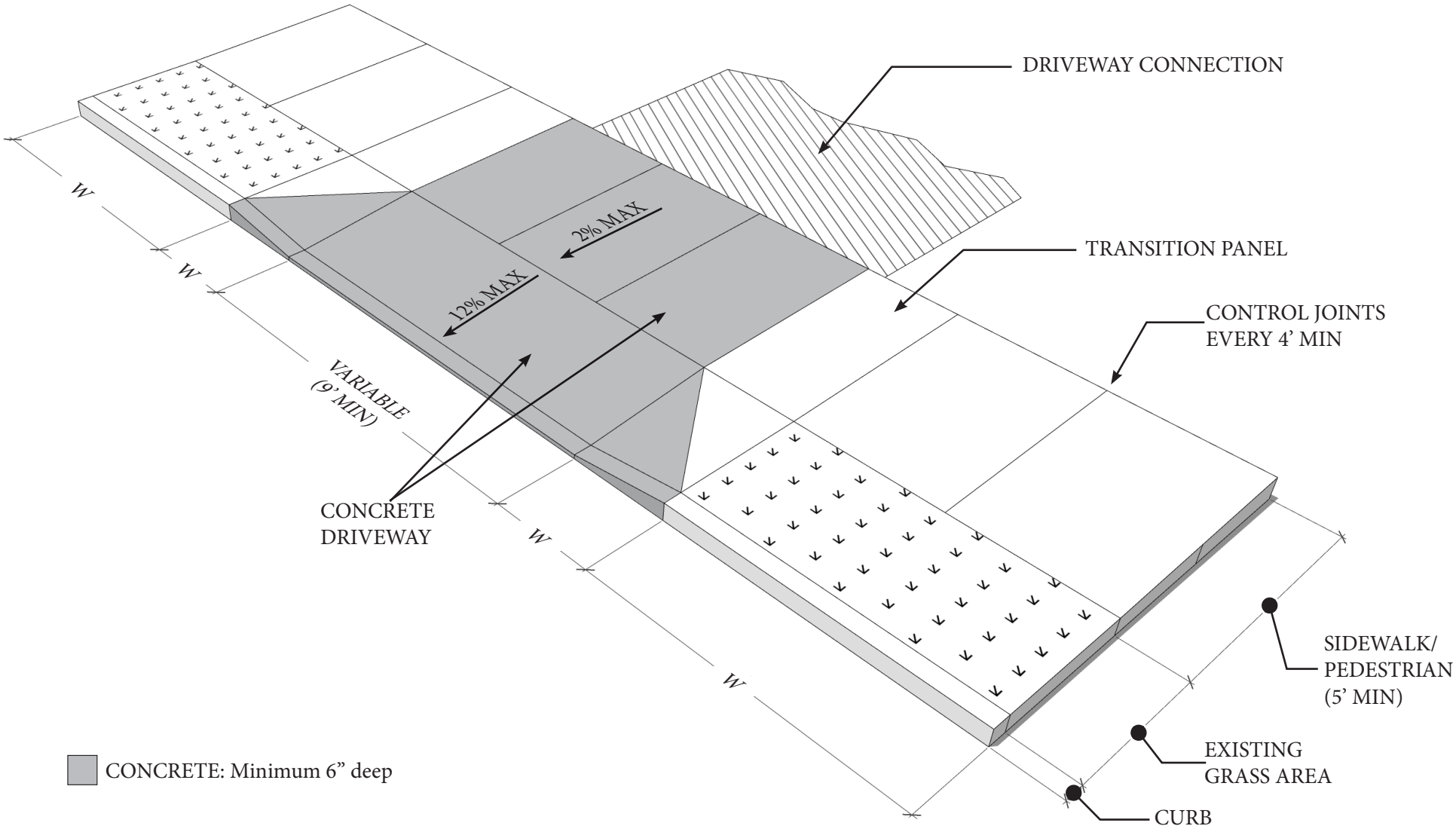
Property Owners Signature _____ **Date** _____

SIDEWALK
IMPROVEMENT
STANDARD DETAILS



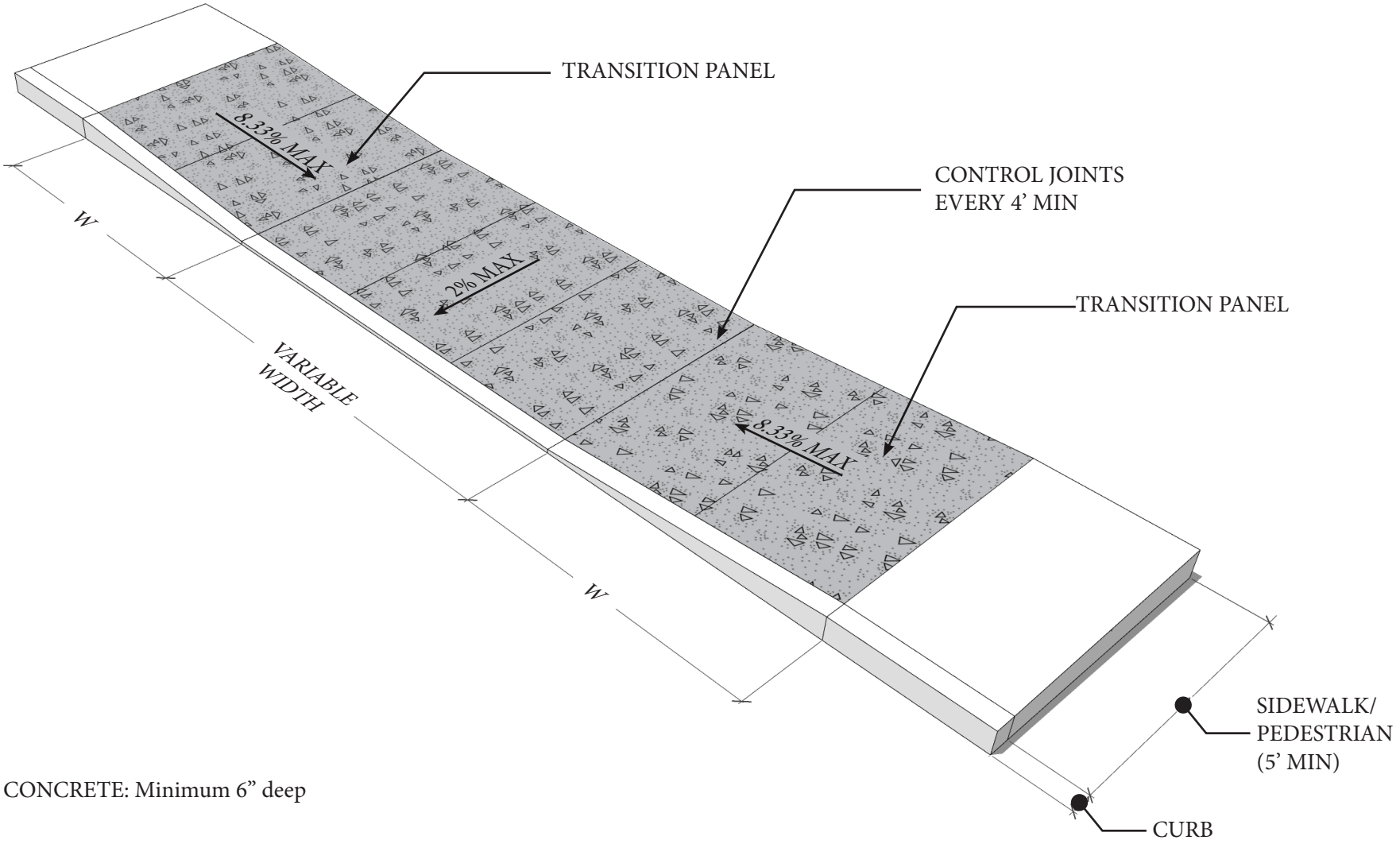






NOTE:

1. Sidewalk and driveways shall have 6 x 6 steel mesh or rebar spaced 6 inches apart.
2. Concrete shall be used for sidewalks and drive approaches and have a compressive strength of not less than 3,5000 P.S.I
3. All edges and joints of the sidewalk and drive shall be rounded. The Surface shall be brushed to create a slightly rough texture



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1. Sidewalk and driveways shall have 6 x 6 steel mesh or rebar spaced 6 inches apart.
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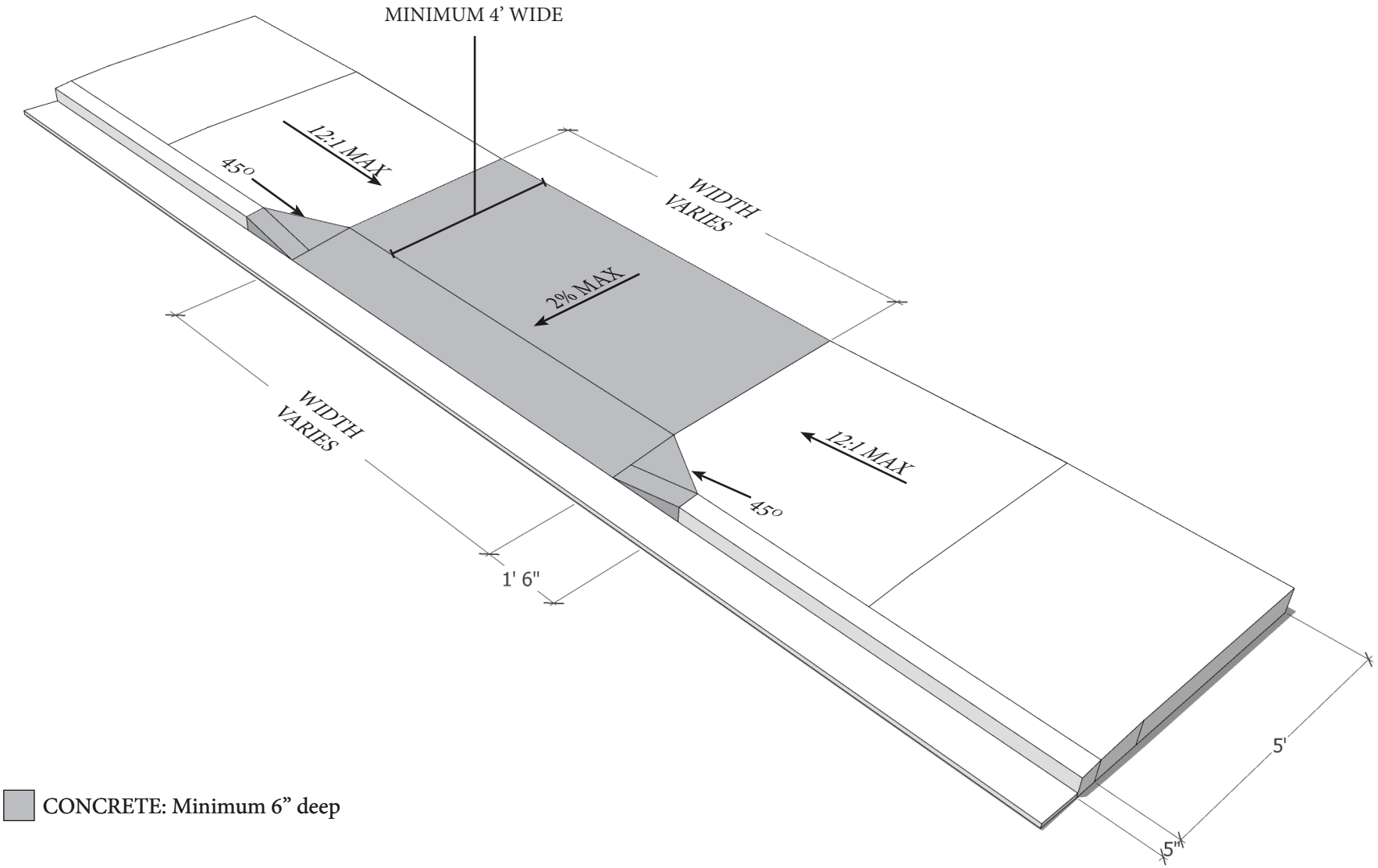
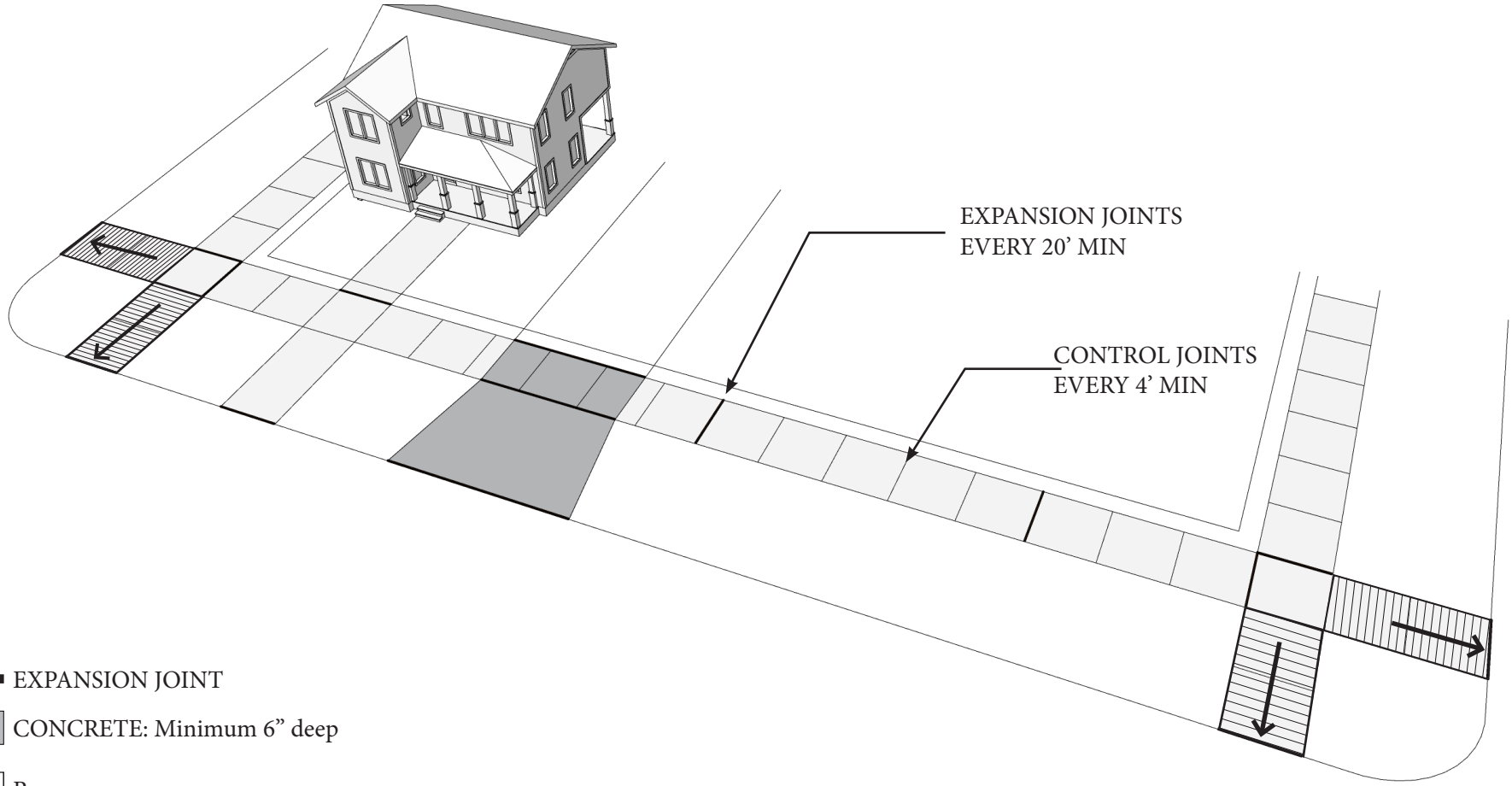


CONCRETE: Minimum 6" deep

NOTE:

1. Sidewalk and driveways shall have 6 x 6 steel mesh or rebar spaced 6 inches apart.
2. Concrete shall be used for sidewalks and drive approaches and have a compressive strength of not less than 3,5000 P.S.I
3. All edges and joints of the sidewalk and drive shall be rounded. The Surface shall be brushed to create a slightly rough texture



EXPANSION JOINT

CONCRETE: Minimum 6" deep

Ramps

NOTE:

1. Other than areas marked dark grey, all location areas are to be 4" thickness of concrete.
2. Slope on ramps to street a maximum of 8.3%.
3. Truncated domes required at the end of ramps by street

Infrastructure Committee
101 East Washington Street
Charles Town, WV 25414

SCHEDULED

AGENDA ITEM (ID #)

Meeting: 10/01/26
Department: Infrastructure Committee
Category: Report
Initiator:

2026-1963: Stormwater Issues and Updates

Greenway Engineering Storm Water Assessment Study review and next steps.

ATTACHMENTS:

- Greenway Engineering Stormwater Study Charles Town Drainage Study Report Part 1 2026.04.23 (1).pdf

Drainage Evaluation and Storm Sewer Inventory Report
Part 1
City of Charles Town, West Virginia

April 23, 2026

Prepared for:

City of Charles Town, West Virginia





Prepared By:

Zach Judy, PE, CFM
Randy Kepler, PE
Zechariah Somers
JN: 7037

FND 1971

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Contents

Executive Summary 4

A. Purpose and Goals 6

B. Means and Methods 7

- Watershed Delineation 7
- Preliminary Field Inventory and Field Investigation Efforts 8
  - Storm Structure Numbering Methodology 8
  - Storm Sewer Inventory 8
- Hydrology 9
  - Karst Considerations 10
  - Ground Cover Analysis and Runoff Factors 12
  - Time of Concentration 13
  - Storm Event Return Periods 13
- Hydraulics 13
  - Storm Sewer Conduit Capacity 14
  - Storm Sewer Inlet Capacity 14
  - Culverts 14
  - Box Culverts/Bridges 15
  - Channel Analysis 15
  - Overland Relief 15

C. Findings and Recommendations 16

Appendix A- Overall Watershed Map and Topography Exhibit 19

Appendix B- Primary Identified Issues List & Exhibit 22

Appendix C- Ground Cover – Land Use Analysis Exhibit 26

Appendix D- Karst Swales Exhibit 28

Appendix E- Full Study Area Storm Sewer Exhibit 30

Appendix F- 11x17 Storm Sewer Inventory Exhibits 32

Appendix -Watershed 1 45

Appendix-Watershed 2 55

Appendix-Watershed 3 61

Appendix-Watershed 4 67
Appendix-Watershed 5 72
Appendix-Watershed 6 75
Appendix-Watershed 7 81
Appendix-Watershed 8 87
Appendix-Watershed 9 92
Appendix-Watershed 10 97

Executive Summary

Studying the City of Charles Town's drainage and inventorying storm sewer within the historic district and central contiguous area was a meticulous undertaking with the age of these systems dating back to the early to mid 1800's. This report seeks to outline not only the results, but the techniques and assumptions utilized to achieve the results.

As outlined in the purpose and goals section later, the scope of this report and associated work constitute part 1 of an overall drainage study. No data within this report should be considered as survey grade accurate. Future work within the City should include a review of all identified issues and computations for the individual watershed where work is proposed and not solely rely on the primary issues list. The engineering analysis is a best approximation needed for the preliminary scope of part 1 and any final construction or approvals of future construction should require a more detailed study of the identified issues.

The report structure includes a main body that outlines purpose and goals, means and methods, as well as findings and recommendations. Appendices 1-10 provide brief summaries of each of the 10 watersheds identified within the City as well as supporting exhibits showing hydraulic evaluation points, drainage area delineations, and storm sewer locations. The computation spreadsheets are also contained within each of these appendices. The spreadsheets contain data to assist with prioritization of identified issues such as upstream road length and number of buildings expected to be impacted by ponding water. Appendix A provides the overall watershed map and arrows representing discharge locations and directions. Appendix B provides an exhibit and list of the primary identified issues for drainage within the study area. Appendices C through E provide documentation and supportive figures of the means and methods utilized. Appendix F provides storm sewer simplified inventory maps in 11"x17" format to facilitate easy reference and use in the field rather than full scale plan sheets.

The study resulted in a final delineation of 10 watersheds. 8 of the ten watersheds drain to Evitts Run and the remaining 2 drain to Flowing Springs Run.

During the evaluation of existing drainage infrastructure, it became apparent that significant infiltration must be taking place due to the karst nature of the region and the lack of evidence of flooding at locations with little to no drainage infrastructure. Suspected karst swales were identified within the study area. Preservation of the remaining undisturbed portions of the karst swales is recommended to maintain areas with high infiltration rates. This preservation promotes water quality and mitigates potential future flooding issues.

It was found during the study that there are many areas lacking sufficient drainage infrastructure resulting in inundation of travel ways and potential impacts to existing buildings. The identified issues consist of long stretches of roadways with no drainage other than the roadway itself acting

as a channel to convey the water and low lying/depressed areas with inadequate conveyance system to prevent significant ponding.

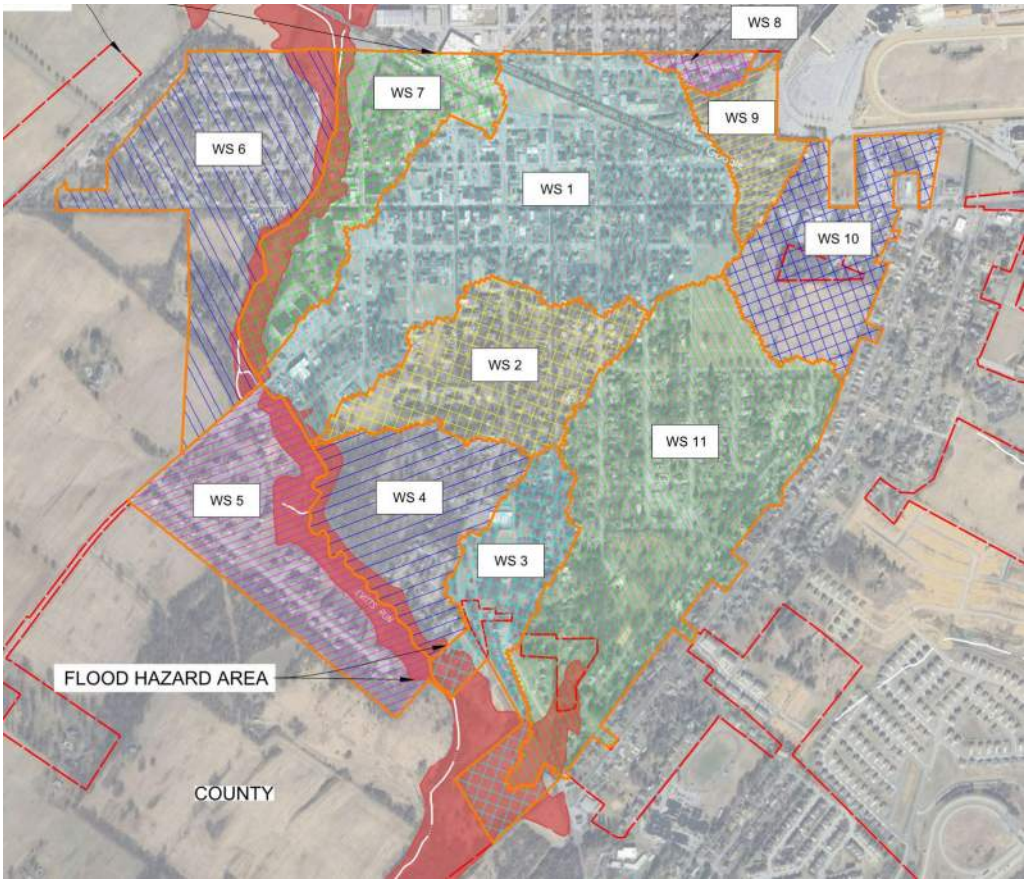
It is recommended that Watersheds 1, 2, 3, 7, and 10 proceed to the full inventory and detailed analysis outlined as part 2 of the overall study. The remaining watersheds have existing drainage concerns, but due to localized nature of the issues, minimal existing drainage infrastructure identified, and small quantity of concerns; it is recommended the individual issues could be addressed without a detailed study of the entire watershed. Greenway Engineering also recommends that the City maintain awareness for the opportunity to acquire land near the outfall of storm sewer system 1.1, where Augustine Avenue crosses Evitt's Run. This outfall represents the most concentrated surface water discharge within the City and presents excellent opportunity to improve water quality through treatment of the discharge. This could be a central component of the stormwater management plan (SWMP) that will need to be developed in the future to comply with MS4 (municipal stormwater) regulations and permitting.

A. Purpose and Goals

The purpose of this report is to outline findings from part 1 of an overall study of the drainage and runoff conditions within the City of Charles Town. The overall study seeks to identify and correct existing and potential future drainage issues.

The study was scoped to be broken down into 5 parts as outlined in the executed Greenway Engineering proposal dated April 17, 2025. Part 1 consisted of data gathering, watershed development and mapping, preliminary field investigation, as well as preliminary hydrological and hydraulic analysis. Part 2 consists of survey grade inventory of identified storm sewers and more detailed hydrological and hydraulic analysis of each watershed individually. Part 3 will consist of potential improvement analysis through concept and schematic design for each watershed individually. Part 4 consists of construction document development and administration of the installation of the proposed work for each improvement selected to move to construction. Part 5 is expected to be a support task where Greenway will assist the City with MS4 permit compliance and program development utilizing the work completed in parts 1-4.

The study area for part 1 was defined as the old town area and was further defined utilizing the watersheds outlined in orange in the following figure.



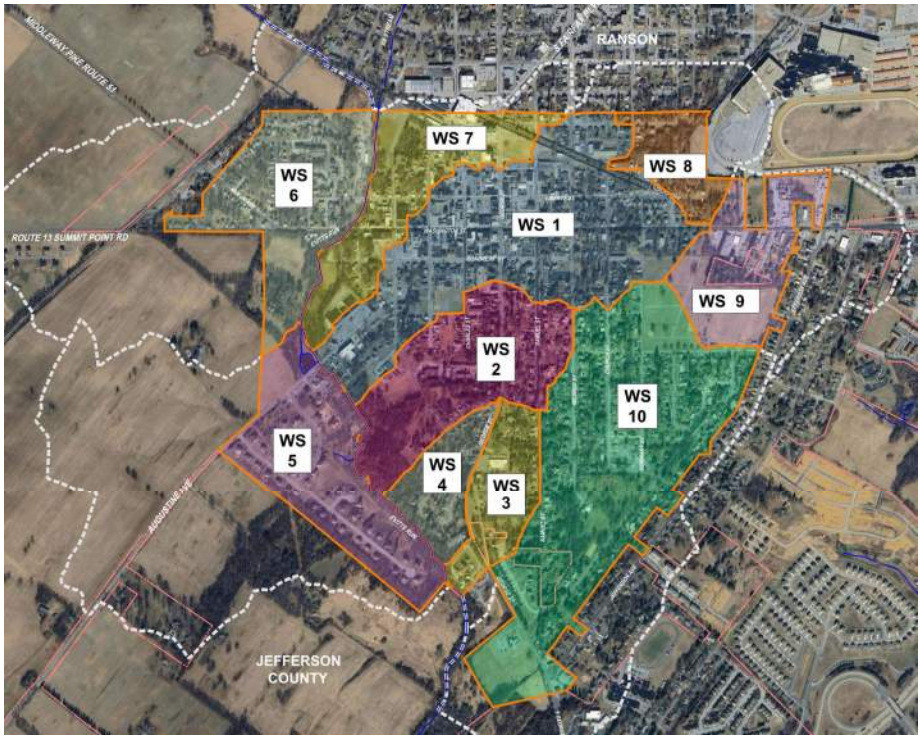
Part 1 is intended to be an economical large-scale assessment with the goal of providing a priority list of identified issues for more detailed study in part 2 of the overall study. Completing an preliminary inventory of the existing storm sewer was an additional goal of part 1 and was needed to support the preliminary hydraulic analyses.

B. Means and Methods

Watershed Delineation

Identifying and mapping the major watersheds began with a review of USGS *Streamstats* application and its delineation of drainage areas for the City. Delineations utilizing this application are prone to errors as it is based on large scale topography data and does not account for storm sewer. The study utilized West Virginia University (WVU) lidar topography data and field observations to refine the watersheds. The WVU lidar topography and field observations were utilized to establish the drainage areas for all the individual runoff calculations presented with this report. Generally, the watersheds were established based on concentrated discharge locations and areas of sheet flow directly surrounding the concentrated discharge points.

Original scoping and preliminary watershed delineation identified 11 watersheds, but ultimately the study area was divided into 10 unique watersheds. The figure below shows the delineated watersheds, and a full-scale exhibit is provided with Appendix A.

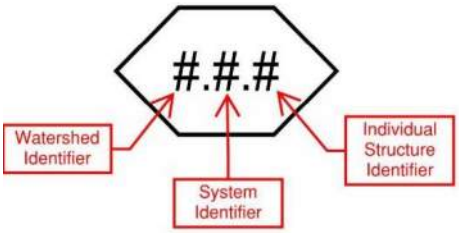


All of the City of Charles Town's runoff flows to the Shenandoah River, then into Potomac River and the Chesapeake Bay. All of the waterbodies have had significant efforts dedicated to improving their water quality. Majority of the watersheds discharge to the Potomac River Tributary known as Evitts Run. Runoff from watersheds 8 and 9 are suspected to discharge to the tributary named Flowing Springs Run.

Preliminary Field Inventory and Field Investigation Efforts

Storm Structure Numbering Methodology

Inventory of the storm structures required development of unique identifiers. The identifiers were decided to consist of a three-digit system delineated by periods. The leading digit identifies the primary watershed the structure lies within. The second digit designates all structures that are directly connected by conduit and are referred to as the individual system or culvert identifier within the primary watershed. The last digit is the structures individual identifier within its connected system. An example figure is provided below.



The numbering of structures generally starts at the bottom/low end of the primary drainage shed and proceeds upward. Outfall structures are generally identified with a 0 as the structure identifier, i.e. 1.1.0. However, some systems without a clear intentional outfall structure may not have a 0 structure.

Storm Sewer Inventory

The field inventory of storm sewer infrastructure was completed through visual inspections of the entire study area and supported by reviews of topography data to identify likely storm sewer inlet and outfall locations. City staff also provided support through discussions and reviews of storm sewer known to them. Several storm systems were identified with no known above ground outlet. Due to the karst nature of the City, it was assumed that many of these systems with no identified outfall were installed as infiltration outfalls/structures and some outfalls may have been buried accidently such as the culvert along George Street in watershed 3. Additional efforts such as camera evaluations could be utilized to verify these outfalls which were not part of the scope of this study, but can be further pursued with part 2. A shape file will be provided with this report containing the line work for identified storm sewer and can be utilized to begin the creation of a GIS database of the City's storm sewer.

Existing stormwater facilities were also identified with the study. All evident stormwater facilities were assigned a unique identifier utilizing similar symbology to the storm sewer identifiers. “SF” was utilized as a prefix for these facilities with the watershed number following and a unique identifier number as well.

The storm sewer inventory and associated data provide a starting point for database building and made best efforts to accurately establish locations and physical properties of the conveyance system. As changes to materials and conduit sizes take place in locations other than accessible structures, the inventory is a best effort and should not be considered 100% accurate. The inventory should not be construed to be an opinion of jurisdiction or responsibility for the infrastructure, although the work included with this report does at times identify infrastructure thought to be private as well as associated with a West Virginia Division of Highways (WVDOH) jurisdictional road.

Appendix E provides a study wide inventory exhibit and utilizes only the two digit watershed and system identifiers for simplicity and Appendix F provides more detailed 11x17 maps of the inventoried storm sewer. Appendix F is intended to provide simple, easily handled exhibits of the inventoried storm sewer. The watershed H&H (hydrology and hydraulics) exhibits contained in appendices 1-10 also identify the inventoried storm sewer. Materials and sizes of the identified storm sewer is communicated through the analysis spreadsheets contained in Appendices 1-10.

Hydrology

Rational Method

Rational method is the simplest technique and the most industry accepted method for storm sewer capacity analysis. Drainage channel evaluations also utilize rational method when the channel in question has a small, localized drainage area. However, rational method is considered limited to drainage areas of 200 acres or less and only provides a peak flow rate estimate. The largest drainage sheds within the study that concentrate stormwater are approximately 200 acres validating the use of rational method for peak flow rate determination in all hydraulic evaluations of drainage features completed with the study. Volumes of runoff are not addressed with the standard rational method which limits the method to evaluations that do not consider detention and attenuation of flow rates. As this study utilizes lidar topography, areas of planned detention such as stormwater management ponds are limited within the City, and the study is being performed at a macro level to determine areas of concern requiring more refined engineering analysis utilizing field survey data; rational method was confirmed as the most appropriate methodology for determining capacities of existing conveyance systems and potential flooding concerns.

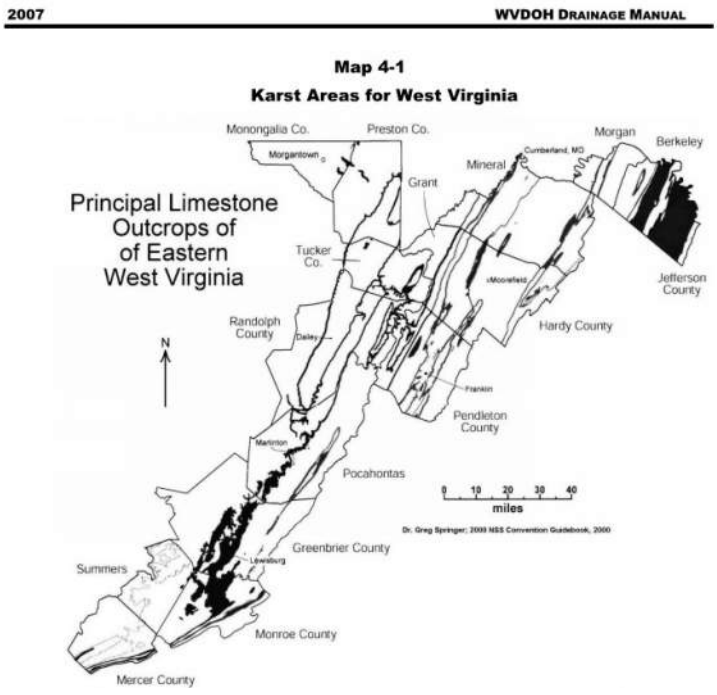
NRCS TR20

NRCS TR20 was developed by the Soils Conservation Service (SCS) as a software-based approach utilizing a vast amount of data references developed through field and lab study. SCS was later renamed the Natural Resources Conservation Service (NRCS). This technique utilizes hydrography methods that account for storm duration and variable rainfall intensities during storm events. TR20 provides a runoff volume estimate unlike the rational method. Volume estimation makes TR20 ideal for water quality analyses and design, as practices that capture and/or treat the runoff from a storm event need to account for runoff volumes to function correctly.

The storm event consisting of one inch of rainfall is considered the design storm for most water quality practices. Capturing and/or treating the runoff from one inch of rainfall is the accepted water quality standard outlined by not only West Virginia state agencies, but also Virginia and Maryland. For these reasons the study has included an overall NRCS TR20 analysis completed utilizing HydroCAD software for each of the major watersheds. Only the volumetric results are included as time of concentration was not evaluated for the watersheds and the flow time assumptions utilized elsewhere in the study were not considered suitable for the overall watersheds. The runoff volume estimates are included on the Ground Cover- Land Use exhibit in Appendix C and the City of Charles Town Watersheds exhibit in Appendix A.

Karst Considerations

Karst topography dominates City of Charles Town and surrounding Jefferson County as shown by the shaded regions on the figure below from the WVDOH drainage manual.



Karst is used to describe topography that is underlain by rock that can be dissolved by water. In the case of Charles Town, the rock is limestone. As water seeps into the ground the rock can be dissolved by the water allowing voids to form underground. Once a small void is opened by this dissolution of the rock, water may flow through the void in a more concentrated fashion and begin moving soil, enlarging the voids. This is the process by which the caves in the local area of Charles Town are formed. Sinkholes can form on the surface because of this process. This natural process leads to karst areas experiencing significant infiltration.

As drainage areas are developed and become highly impervious, the natural karst infiltration is reduced as the developed impervious areas and excavation activities change the natural topography and hydrology. Many jurisdictions provide guidance that karst adjustments should not be made for previously developed/disturbed areas. However, this approach was found unacceptable as the method developed unrealistic flows. The flows were found to be unrealistic based on field observations that found little evidence of erosion or flooding at existing flow constraints.

The WVDOH drainage manual indicates peak runoff rates should be adjusted based on the percentage of the drainage shed found to be underlain by karst. The manual provides the following table of coefficients for adjustment of peak flow rates.

WVDOH DRAINAGE MANUAL 2007

Table 4-1

Karst Loss Coefficient

% Karst	Storm Return Period				
	2	10	25	50	100
100	0.33	0.43	0.44	0.46	0.50
90	0.35	0.46	0.48	0.50	0.56
80	0.38	0.51	0.53	0.56	0.62
70	0.47	0.58	0.60	0.62	0.68
60	0.55	0.66	0.67	0.70	0.74
50	0.64	0.73	0.74	0.76	0.80
40	0.73	0.80	0.81	0.82	0.85
30	0.82	0.86	0.87	0.87	0.89
20	0.91	0.92	0.92	0.92	0.93
10	1.00	0.98	0.98	0.98	0.97
0	1.00	1.00	1.00	1.00	1.00

Source: Adjusting Hydrology Models for Karst Geology, John Laughland P.E.

The determination of the percentage of a drainage area to be considered karst was completed utilizing the approximate percent pervious area for each land cover identified. For the downtown business land cover, no karst corrections were applied due to the imperviousness and lack of pervious overland flow areas. Overall karst factors were computed for each watershed, except watershed 1, and utilized for all computations within the watershed. The Rational analyses performed multiplied the appropriate karst coefficients by the resulting peak flow rate. The

resulting karst factors for each watershed are shown on the Ground Cover – Land Use Analysis exhibit included in Appendix C.

For Watershed 1 rational C factor adjustments were made to the land covers other than downtown business areas. This was done to prevent reduction of flows in the computations for the downtown business areas where significant imperviousness is preventing infiltration. The C factors were reduced by 35% which is approximately equivalent to the 10-year reduction imposed by karst factors for the major residential ground cover within watershed.

Karst swales are a recognized geological and hydraulic feature. This study identified several significant swales within the City which are expected to function as karst swales. The expected historical extent and currently undisturbed portions of these areas have been identified and considered with this study. Appendix D consists of an exhibit showing the identified areas. The exhibit was developed to assist with the study as well as future development considerations.

The Chesapeake Stormwater Network has published a document titled *CSN TECHINICAL BULLETIN No. 1, STORMWATER DESIGN GUIDELINES FOR KARST TERRAIN IN THE CHESAPEAKE BAY WATERSHED VERSION 2.0* that provides guidance for protection of karst swales and outlines stormwater quality credits that should be associated with this preservation. The document is currently available on the Jefferson County Foundations website. This preservation could be one component of a SWMP when the City begins development of a SWMP for MS4 permitting compliance.

Areas draining to apparent infiltration points with no available outfall were removed from analysis performed downstream as outlined in the WVDOH drainage manual. Areas draining through assumed karst swales with minimal development or obvious historical disturbance, significant flow lengths within the karst swale and no defined channel were also removed from downstream analysis.

Ground Cover Analysis and Runoff Factors

The rational method and TR20 method require delineation of ground cover conditions. TR20 also includes considerations for underlying soil types in the form of hydraulic soil group (HSG) classification. The majority of the City is identified as HSG D as is typical for urbanized areas. HSG D was assumed for all ground covers other than farms/unimproved areas, which were assumed to be B based on a review of soil survey data. The following references were used to determine appropriate ground cover category and runoff characteristics (C factor for rational and curve number/CN for TR20) in the study:

NRCS Web Soil Survey - https://websoilsurvey.nrcs.usda.gov/app/

Table 4.1. Runoff Coefficients for the Rational Method – FHWA HEC 22 Urban Drainage Design Manual

Figure 2-7 Runoff Curve Numbers – Title 210 National Engineering Handbook

Detailed satellite imagery was utilized to delineate business, residential, parks/cemeteries and unimproved areas within the study area and appropriate CN's and C factors were assigned. Weighted C factor and CN's were developed for each drainage area analyzed based on the overall ground cover delineations. The Ground Cover – Land Use Analysis exhibit is included in Appendix C.

Time of Concentration

Time of concentration (Tc) for each of the drainage areas could not be determined to a reasonable degree of accuracy or confidence with use of the lidar topography in the urban landscape. To complete the runoff computations utilizing the Rational or TR20 methodology a time of concentration value must be developed. For this study it was found reasonable to make conservative Tc estimates, based on the size of the drainage area. The table below shows the assumptions utilized for the study.

Time of Concentration	
Drainage Area	**Tc Value Assigned**
(Acres)	(Minutes)
0.01 - 1.00	5 mins.
1.01 - 4.99	10 mins.
5.00 - 9.99	15 mins.
10.00 and greater	20 mins.

Storm Event Return Periods

The WVDOH drainage manual dictates a 10-year return period to be utilized for storm sewer and channel designs. This return period/storm event was utilized for the primary evaluation of all storm sewers, and 2-year analysis was performed to assist in ranking the identified issues and identify more common nuisances. Larger storm events are evaluated for overland relief and channel capacities. Overland flow evaluations were completed for the 100-year and 10-year storm events. Channel computations also included the 2-year storm event to identify the areas that may experience issues during more common storm events. Rainfall intensities and depths were obtained from the National Oceanic and Atmospheric Administration's Atlas 14.

Hydraulics

Part 1 of the study provided preliminary hydraulic analysis of the study area to identify public road inundation and threats to existing buildings due to runoff. The study does not address water quality needs. The study also does not address erosion concerns as no significant evidence of

erosion issues were observed during field work. The following sections outline each form of hydraulic analysis performed and the techniques and assumptions utilized.

Storm Sewer Conduit Capacity

As this initial preliminary part 1 of the study encompassed a majority of the City's historical area and further detailed studies of individual drainage areas are to follow, the storm sewer analysis did not include full system modeling or hydraulic grade line development. Capacity of storm sewers were evaluated utilizing Mannings open channel analysis. The WV DOH drainage manual recommends this as the default sizing methodology for storm sewers with a recommended maximum flow depth of 0.8 times the pipe diameter during the design storm. The manual does allow for storm sewers to surcharge during the design storm at the engineer's discretion. This would require hydraulic grade line evaluation to ensure appropriate sizing of storm sewers and is far less conservative design methodology than the open channel flow approach. Hydraulic grade line evaluation can be performed with the detailed studies that are expected to follow this initial study and will be able to utilize accurate field survey data not considered part of the scope of this study. Applying the open channel methodology will allow for existing capacity issues to be compared based on severity utilizing one equivalent analysis technique. Computations are provided within Appendices 1-10 for each watershed. For the storm sewer system identified as 1.1, within Watershed 1, a previous report titled *"Stormwater Runoff Evaluation Task #1 – Liberty Street Flooding and Storm Sewer Trunk Line Capacity Analysis"* was published in December 2020 by Greenway Engineering. The analyses and computations from the previous report were integrated into this study. The computations presented for the storm sewer in this report should not be considered accurate enough to base future designs on without detailed survey verification of existing infrastructure.

Storm Sewer Inlet Capacity

Accurate drainage inlet capacity requires detailed measurements and calculations for each individual inlet. The preliminary/global nature of this part of the study did not include such detailed analysis within its scope. Where redundant grate inlets, curb/throat inlets, or culvert inlets are present capacities of the underlaying storm sewer system is accounted for in channel and overland relief computations.

Culverts

Culverts were analyzed utilizing the same capacity technique described for storm sewer. This simplified approach allowed for ranking of culvert issues with the same methodology as storm sewer. This simplified approach does not account for all hydraulic elements of culverts and standard industry methods should be utilized for further detailed analysis. Computations are provided within Appendices 1-10 for each watershed.

Box Culverts/Bridges

Four bridge/box culverts are present within the study area. All the bridges excluding one have been assessed through flood studies available through FEMA and are not reassessed with this study. The bridge along Washington, just west of its intersection with MLK Jr Avenue, was not assessed with the FEMA flood study or this study, but has minimal drainage area and provides drainage for a WVDOH road.

Channel Analysis

Roadside drainage/spreads were evaluated as channels in the study. Analysis included the 2, 10, and 100- year storms. Computations are provided within Appendices 1-10 for each watershed.

Computations identified as spread are evaluations of flow along curbed streets. Computations identified as roadside ditch evaluated drainage along roads with no curb. The peak flows utilized in the channel analyses were adjusted to account for existing storm sewer full flow capacities where redundant grate inlets, curb inlets, or culvert inlets were present. The capacities of the pipes directly downstream were utilized in the analyses as it was assumed that surcharging would lead to discharges both upstream and downstream of the analyses point making the pipe directly downstream of the surface feature the constraint.

The points identified for analyses are generally the most concerning downstream locations within the watersheds and the study did not analyze individual points upstream of the identified locations. The analysis communicates spread issues at not only the selected location, but upstream areas as well. The length of roads and number of intersections upstream were measured to assist with ranking the identified issues. Detailed analyses should explore spreads upstream of the identified points.

Overland Relief

Overland relief (OLR) was evaluated for identified local depressions(sags) and utilized industry standard weir analysis. Sags/low points with minor drainage areas and evident available overland relief, with little threat to property were excluded. Some low points along roadways have been assessed utilizing channel computations and did not include an overland relief analysis for overtopping curbs or roadway crowns where significant upstream flow length is present, and it was deemed the associated impacts were better classified as roadway spread to account for upstream impacts with the road length and intersection count metrics. A few locations were analyzed utilizing overland relief and channel analysis where significant flow rates could create significant ponding and there were significant upstream flow lengths, as well as places where the flow must cross an intersection that could not be communicated through OLR analysis. Overland relief analysis can be highly susceptible to small variances in elevation

data and only lidar was utilized within this study. Use of the OLR analysis within this study for purposes outside the study is highly discouraged. Many assumptions and interpretations of lidar/field observations were utilized to approximate OLR.

OLR analyses typically ignore the presence of storm sewers. Due to the historical nature of Charles Town, much of the City was constructed prior to the implementation of current engineering and development practices. Also, full overland relief is not possible in many urban settings and storm sewer can be upsized to provide the needed drainage capacity for larger storm events in many situations. For these reasons the analysis presented in this study deducted the full flow capacity of the storm sewer from the runoff/flow rates utilized in the OLR analyses if storm sewer was present with redundant grate inlets, curb inlets, or culvert inlets.

Inlet capacities were not assessed, and it was assumed that locations with multiple inlets in the low area as well as upstream inlets would allow for the storm sewer pipes to flow full during large storm events. The capacities of the pipes directly downstream were utilized in the analyses as it was assumed that surcharging would lead to discharges both upstream and downstream of the analyses point. Locations having only one grate inlet upstream did not account for storm sewer capacity due to the higher potential of grate clogging.

Expected roadway inundation lengths and number of buildings suspected to be impacted by water ponding around the structures are provided with the computations. The buildings may or may not experience interior flooding, floor elevation assessment is not included in this study. Computations are provided within Appendices 1-10 for each watershed.

C. Findings and Recommendations

The study found it was appropriate to break the City into 10 watersheds based on concentration points and discharge directions as shown in Appendix A. The primary issues identified in Appendix B were selected based on travel way inundation, threat to buildings due to ponding, location of the impacts, flow rates, and flow depths. It was found that many of the existing City streets contain no drainage infrastructure, such as appropriately sized roadside ditches or storm sewer, leading to significant inundation of the public roadways. The exhibit provided in Appendix B identifies the location of the primary issues and spreadsheets are provided listing the issues and primary data pertaining to the issues.

The channel/roadway spread issues tables in Appendices 1-10 and Appendix B provide the findings of the channel analysis that were performed for the 2, 10, and 100-year storms. The upstream road length column indicates the length of roadway upstream of the analysis point. It is not expected that the spread issue exists along the entire upstream road length, but this indicates the maximum amount of roadway length that may be impacted due to the identified

issue and provides a metric to compare the identified issues. The upstream intersections listed on the tables indicate the number of intersections where runoff associated with the identified issue may have to flow across the travel way of the intersection. This flow may increase the risk for hydroplaning and ice in the intersection during the winter. The overland flow listed in the table indicates the amount of runoff that is expected to flow along the surface and accounts for any underlying storm sewer capacity as described in previous sections. Thus, some of the identified issues may have a value of 0 for overland flow during the 2 or 10-year storms. The roadway surcharge column indicates the depth of water flow expected at the edge of the roadway and provides a good indicator of the severity of the drainage issue. The travel lane spread column lists the distance water may spread into an assumed 10' travel lane assuming typical road cross slopes (2% slope). This spread value is the primary variable considered in current design manuals in relation to the comps presented. The WVDOH drainage manual dictates a maximum spread of 3 feet into travel lanes during the 10-year storm to mitigate hydroplaning risks. All the primary issues identified exceed this value. Issues with the travel lane spread listed as "full" indicate the spread covers the entire assumed travel lane.

The overland relief/ponding issues tables in Appendices 1-10 and Appendix B provide the results of ponding analysis where runoff must accumulate/pond and overtop a barrier to continue downstream for the 10 and 100-year storms. In addition to listing the location and a description of the expected barrier, the table lists the assumed weir elevations that runoff must overcome. This is provided as variations in the assumed elevations would change the resulting ponding elevations. OLR flow rates are provided that account for storm sewer capacity as previously described in this report. Depth of flow across the weir is provided and the approximated water surface elevations. Four values are provided to assist with gauging the severity of the issues. The number of buildings that water ponding may reach, the length of local roadway inundation, the length of inundation of any roads considered primary routes, and whether the impacted roads function as a sole point of access to residences or businesses.

The storm sewer pipe analysis tables provided in Appendices 1-10 provide pipe capacity analysis results and the inventory data for storm sewers. The 10-year storm event should generally dictate the size of the pipes as outlined in the WVDOH drainage manual. However, there are situations within the City where it may be appropriate to size the pipes for larger storms based on surface drainage issues as identified with the OLR and channel analysis. The final column in the highlighted regions for the 2 and 10-year storms compares the runoff rates to the open channel capacity of the storm sewer runs. Values under 100% indicate the runoff can be fully handled by the installed pipe. Values exceeding 100% indicate the pipe is undersized for the existing drainage area flowing to the system. These results were not considered primary drainage issues as a pipe being over capacity is not a flooding issue but may cause a flooding issue that would be identified through the provided OLR and channel analyses.

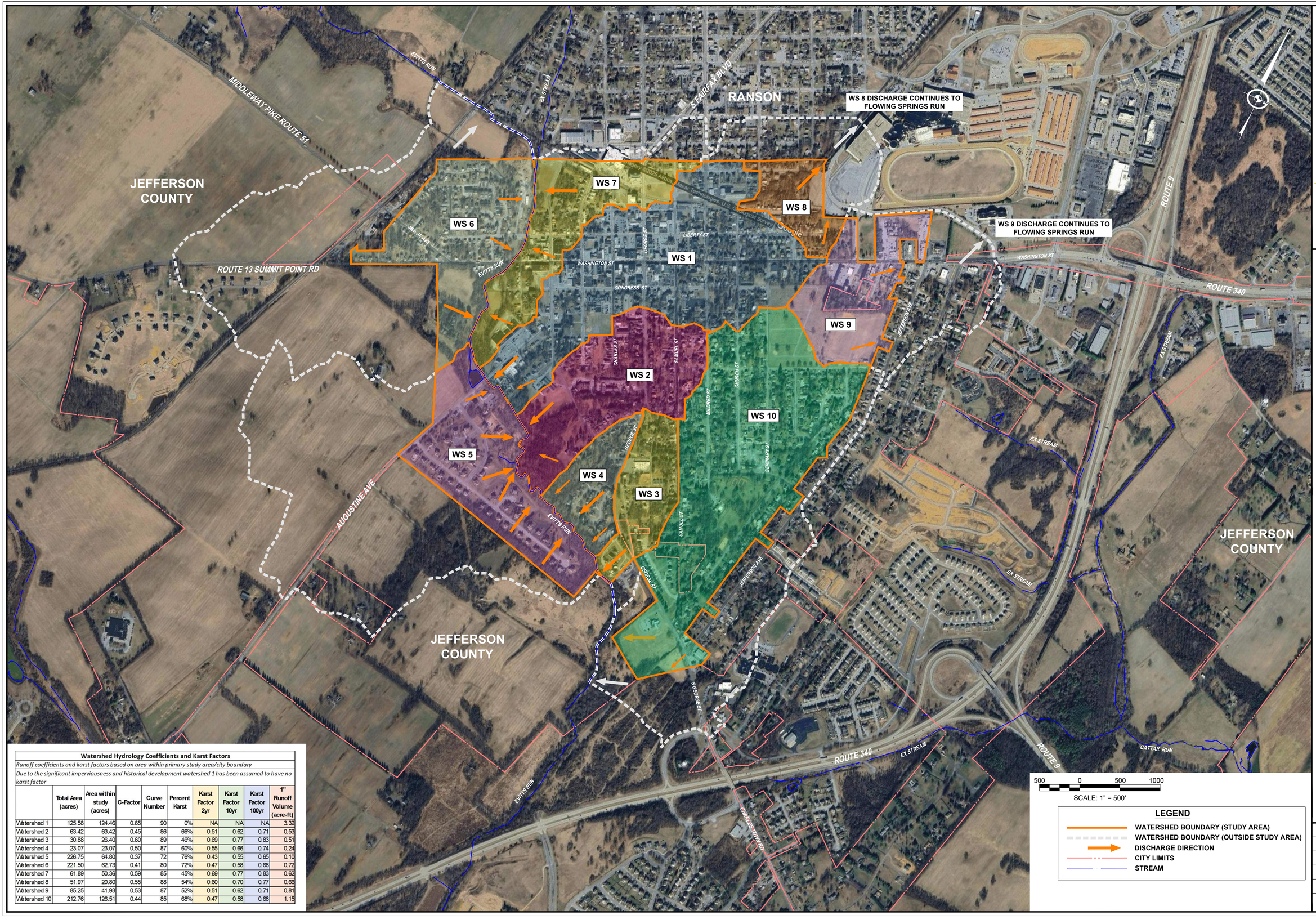
Many depressions were identified with no drainage, inadequate drainage, or lack of redundant inlets to mitigate potential inlet clogging. The identified issues could be resolved with appropriate storm sewer installations. One of the depressions analyzed in Watershed 3 (O.3.1) seems to have been created by residential infill lot development. Another OLR analyses point (O.8.1) located in Watershed 8 seems to have had the existing issue exacerbated by construction on a residential infill lot. This location was not included in the priority issues as the depth of ponding was found to be minimal. It is recommended that the City institute a drainage and grading review process for any future infill lot development.

Much of the inventoried storm sewer consists of aging terracotta and corrugated metal pipes with many lacking the needed capacity. The structural evaluation of the aging pipes would require camera inspection efforts of the existing storm sewer. It is recommended that prior to expending resources to maintain existing storm sewer systems that detailed analysis be performed to evaluate if upsizing of the exiting pipes would be appropriate during the maintenance operations. This evaluation should carefully consider future potential upstream expansion of the storm sewer systems. Based on many of the identified drainage issues, it is thought that upsizing and expansion of many of the storm sewer systems would mitigate flooding and runoff issues. However, storm sewer capacities themselves were not utilized to identify primary drainage issues. The primary issues identified are based on surface drainage issues that may be a result of storm sewer that is over capacity.

Greenway Engineering recommends that the City maintain awareness for the opportunity to acquire land near the outfall of storm sewer system 1.1, where Augustine Avenue crosses Evitt's Run. This outfall represents the most concentrated surface water discharge within the City and presents excellent opportunity to improve water quality through treatment of the discharge. This could be a central component of the stormwater management plan (SWMP) that will need to be developed in the future to comply with MS4 (municipal stormwater) regulations and permitting.

Based on the issues identified and outlined scope of the overall study, part 1 has resulted in the following primary recommendations. Watersheds 1, 2, 3, 7, and 10 should advance to the full analysis and inventory outlined in part 2 of the study. Watersheds 4, 6, 8, and 9 have identified issues, but the issues are few and localized. It appears these issues could proceed with combined detailed existing analysis (part 2) and improvement analysis (part 3) for each individually identified issue. Watershed 5 had no identified issues other than potential capacity issues for one identified storm sewer system that presents minimal threats to public roads or existing buildings. Watershed 5 is not recommended for further detailed study.

Appendix A- Overall Watershed Map and Topography Exhibit



Watershed Hydrology Coefficients and Karst Factors

Runoff coefficients and karst factors based on area within primary study area/city boundary

Due to the significant imperviousness and historical development watershed 1 has been assumed to have no karst factor

	Total Area (acres)	Area within study (acres)	C-Factor	Curve Number	Percent Karst	Karst Factor 2yr	Karst Factor 10yr	Karst Factor 100yr	1" Runoff Volume (acre-ft)
Watershed 1	125.58	124.46	0.65	90	0%	NA	NA	NA	3.32
Watershed 2	63.42	63.42	0.45	86	66%	0.51	0.62	0.71	0.53
Watershed 3	30.88	26.40	0.60	89	46%	0.69	0.77	0.83	0.51
Watershed 4	23.07	23.07	0.50	87	60%	0.55	0.66	0.74	0.24
Watershed 5	226.75	64.80	0.37	72	76%	0.43	0.55	0.65	0.10
Watershed 6	221.50	62.73	0.41	80	72%	0.47	0.58	0.68	0.72
Watershed 7	61.89	50.36	0.59	85	45%	0.69	0.77	0.83	0.62
Watershed 8	51.97	20.80	0.55	88	54%	0.60	0.70	0.77	0.68
Watershed 9	85.25	41.93	0.53	87	52%	0.51	0.62	0.71	0.81
Watershed 10	212.76	126.51	0.44	85	68%	0.47	0.58	0.68	1.15

500 0 500 1000

SCALE: 1" = 500'

LEGEND

- WATERSHED BOUNDARY (STUDY AREA)
- WATERSHED BOUNDARY (OUTSIDE STUDY AREA)
- DISCHARGE DIRECTION
- CITY LIMITS
- STREAM

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OFFICES IN: MARTINSBURG, WV WINCHESTER, VA & ASHBURN, VA

CITY OF CHARLES TOWN WATERSHEDS

CITY OF CHARLES TOWN - JEFFERSON COUNTY, WEST VIRGINIA

Date:	03/23/2026
Scale:	1" = 500'
Designed By:	ZJ/RLK/ZS
File No.	7037
Sheet	1 Of 1

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CITY OF CHARLES TOWN WATERSHEDS

TOPOGRAPHY

CITY OF CHARLES TOWN - JEFFERSON COUNTY, WEST VIRGINIA

WS 1
WS 2
WS 3
WS 4
WS 5
WS 6
WS 7
WS 8
WS 9
WS 10

TOPOGRAPHIC DATA FROM WVU OPEN SOURCE LIDAR DATASET

LEGEND

- 2' CONTOUR
- 10' CONTOUR
- MINOR DRAINAGE DIVIDE
- WATERSHED DIVIDE
- WATERSHED DIVIDE (BEYOND CITY LIMITS)
- CITY LIMITS
- GIS PARCEL BOUNDARIES
- STREAM
- GIS BUILDING OUTLINES

300 0 300 600
SCALE: 1" = 300'

Date:	04/13/2026
Scale:	1" = 300'
Designed By:	ZJ/RLK/ZS
File No.	7037
Sheet	1 Of 1

Appendix B- Primary Identified Issues List & Exhibit

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PRIMARY ISSUES IDENTIFIED

CITY OF CHARLES TOWN WATERSHEDS

CITY OF CHARLES TOWN - JEFFERSON COUNTY, WEST VIRGINIA

LEGEND

- WATERSHED BOUNDARY (STUDY AREA)
- C.## — CHANNEL/SPREAD COMP
- O.## — OLR (OVERLAND RELIEF) COMP
- APPROXIMATE 100 YEAR PONDING BASED ON OLR ANALYSIS

300 0 300 600

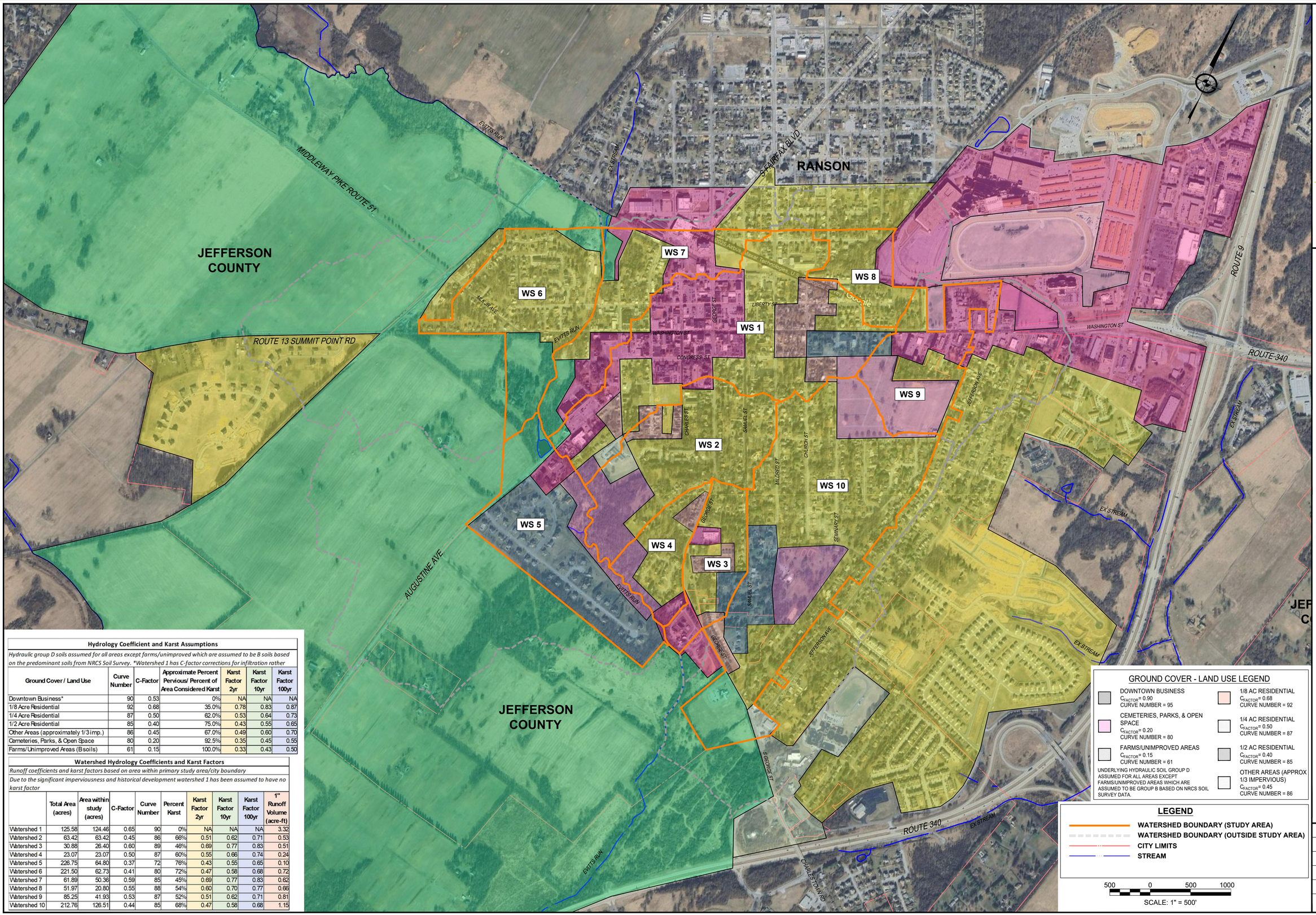
SCALE: 1" = 300'

Date:	04/13/2026
Scale:	1" = 300'
Designed By:	ZJ/RLK/ZS
File No.	7037
Sheet	1 Of 1

Channel/Roadway Spread Issues						2 year storm			10 year storm			100 year storm		
Identifier	Location	Description	Upstream Road Length(ft)	Upstream Intersections	Drainage Area (Acre)	Overland Flow (cfs)	Roadway Surcharge (ft)	Travel Lane Spread (ft)	Overland Flow (cfs)	Roadway Surcharge (ft)	Travel Lane Spread (ft)	Overland Flow (cfs)	Roadway Surcharge (ft)	Travel Lane Spread (ft)
Watershed 1 - 6 Primary Channel Flow Issues Identified														
C.1.1	Augustine Ave westside	Spread	1835	1	5.34	0.00	0.00	0.00	12.77	0.33	8.46	27.76	0.44	Full
C.1.3	Congress St southside	Spread	2600	2	7.78	0.00	0.00	0.00	22.76	0.47	Full	31.80	0.53	Full
C.1.4	Congress St northside	Spread	1500	1	79.49	0.00	0.00	0.00	17.15	0.42	Full	82.87	0.76	Full
C.1.5	George St eastside	Spread	2100	3	9.83	7.43	0.31	5.29	12.36	0.37	8.50	19.54	0.44	Full
C.1.10	Liberty St southside	Spread	2000	3	14.71	11.69	0.30	4.75	16.64	0.34	6.83	23.98	0.39	9.33
C.1.12	Samuel St	Spread	1540	2	9.10	10.24	0.35	Full	14.07	0.39	Full	19.66	0.44	Full
Watershed 2 - 3 Primary Channel Flow Issues Identified														
C.2.2	Samuel Street westside	Spread	1015	1	0.74	0.89	0.12	3.04	1.50	0.15	4.38	2.42	0.18	5.83
C.2.3	Samuel Street eastside	Spread	1360	1	5.87	4.55	0.22	8.17	7.61	0.27	Full	12.17	0.32	Full
C.2.4	Charles Street eastside	Roadside ditch	1200	1	23.11	8.74	0.21	9.00	20.16	0.32	Full	37.55	0.44	Full
Watershed 3 - 2 Primary Channel Flow Issues Identified														
C.3.1	George Street Ext	Roadside ditch	550	0	11.48	12.50	0.24	Full	19.33	0.32	Full	29.46	0.42	Full
C.3.2	Samuel Street	Spread	1000	2	0.83	1.33	0.14	5.04	2.05	0.17	6.29	3.12	0.19	7.71
Watershed 4 - 1 Primary Channel Flow Issues Identified														
C.4.1	Mordington north side	Roadside ditch	800	1	1.17	1.20	0.07	3.50	1.96	0.13	6.50	3.04	0.10	5.00
Watershed 6 - 2 Primary Channel Flow Issues Identified														
C.6.2	Eagle Ave westside & MLK Intx	Roadside Ditch	590	1	2.55	2.23	0.17	8.50	3.75	0.23	Full	6.10	0.29	Full
C.6.3	Water St southwest side	Roadside Ditch	600	0	6.20	4.43	0.14	6.50	7.52	0.22	Full	12.31	0.30	Full
Watershed 7 - 3 Primary Channel Flow Issues Identified														
C.7.1	Water St westside	Spread	530	0	1.36	3.04	0.16	8.08	4.62	0.19	9.46	6.90	0.25	Full
C.7.4	Lawrence St westside	Spread	680	0	1.82	2.34	0.23	7.29	3.55	0.26	9.21	5.31	0.31	Full
C.7.5	Lawrence St eastside	Spread	750	0	2.12	3.43	0.26	9.04	5.21	0.31	Full	7.79	0.35	Full
Watershed 8 - 1 Primary Channel Flow Issues Identified														
C.8.1	North St northside	Spread	800	0	1.90	2.21	0.19	9.71	3.51	0.23	Full	5.35	0.27	Full
Watershed 9 - 1 Primary Channel Flow Issues Identified														
C.9.1	Washington St southside	Spread	1490	1	6.32	4.90	0.13	3.50	8.19	0.18	5.92	13.10	0.23	8.63
Watershed 10 - 7 Primary Channel Flow Issues Identified														
C.10.1	Samuel St eastside	Roadside ditch	600	0	4.67	4.08	0.14	6.00	6.87	0.20	9.00	11.16	0.26	Full
C.10.5	Mildred St eastside	Spread	1994	2	10.34	6.48	0.23	5.63	11.08	0.28	8.00	18.36	0.34	Full
C.10.6	Mildred St westside	Spread	1425	1	5.51	3.94	0.21	5.58	6.68	0.26	7.88	10.94	0.31	Full
C.10.7	Church St westside	Spread	1700	0	11.97	7.65	0.29	6.58	13.09	0.36	9.92	21.69	0.43	Full
C.10.8	Seminary St westside	Spread	1950	2	6.02	4.30	0.20	7.13	7.30	0.25	9.38	11.95	0.30	Full
C.10.10	Morrison St eastside	Spread	625	0	11.94	7.48	0.27	7.50	12.79	0.33	Full	21.20	0.37	Full
C.10.12	Morrison St westside	Spread	200		7.00	4.70	0.26	Full	7.98	0.31	Full	13.07	0.38	Full

Overland Relief/Ponding Issues					10 year storm							100 year storm						
Identifier	Location	Description	Approximated Weir Elevation	Drainage Area (Acre)	OLR Flow (cfs)	Depth (ft)	Approximated WSE	Buildings Impacted	Local Roadway Inundation (ft)	Primary Route Inundation (ft)	Singular Access Point Impacts	OLR Flow (cfs)	Depth (ft)	Approximated WSE	Buildings Impacted	Local Roadway Inundation (ft)	Primary Route Inundation (ft)	Singular Access Point Impacts
Watershed 1 - 4 Primary OLR Issues Identified																		
O.1.1	Avis Street	Roadway, Building, Parking Lot	497.00	92.68	115.84	1.70	498.70	1	160	0	No	195.36	1.99	498.99	2	170	0	No
O.1.2	Congress Street	Curb	499.50	89.33	50.19	0.39	499.89	1	80	0	No	126.83	0.65	500.15	2	105	0	No
O.1.3	Washington Street	Roadway	504.10	76.95	6.63	0.18	504.28	0	0	60	No	69.05	0.47	504.57	1	0	150	No
O.1.4	Liberty Street	Roadway	509.90	4.48	20.22	0.30	510.20	0	75	0	No	28.03	0.34	510.24	0	85	0	No
Watershed 2 - 3 Primary OLR Issues Identified																		
O.2.1	Mordington Ave	Roadway	494.25	44.43	26.44	0.36	494.61	0	65	0	No	55.04	0.49	494.74	0	85	0	No
O.2.2	George St and Academy St	Roadway	526.25	3	8.55	0.09	526.34	0	0	135	No	21.87	0.17	526.42	0	0	135	No
O.2.3	Samuel St and Academy St	Roadway	537.00	7.38	9.56	0.23	537.23	0	40	0	No	15.30	0.29	537.29	0	50	0	No
Watershed 3 - 3 Primary OLR Issues Identified																		
O.3.1	George Street Ext	Houses/Yards	493.00	10.28	17.31	0.69	493.69	2	0	0	No	26.38	0.80	493.80	2	0	0	No
O.3.2	Shutter Street	Roadway	501.00	9.35	17.76	0.21	501.21	1	50	0	No	26.74	0.27	501.27	1	75	0	No
O.3.3	Wall Street	Houses/Yards	512.10	7.63	14.24	0.41	512.51	2	220	0	No	21.45	0.64	512.74	2	240	0	No
Watershed 6 - 2 Primary OLR Issues Identified																		
O.6.1	MLK Jr Ave	Roadway	513.50	7.22	8.75	0.21	513.71	2	0	50	No	14.34	0.26	513.76	3	0	75	No
O.6.2	MLK Jr Ave	Roadway	513.70	5.38	6.52	0.18	513.88	1	0	40	No	10.68	0.22	513.92	2	0	85	No
Watershed 10 - 3 Primary OLR Issues Identified																		
O.10.1	Forrest Ave	Roadway	491.00	27.32	29.87	0.23	491.23	0	0	60	No	49.51	0.30	491.30	0	0	115	No
O.10.2	4th St	Curb	515.00	6.14	7.00	0.37	515.37	2	50	0	No	11.46	0.45	515.45	2	110	0	No
O.10.3	Hunter St	Houses/Yards	517.50	12.78	8.38	0.52	518.02	2	80	0	No	13.90	0.63	518.13	2	100	0	No

Appendix C- Ground Cover – Land Use Analysis Exhibit



Hydrology Coefficient and Karst Assumptions

*Hydraulic group D soils assumed for all areas except farms/unimproved which are assumed to be B soils based on the predominant soils from NRCS Soil Survey. *Watershed 1 has C-factor corrections for infiltration rather*

Ground Cover / Land Use	Curve Number	C-Factor	Approximate Percent Pervious/ Percent of Area Considered Karst	Karst Factor 2yr	Karst Factor 10yr	Karst Factor 100yr
Downtown Business*	90	0.53	0%	NA	NA	NA
1/8 Acre Residential	92	0.68	35.0%	0.78	0.83	0.87
1/4 Acre Residential	87	0.50	62.0%	0.53	0.64	0.73
1/2 Acre Residential	85	0.40	75.0%	0.43	0.55	0.65
Other Areas (approximately 1/3 imp.)	86	0.45	67.0%	0.49	0.60	0.70
Cemeteries, Parks, & Open Space	80	0.20	92.5%	0.35	0.45	0.55
Farms/Unimproved Areas (Bsoils)	61	0.15	100.0%	0.33	0.43	0.50

Watershed Hydrology Coefficients and Karst Factors

Runoff coefficients and karst factors based on area within primary study area/city boundary

Due to the significant imperviousness and historical development watershed 1 has been assumed to have no karst factor

	Total Area (acres)	Area within study (acres)	C-Factor	Curve Number	Percent Karst	Karst Factor 2yr	Karst Factor 10yr	Karst Factor 100yr	1" Runoff Volume (acre-ft)
Watershed 1	125.58	124.46	0.65	90	0%	NA	NA	NA	3.32
Watershed 2	63.42	63.42	0.45	86	66%	0.51	0.62	0.71	0.53
Watershed 3	30.88	26.40	0.60	89	46%	0.69	0.77	0.83	0.51
Watershed 4	23.07	23.07	0.50	87	60%	0.55	0.66	0.74	0.24
Watershed 5	226.75	64.80	0.37	72	76%	0.43	0.55	0.65	0.10
Watershed 6	221.50	62.73	0.41	80	72%	0.47	0.58	0.68	0.72
Watershed 7	61.89	50.36	0.59	85	45%	0.69	0.77	0.83	0.62
Watershed 8	51.97	20.80	0.55	88	54%	0.60	0.70	0.77	0.66
Watershed 9	85.25	41.93	0.53	87	52%	0.51	0.62	0.71	0.81
Watershed 10	212.76	126.51	0.44	85	68%	0.47	0.58	0.68	1.15

GROUND COVER - LAND USE LEGEND

- DOWNTOWN BUSINESS — C_{FACTOR} = 0.90, CURVE NUMBER = 95
- CEMETERIES, PARKS, & OPEN SPACE — C_{FACTOR} = 0.20, CURVE NUMBER = 80
- FARMS/UNIMPROVED AREAS — C_{FACTOR} = 0.15, CURVE NUMBER = 61
- 1/8 AC RESIDENTIAL — C_{FACTOR} = 0.68, CURVE NUMBER = 92
- 1/4 AC RESIDENTIAL — C_{FACTOR} = 0.50, CURVE NUMBER = 87
- 1/2 AC RESIDENTIAL — C_{FACTOR} = 0.40, CURVE NUMBER = 85
- OTHER AREAS (APPROX 1/3 IMPERVIOUS) — C_{FACTOR} = 0.45, CURVE NUMBER = 86

UNDERLYING HYDRAULIC SOIL GROUP D ASSUMED FOR ALL AREAS EXCEPT FARMS/UNIMPROVED AREAS WHICH ARE ASSUMED TO BE GROUP B BASED ON NRCS SOIL SURVEY DATA.

LEGEND

- WATERSHED BOUNDARY (STUDY AREA)
- WATERSHED BOUNDARY (OUTSIDE STUDY AREA)
- CITY LIMITS
- STREAM

500 0 500 1000

SCALE: 1" = 500'

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CITY OF CHARLES TOWN WATERSHEDS

GROUND COVER - LAND USE ANALYSIS

CITY OF CHARLES TOWN - JEFFERSON COUNTY, WEST VIRGINIA

Date: 03/23/2026

Scale: 1" = 500'

Designed By: ZJ/RLK/ZS

File No. 7037

Sheet 1 Of 1

Appendix D- Karst Swales Exhibit

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CITY OF CHARLES TOWN WATERSHEDS

KARST SWALES

CITY OF CHARLES TOWN - JEFFERSON COUNTY, WEST VIRGINIA

WS 1
WS 2
WS 3
WS 4
WS 5
WS 6
WS 7
WS 8
WS 9
WS 10

SUSPECTED SINKHOLE

MIDDLEWAY PIKE ROUTE 51
SUMMIT POINT RD ROUTE 13
EAGLE AVE
PARK ST
CENTER ST
LIBERTY STREET
WASHINGTON STREET
CONGRESS STREET
AVIS STREET
ACADEMY STREET
ANN STREET
HUNTER STREET
NORTH STREET
1st AVE
MASON STREET
GREEN STREET
FORREST AVE
WALL STREET
SHUTTER STREET
MORRISON STREET
MORRISON STREET EXT
MARYLEE AVE
M.L.K. AVE
HIGGS BLVD
MT PARK STREET
WATER STREET
WEST STREET
LAWRENCE STREET
CHARLES STREET
GEORGE STREET
SAMUEL STREET
MILDRED STREET
CHURCH STREET
SEMINARY STREET
PRESTON STREET
BROOME STREET
JEFFERSON AVE
AUGUSTINE AVE
PERRY DRIVE
SHUTT CT
CRAIGHILL DRIVE
MOORE CT
MORNINGTON STREET
SPRING BALE DR
VISTA CT
SWAN LAKE CT
RICE CT

KARST SWALES LEGEND

- UNDISTURBED KARST AREAS
- HISTORICAL KARST AREAS
- WATERSHED DIVIDE
- CITY LIMITS

300 0 300 600

SCALE: 1" = 300'

Date:	03/23/2026
Scale:	1" = 300'
Designed By:	ZJ/RLK/ZS
File No.	7037
Sheet	1 Of 1

Appendix E- Full Study Area Storm Sewer Exhibit

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CITY OF CHARLES TOWN WATERSHEDS

STORM SEWER INVENTORY

CITY OF CHARLES TOWN - JEFFERSON COUNTY, WEST VIRGINIA

WS 1
WS 2
WS 3
WS 4
WS 5
WS 6
WS 7
WS 8
WS 9
WS 10

1.1, 1.2, 1.3 & 1.4
1.5, 1.6 & 1.7
1.8, 1.9, 1.10, 1.11 & 1.12
2.1
2.2 & 2.3
3.1, 3.2 & 3.3
3.4 & 3.5
4.1, 4.2 & 4.3
5.1
5.2
5.3
5.4 & 5.5
5.6 & 5.7
5.8 & 5.9
5.10
6.1, 6.2, & 6.5
6.3 & 6.4
7.1, 7.2 & 7.3
7.4, 7.5 & 7.6
8.1
9.1 & 9.2
10.1, 10.2 & 10.3
10.4 & 10.5
10.6 & 10.7

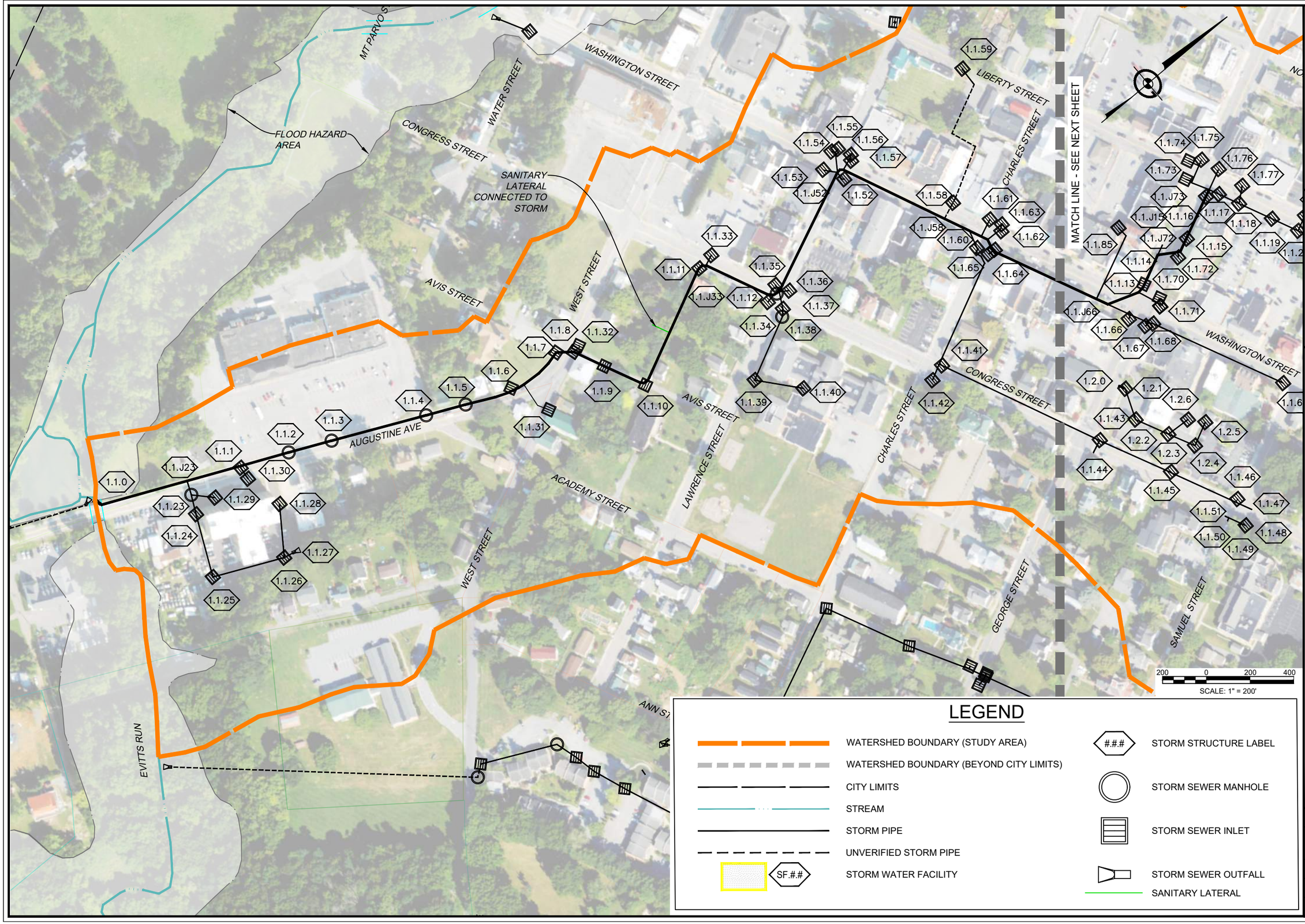
STORM INFRASTRUCTURE LEGEND

- STORM SEWER INLET
- STORM SEWER MANHOLE
- STORM PIPE
- CULVERT INLET, STORM SEWER OUTFALL
- WATERSHED DIVIDE
- 1.1 STORM SEWER SYSTEM
- CITY LIMITS

300 0 300 600
SCALE: 1" = 300'

Date:	03/23/2026
Scale:	1" = 300'
Designed By:	ZJ/RLK/ZS
File No.	7037
Sheet	1 Of 1

Appendix F- 11x17 Storm Sewer Inventory Exhibits



LEGEND

- WATERSHED BOUNDARY (STUDY AREA)
- WATERSHED BOUNDARY (BEYOND CITY LIMITS)
- CITY LIMITS
- STREAM
- STORM PIPE
- UNVERIFIED STORM PIPE
- SF.## STORM WATER FACILITY
- ### STORM STRUCTURE LABEL
- STORM SEWER MANHOLE
- STORM SEWER INLET
- STORM SEWER OUTFALL
- SANITARY LATERAL

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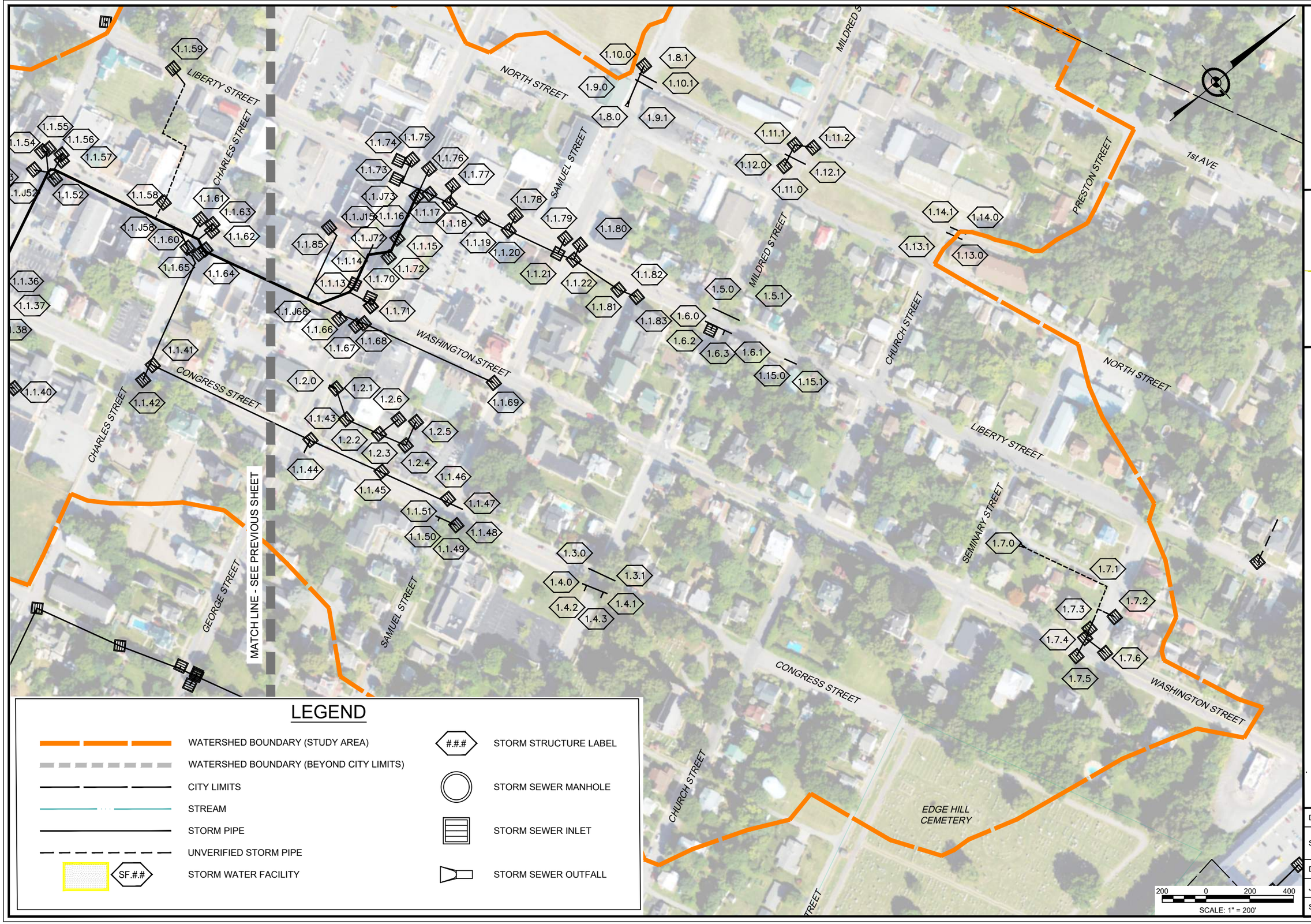
City of Charles Town Watersheds

City of Charles Town - Jefferson County, West Virginia

WATERSHED 1 STORM SEWER

DATE:	04/13/2026
SCALE:	1" = 200'
DESIGNED BY:	ZJ/ZS
JOB NO.	7037
SHEET	1 OF 2



LEGEND

- WATERSHED BOUNDARY (STUDY AREA)
- WATERSHED BOUNDARY (BEYOND CITY LIMITS)
- CITY LIMITS
- STREAM
- STORM PIPE
- UNVERIFIED STORM PIPE
- SF.#.# — STORM WATER FACILITY
- #.#.# — STORM STRUCTURE LABEL
- STORM SEWER MANHOLE
- STORM SEWER INLET
- STORM SEWER OUTFALL

200 0 200 400
SCALE: 1" = 200'

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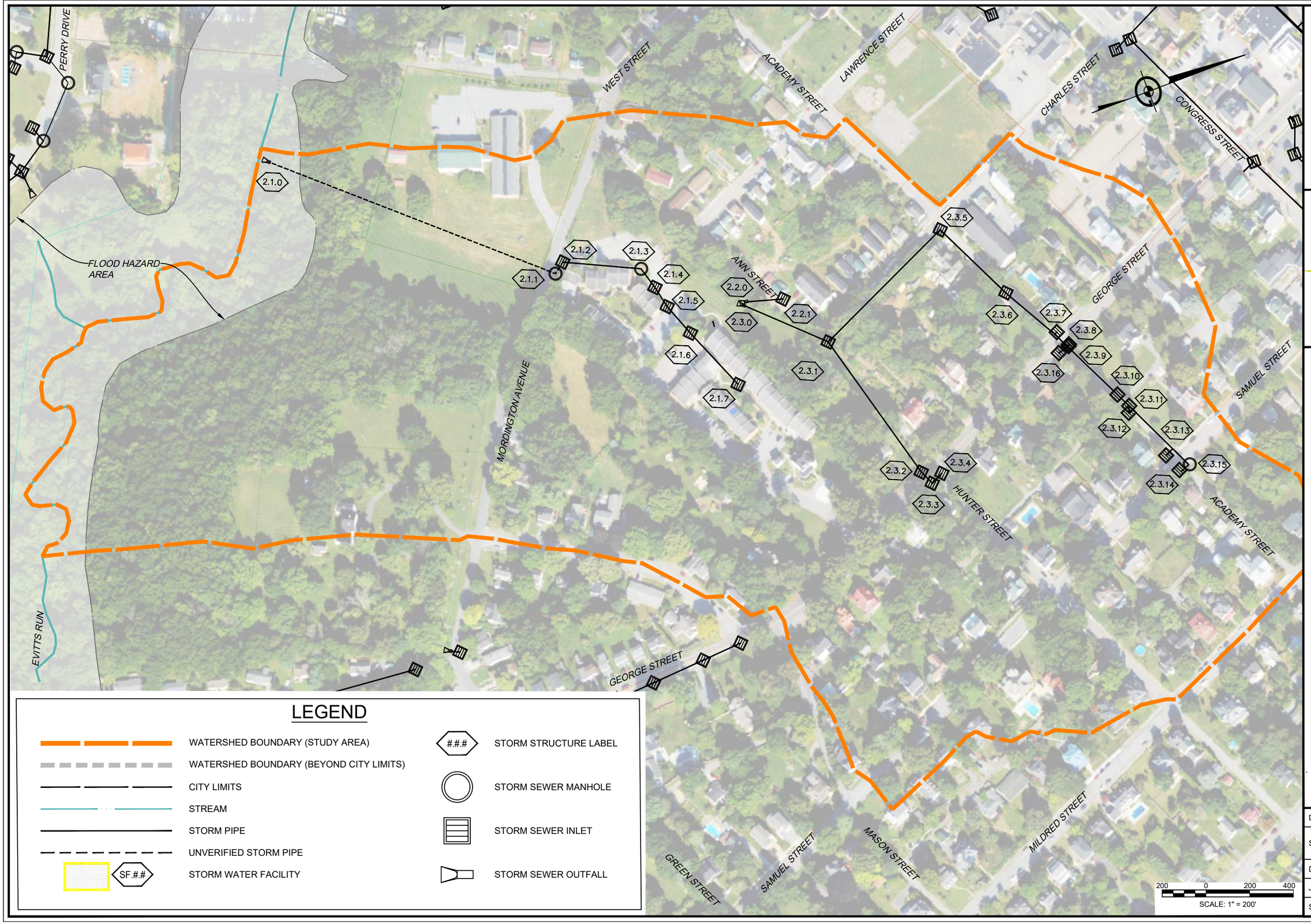
City of Charles Town - Jefferson County, West Virginia

WATERSHED 1 STORM SEWER

DATE: 04/13/2026
SCALE: 1" = 200'
DESIGNED BY: ZJ/ZS
JOB NO. 7037
SHEET 2 OF 2



LEGEND

- WATERSHED BOUNDARY (STUDY AREA)
- WATERSHED BOUNDARY (BEYOND CITY LIMITS)
- CITY LIMITS
- STREAM
- STORM PIPE
- UNVERIFIED STORM PIPE
- SF.#.# — STORM WATER FACILITY
- #.#.# — STORM STRUCTURE LABEL
- STORM SEWER MANHOLE
- STORM SEWER INLET
- STORM SEWER OUTFALL

200 0 200 400
SCALE: 1" = 200'

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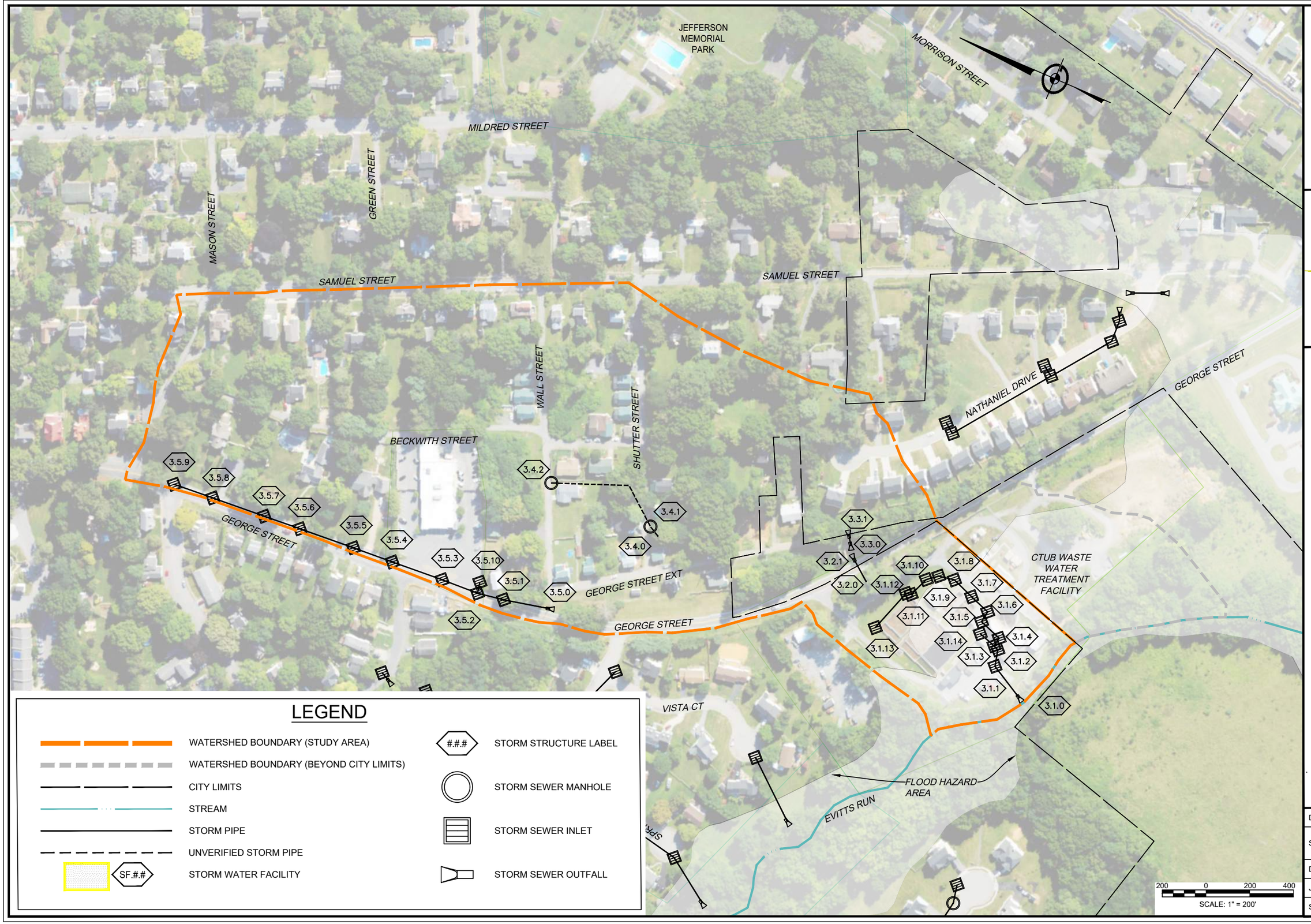
WATERSHED 2 STORM SEWER

DATE: 04/13/2026
SCALE: 1" = 200'
DESIGNED BY: ZJ/ZS
JOB NO. 7037
SHEET 1 OF 1



LEGEND

- WATERSHED BOUNDARY (STUDY AREA)
- WATERSHED BOUNDARY (BEYOND CITY LIMITS)
- CITY LIMITS
- STREAM
- STORM PIPE
- UNVERIFIED STORM PIPE
- SF.#.# STORM WATER FACILITY
- #.#.# STORM STRUCTURE LABEL
- STORM SEWER MANHOLE
- STORM SEWER INLET
- STORM SEWER OUTFALL

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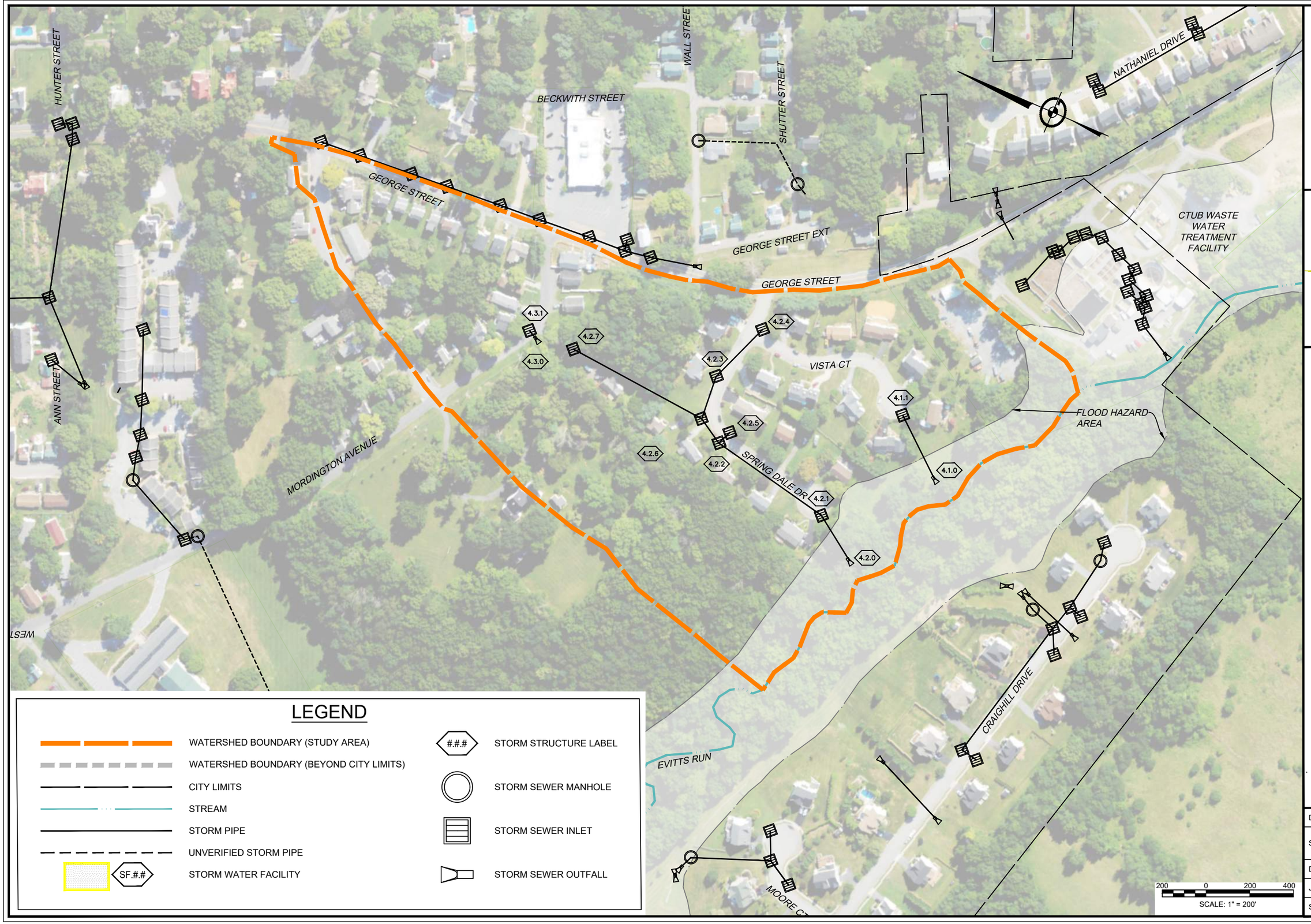
City of Charles Town - Jefferson County, West Virginia

WATERSHED 3 STORM SEWER

DATE:	04/13/2026
SCALE:	1" = 200'
DESIGNED BY:	ZJ/ZS
JOB NO.	7037
SHEET	1 OF 1



LEGEND

- WATERSHED BOUNDARY (STUDY AREA)
- WATERSHED BOUNDARY (BEYOND CITY LIMITS)
- CITY LIMITS
- STREAM
- STORM PIPE
- UNVERIFIED STORM PIPE
- SF.#.# — STORM WATER FACILITY
- #.#.# — STORM STRUCTURE LABEL
- STORM SEWER MANHOLE
- STORM SEWER INLET
- STORM SEWER OUTFALL

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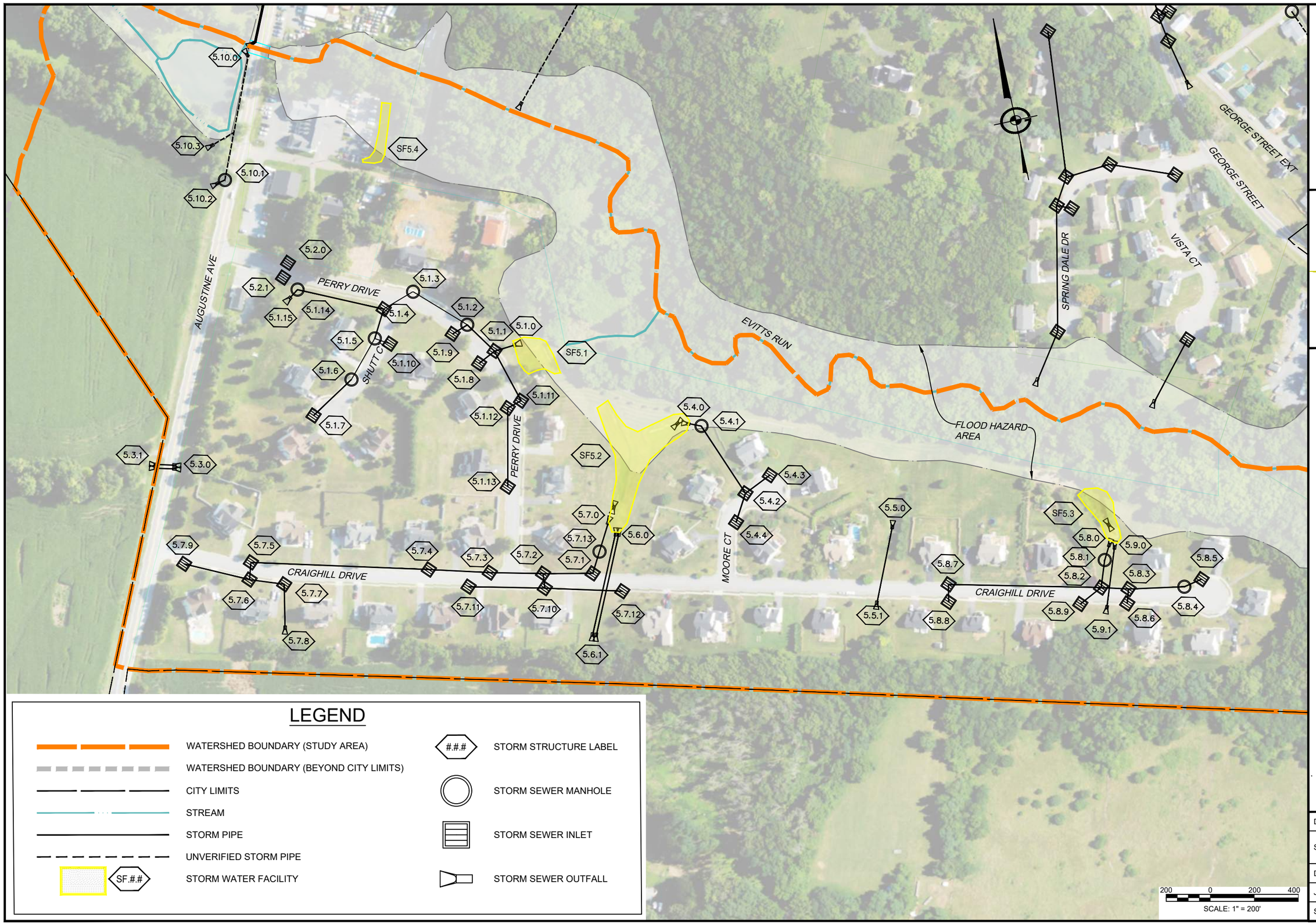
City of Charles Town - Jefferson County, West Virginia

WATERSHED 4 STORM SEWER

DATE:	04/13/2026
SCALE:	1" = 200'
DESIGNED BY:	ZJ/ZS
JOB NO.	7037
SHEET	1 OF 1



LEGEND

- WATERSHED BOUNDARY (STUDY AREA)
- WATERSHED BOUNDARY (BEYOND CITY LIMITS)
- CITY LIMITS
- STREAM
- STORM PIPE
- UNVERIFIED STORM PIPE
- SF.#.# — STORM WATER FACILITY
- #.#.# — STORM STRUCTURE LABEL
- STORM SEWER MANHOLE
- STORM SEWER INLET
- STORM SEWER OUTFALL

200 0 200 400
SCALE: 1" = 200'

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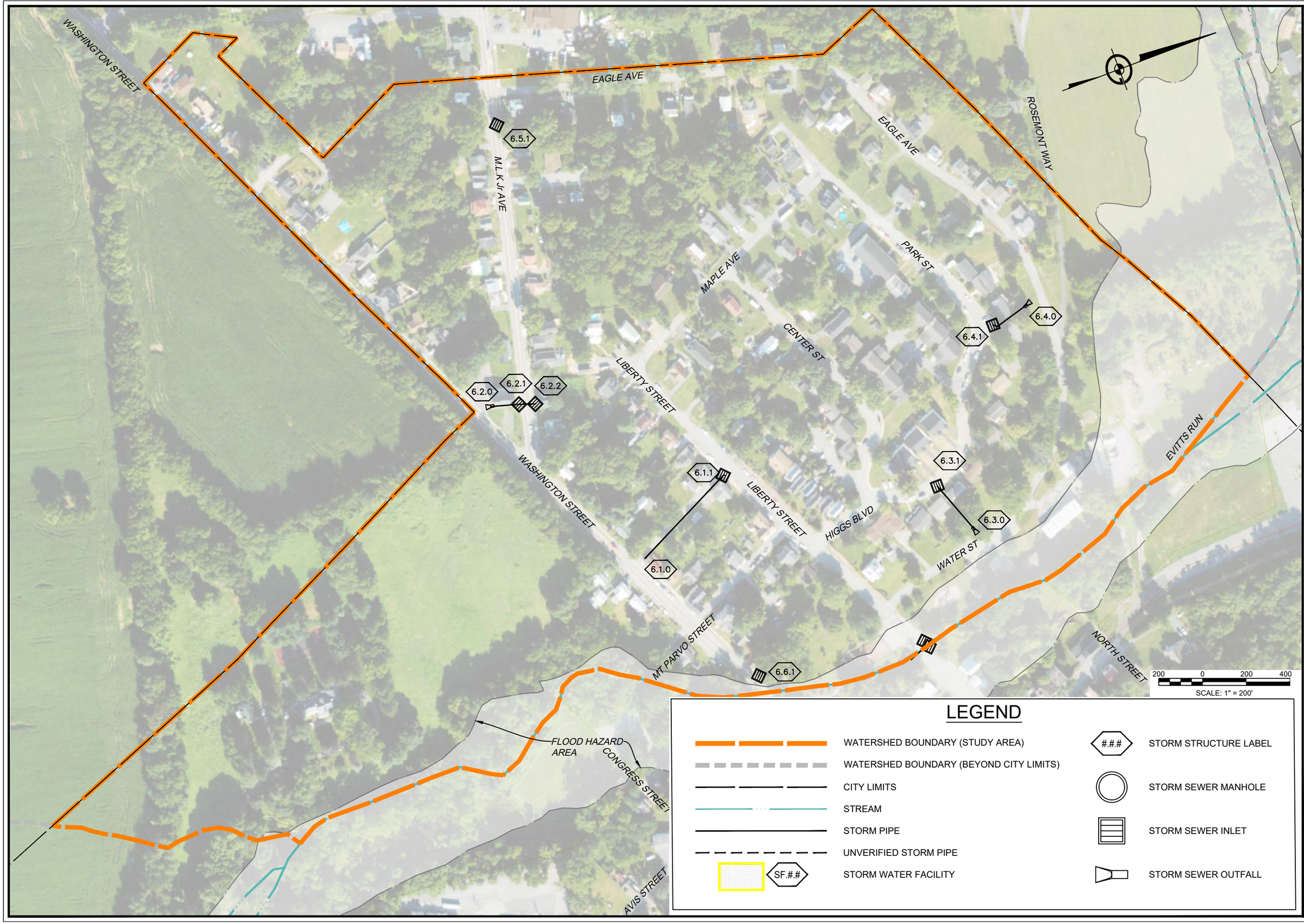
City of Charles Town - Jefferson County, West Virginia

WATERSHED 5 STORM SEWER

DATE: 04/13/2026
SCALE: 1" = 200'
DESIGNED BY: ZJ/ZS
JOB NO. 7037
SHEET 1 OF 1



LEGEND

- WATERSHED BOUNDARY (STUDY AREA)
- WATERSHED BOUNDARY (BEYOND CITY LIMITS)
- CITY LIMITS
- STREAM
- STORM PIPE
- UNVERIFIED STORM PIPE
- SF.## STORM WATER FACILITY
- #.## STORM STRUCTURE LABEL
- STORM SEWER MANHOLE
- STORM SEWER INLET
- STORM SEWER OUTFALL

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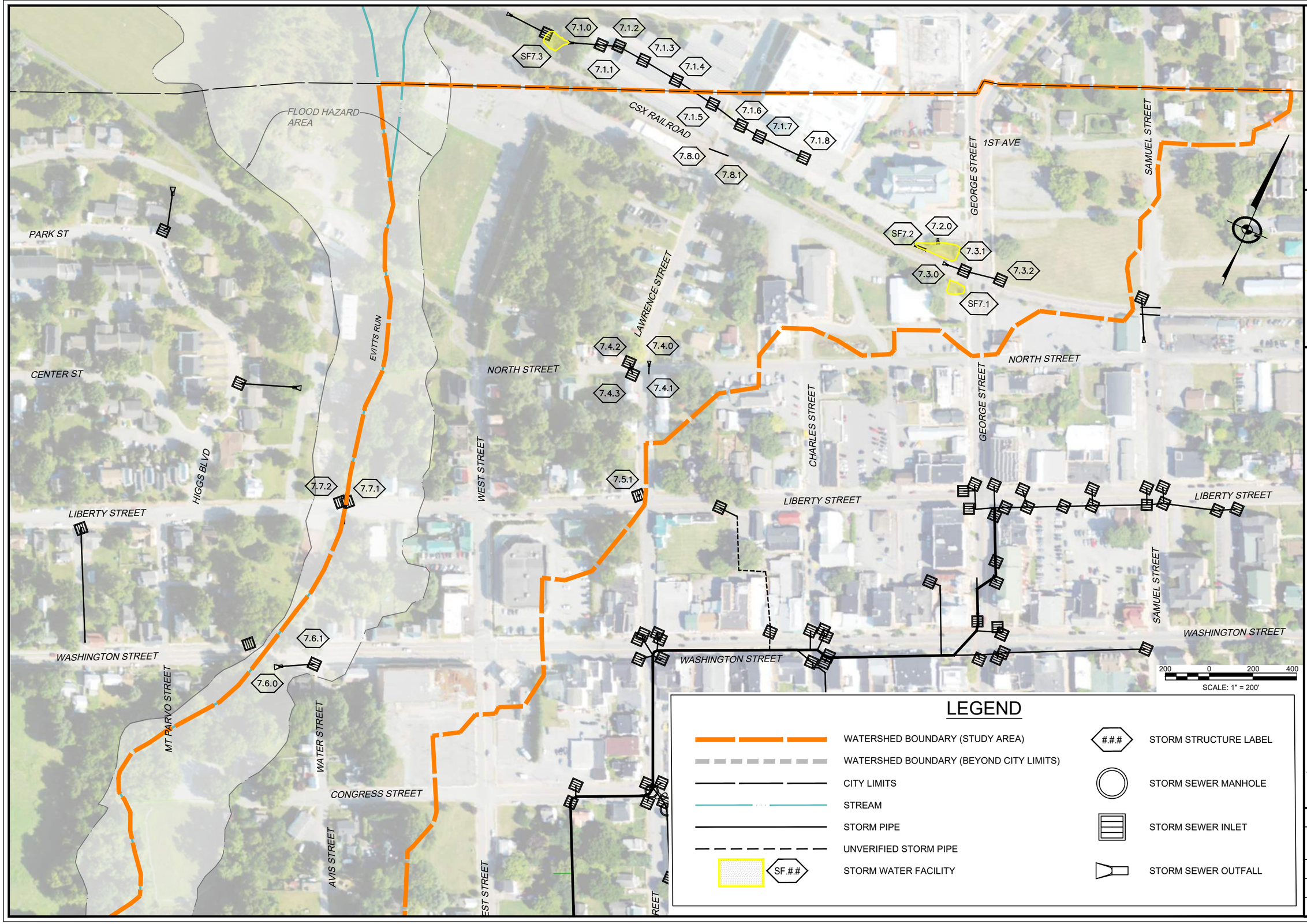
WATERSHED 6 STORM SEWER

DATE: 04/13/2026
SCALE: 1" = 200'
DESIGNED BY: ZJ/ZS
JOB NO. 7037
SHEET 1 OF 1



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City of Charles Town - Jefferson County, West Virginia

WATERSHED 7 STORM SEWER

DATE:	04/13/2026
SCALE:	1" = 200'
DESIGNED BY:	ZJ/ZS
JOB NO.	7037
SHEET	1 OF 1

MILDRED STREET

1st AVE

1st AVE

PRESTON STREET

CHARLES TOWN RACES

NORTH STREET

SAMUEL STREET

MILDRED STREET

CHURCH STREET

NORTH STREET

SEMINARY STREET

8.1.0

8.1.1

CHURCH STREET

WASHINGTON STREET

200 0 200 400

SCALE: 1" = 200'

LEGEND

- WATERSHED BOUNDARY (STUDY AREA)
- WATERSHED BOUNDARY (BEYOND CITY LIMITS)
- CITY LIMITS
- STREAM
- STORM PIPE
- UNVERIFIED STORM PIPE
- SF.## STORM WATER FACILITY
- #.#.# STORM STRUCTURE LABEL
- STORM SEWER MANHOLE
- STORM SEWER INLET
- STORM SEWER OUTFALL

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City of Charles Town Watersheds

City of Charles Town - Jefferson County, West Virginia

WATERSHED 8 STORM SEWER

DATE: 04/13/2026

SCALE: 1" = 200'

DESIGNED BY: ZJ/ZS

JOB NO. 7037

SHEET 1 OF 1

CHURCH STREET
SEMINARY STREET
WASHINGTON STREET
EDGE HILL CEMETERY
HUNTER STREET
MORRISON STREET
JEFFERSON AVENUE
WASHINGTON STREET
JEFFERSON AVENUE
WASHINGTON STREET
HUNTER STREET
JEFFERSON AVENUE
9.2.1
9.2.2
9.2.0
9.1.2
SF9.1
9.1.1
9.1.0
SF9.2
200 0 200 400
SCALE: 1" = 200'

LEGEND

- WATERSHED BOUNDARY (STUDY AREA)
- WATERSHED BOUNDARY (BEYOND CITY LIMITS)
- CITY LIMITS
- STREAM
- STORM PIPE
- UNVERIFIED STORM PIPE
- SF.#.# STORM WATER FACILITY
- #.#.# STORM STRUCTURE LABEL
- STORM SEWER MANHOLE
- STORM SEWER INLET
- STORM SEWER OUTFALL

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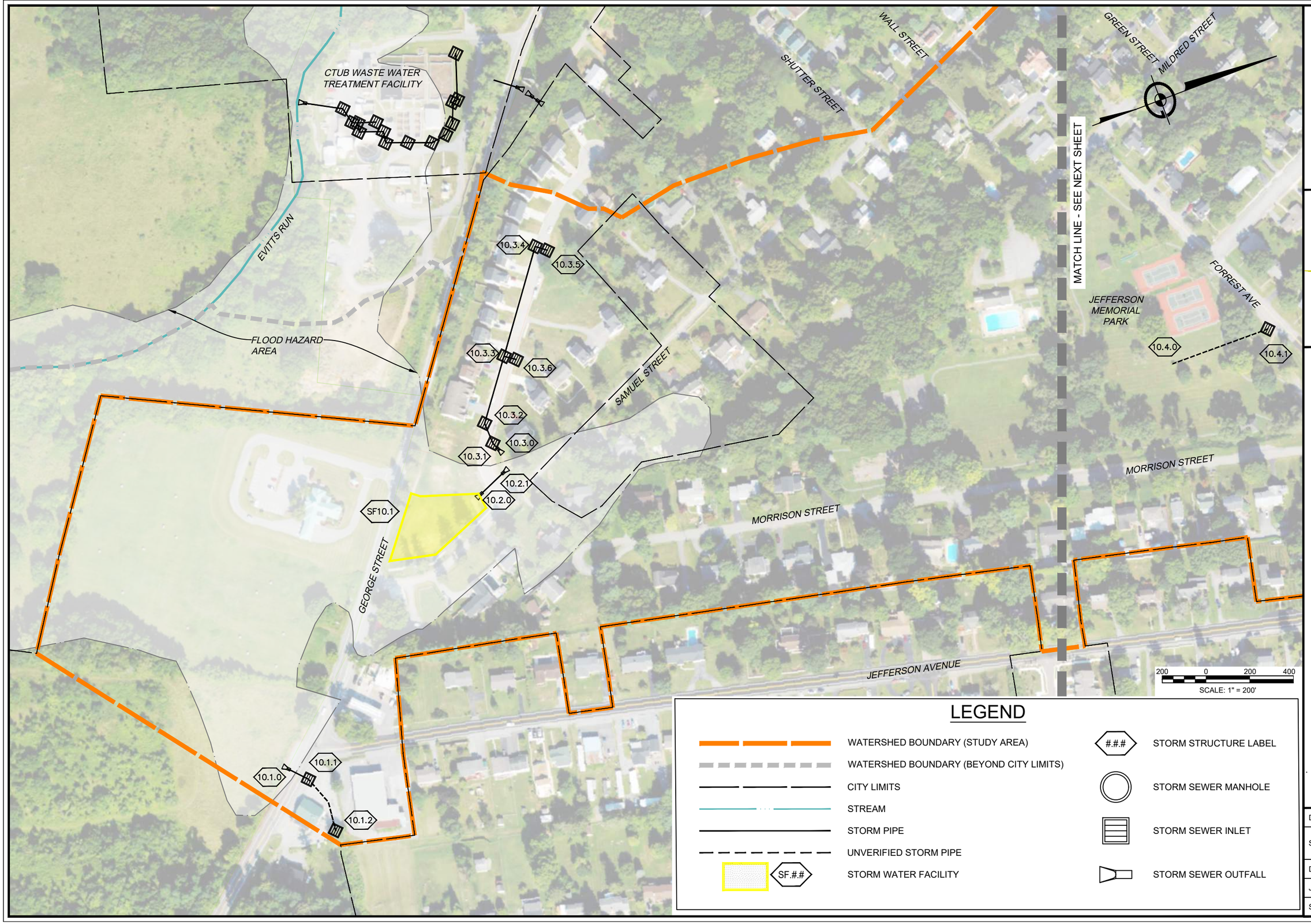
City of Charles Town Watersheds

City of Charles Town - Jefferson County, West Virginia

WATERSHED 9 STORM SEWER

DATE: 04/13/2026
SCALE: 1" = 200'
DESIGNED BY: ZJ/ZS
JOB NO. 7037
SHEET 1 OF 1



LEGEND

- WATERSHED BOUNDARY (STUDY AREA)
- WATERSHED BOUNDARY (BEYOND CITY LIMITS)
- CITY LIMITS
- STREAM
- STORM PIPE
- UNVERIFIED STORM PIPE
- SF.#.# — STORM WATER FACILITY
- #.#.# — STORM STRUCTURE LABEL
- STORM SEWER MANHOLE
- STORM SEWER INLET
- STORM SEWER OUTFALL

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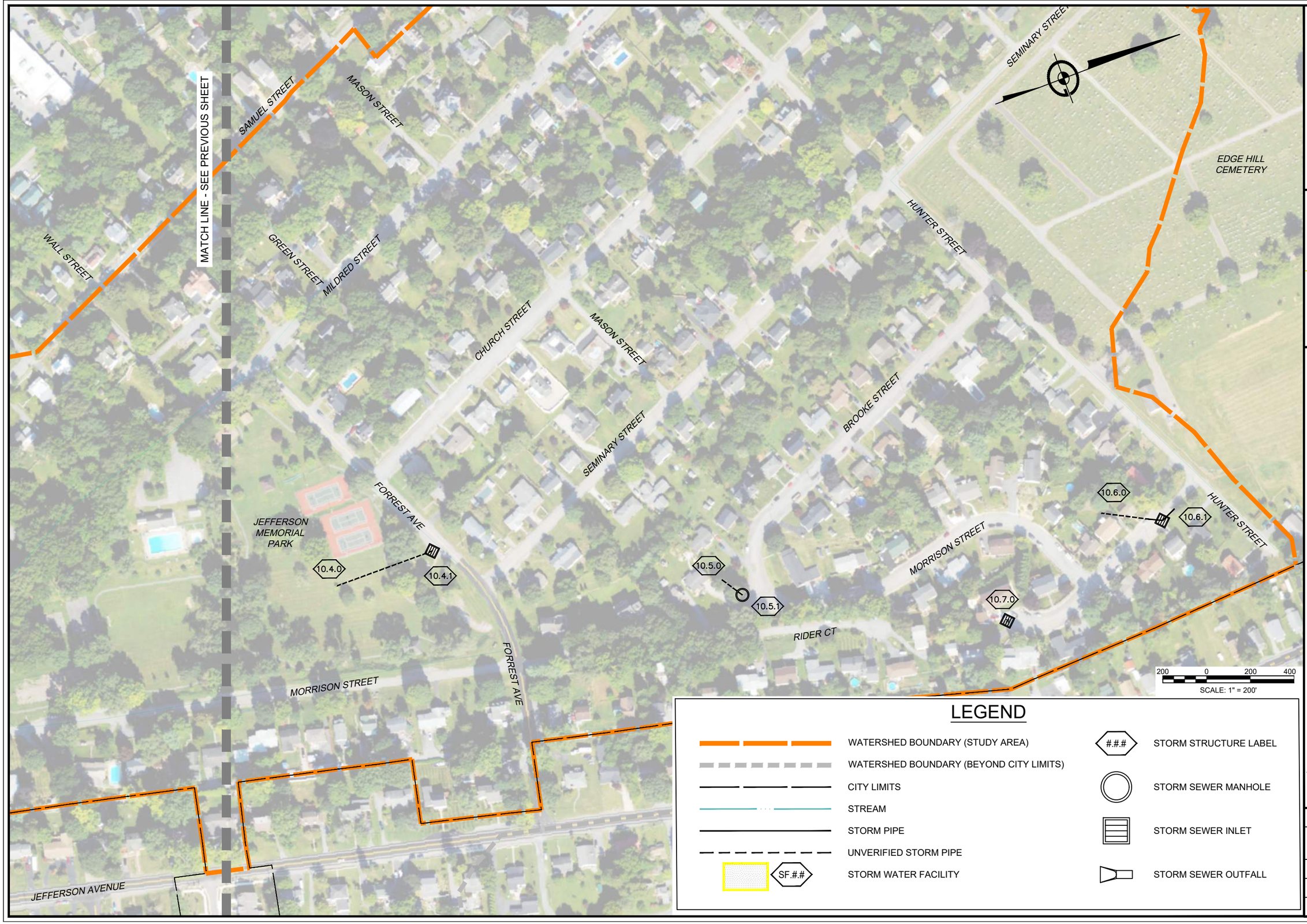
City of Charles Town Watersheds

City of Charles Town - Jefferson County, West Virginia

WATERSHED 10 STORM SEWER

DATE:	04/13/2026
SCALE:	1" = 200'
DESIGNED BY:	ZJ/ZS
JOB NO.	7037
SHEET	1 OF 2



LEGEND

- WATERSHED BOUNDARY (STUDY AREA)
- WATERSHED BOUNDARY (BEYOND CITY LIMITS)
- CITY LIMITS
- STREAM
- STORM PIPE
- UNVERIFIED STORM PIPE
- SF.#.# — STORM WATER FACILITY
- #.#.# — STORM STRUCTURE LABEL
- STORM SEWER MANHOLE
- STORM SEWER INLET
- STORM SEWER OUTFALL

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City of Charles Town Watersheds

City of Charles Town - Jefferson County, West Virginia

WATERSHED 10 STORM SEWER

DATE:	04/13/2026
SCALE:	1" = 200'
DESIGNED BY:	ZJ/ZS
JOB NO.	7037
SHEET	2 OF 2

Appendix -Watershed 1

Watershed 1 consists of majority of the historic section of Charles Town and its drainage path to Evitts Run. This watershed is the largest and most intensely developed within the City. A previous analysis was performed for the primary storm sewer trunk line identified as system 1.1 which represents the most concentrated discharge within the City. This system was not re analyzed with this overall city evaluation and the previously published computations were integrated into this study. A portion of watershed 1 lies to the North of the CSX railroad and although two systems provide drainage across the track it is assumed that majority of the runoff from this area infiltrates through the ballast of the railroad or is conveyed through the ballast along the track. No suspected stormwater management facilities were identified within watershed 1.

Storm Sewer and Culverts

The storm sewer within watershed 1 includes fifteen individually identified systems/culverts.

System 1 discharges to Evitts Run at the stream crossing on Augustine Avenue. This system utilized brick box culverts and structures for the trunk line. In many areas the trunk line is extremely shallow and is capped with sidewalk or steel plates directly under the roadway pavement. It is recommended the City perform periodic structural assessments of these areas of the trunk line to ensure stability as structural failure would present a significant threat to public safety. Due to the custom nature of these underground structures a licensed structural engineer should provide structural assessments. The upper end of system 1 is located along Liberty Street and has undergone recent improvements to provide additional inlet and conduit capacity along Liberty Street. A sanitary lateral connection has been documented connecting to the trunk line between structures 1.1.10 and 1.1.11. Other sanitary connections may exist and would require a more intensive study to document or rule out.

System 2 consists of a private storm sewer system surrounding the Bank of Charles Town. This system was not evaluated.

Systems 3 and 4 provide drainage across the intersection of Congress and Mildred Street. The systems most likely were installed as culverts originally and modified over the years with street and sidewalk improvements.

Systems 5 and 6 provide drainage across the intersection of Mildred and Liberty Street. The systems most likely were installed as culverts and modified over the years with street and sidewalk improvements.

System 7 provides drainage at the intersection of Court and Washington Street. This area is a low point along Washington Street and receives runoff from not only the roads but an upland area to

the south of Washington Street. The routing to the outfall (1.7.0) is unclear and either contains a buried structure or utilized bends in the storm sewer pipe. The system discharges along Jenkins Way.

Systems 8, 9, and 10 provide drainage around the intersection of Samuel Street and the CSX railroad. Culverts identified as systems 9 and 10 seem to have little actual functionality as they were installed such that the culvert ends are above grade.

Systems 11 and 12 provide drainage around the intersection of Mildred Street and the CSX railroad. The culvert identified as system 12 seem to have little actual functionality as it was installed such that the culvert ends are above grade.

Systems 13 and 14 consist of culverts on each side of the CSX railroad at its intersection with Church Street. The culverts seem to have little actual functionality as they were installed such that the culvert ends are above grade.

System 15 consists of a culvert serving a private driveway.

Channel/Roadway Spread Analysis

Watershed 1 contains no major open space channels and many roadway spread concerns. Twelve points were analyzed for roadway spread and are listed in the table below.

Identifier	Location	Description
C.1.1	Augustine Ave westside	Spread
C.1.2	Augustine Ave eastside	Spread
C.1.3	Congress St southside	Spread
C.1.4	Congress St northside	Spread
C.1.5	George St eastside	Spread
C.1.6	Mildred St eastside	Spread
C.1.7	Washington southside	Spread
C.1.8	Washington northside	Spread
C.1.9	George St eastside	Spread
C.1.10	Liberty St southside	Spread
C.1.11	Liberty St northside	Spread
C.1.12	Samuel St	Spread

Depressions

Three depressions were identified within watershed 1.

D1.1 is a depression within private property contained in the City block surrounded by Washington, Liberty, Charles and Lawrence streets and does not appear to have storm sewer drainage. A concrete structure top was identified behind 220 Washington Street and potentially

facilitates drainage. The structure top was inaccessible due to an aging manhole top and parked vehicles. Overland relief was not assessed as this appears to be a private drainage issue.

D1.2 is a depression behind United Bank located at 106 Washington Street and contains a trench drain (1.1.85) that is expected to be connected to the trunk line along Washington Street identified as system 1. The routing of the storm conduit is unclear and would require further study. The depression is identified as it is expected to have inadequate drainage. Overland relief was not assessed as this appears to be a private drainage issue.

D1.3 appears to be a sinkhole located in the playground associated with Oakland Community Church (301 North Mildred Street). This suspected sinkhole is located on private property.

Overland Relief

Six points within watershed 1 were evaluated for overland relief.

O.1.1 evaluates potential ponding at the intersection of Avis Street and West Street. Water must overtop a private gravel parking area and the curb ramp at West Street before continuing down Augustine Avenue. A storm sewer inlet (1.1.9) is present at the low point as well as many upstream inlets within the drainage and the pipe capacity is accounted for in the analyses.

O.1.2 evaluates ponding at the low point in Congress Street between West and Lawrence Streets. Runoff must overtop the curb and pass between the houses to the south of Congress Street. An inlet is present on both sides of the low point in Congress Street (1.1.11 and 1.1.33) and the flow capacity of the pipe has been deducted from the calculated flow rates to this analyses point.

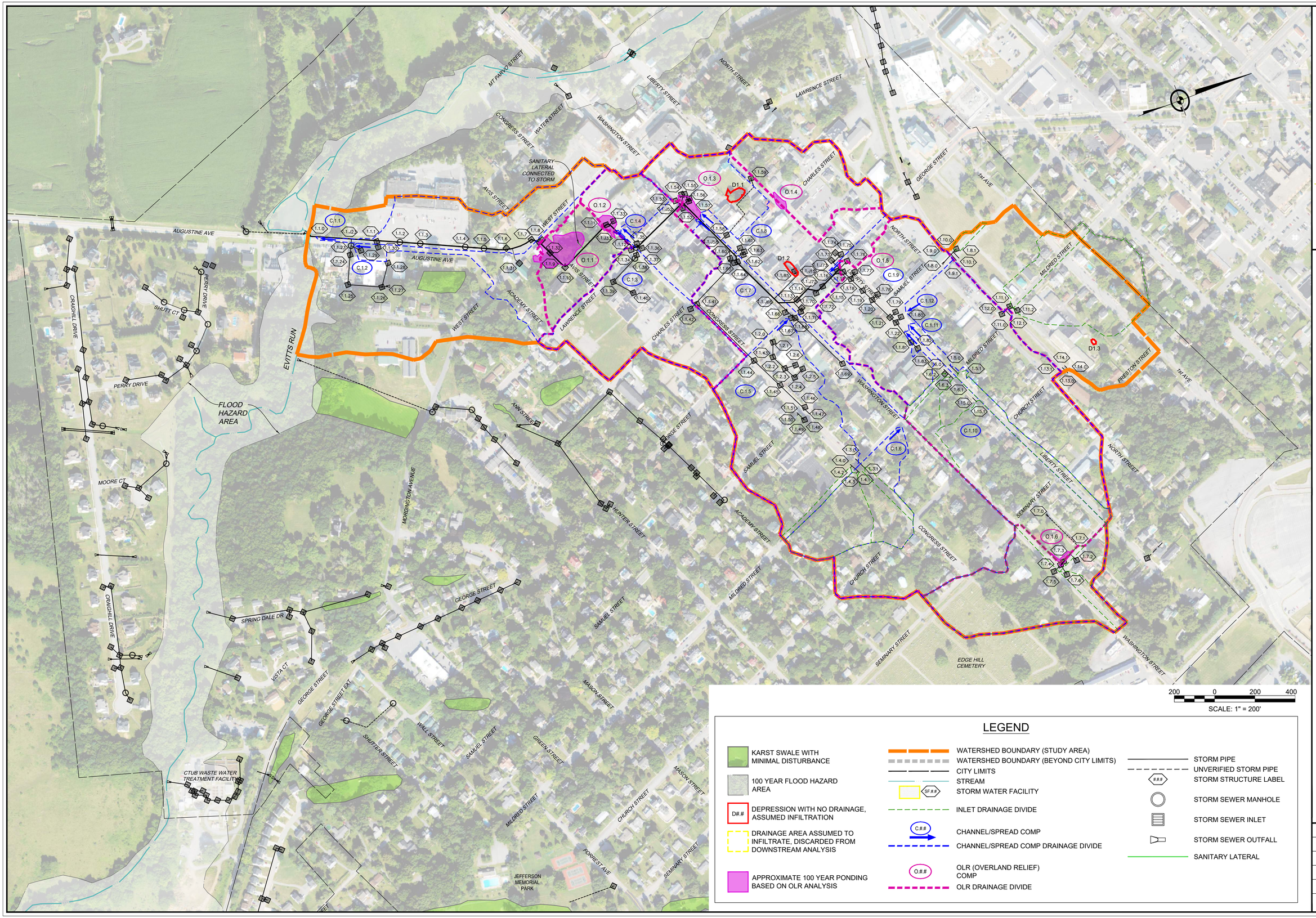
O.1.3 analyzes where water must overtop the crown of Washington Street at its intersection with Lawrence Street. The runoff continues down Lawrence Street after overtopping the crown of the roadway. As many inlets are present along Washington Street the storm sewer capacity was accounted for in the analyses.

O.1.4 assessed the ponding resulting from runoff overtopping the crown of Liberty Street at its intersection with Charles Street. No inlets were present at this location or upstream.

O.1.5 evaluated potential ponding at the corner of Liberty Street and George Street. It was found that the storm sewer provides adequate capacity to carry the 100 year storm at this location and recent improvements were completed to provide additional inlet capacity along the low point of Liberty Street.

O.1.6 evaluated ponding at the low point in Washington Street near its intersection with Court Street. Storm sewer(system 1.7) is present at this location mitigating the potential ponding.

O.1.7 analysis flows across the crown of George street.



LEGEND

- KARST SWALE WITH MINIMAL DISTURBANCE
- 100 YEAR FLOOD HAZARD AREA
- D#.# — DEPRESSION WITH NO DRAINAGE, ASSUMED INFILTRATION
- DRAINAGE AREA ASSUMED TO INFILTRATE, DISCARDED FROM DOWNSTREAM ANALYSIS
- APPROXIMATE 100 YEAR PONDING BASED ON OLR ANALYSIS
- WATERSHED BOUNDARY (STUDY AREA)
- WATERSHED BOUNDARY (BEYOND CITY LIMITS)
- CITY LIMITS
- STREAM
- SF.## — STORM WATER FACILITY
- INLET DRAINAGE DIVIDE
- C.## — CHANNEL/SPREAD COMP
- CHANNEL/SPREAD COMP DRAINAGE DIVIDE
- O.## — OLR (OVERLAND RELIEF) COMP
- OLR DRAINAGE DIVIDE
- STORM PIPE
- UNVERIFIED STORM PIPE
- ### — STORM STRUCTURE LABEL
- STORM SEWER MANHOLE
- STORM SEWER INLET
- STORM SEWER OUTFALL
- SANITARY LATERAL

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CITY OF CHARLES TOWN WATERSHEDS

WATERSHED 1 H&H ANALYSIS EXHIBIT

CITY OF CHARLES TOWN - JEFFERSON COUNTY, WEST VIRGINIA

Date:	04/08/2026
Scale:	1" = 200'
Designed By:	ZJ/RLK/ZS
File No.	7037
Sheet	1 Of 1

Roadside Ditch and Roadway Spread Analysis

Watershed 1

															2 Year							10 Year							100 Year						
															2yr Karst Factor	1						10yr Karst Factor	1						100yr Karst Factor	1					
Identifier	Location	Description	Side Slope 1 (H ft:1 ft)	Side Slope 2 (H ft:1 ft)	Upstream Road Length(ft)	Upstream Intersections	Available Depth for Ditch/Gutter(ft)	Available Width for Spread (ft)	Approximate Running Slope (%)	Drainage Area (Acre)	C Factor	Tc (Min)	Inlets Present	Throat Inlet or 2 Grates Present	Storm sewer capacity (cfs)	Rainfall Intensity (in/hr)	Flow (cfs)	Overland Flow (cfs)	Depth of flow (ft)	Roadway Surcharge (ft)	Spread (ft)	Travel Lane Spread (ft)	Rainfall Intensity (in/hr)	Flow (cfs)	Overland Flow (cfs)	Depth of flow (ft)	Roadway Surcharge (ft)	Spread (ft)	Travel Lane Spread (ft)	Rainfall Intensity (in/hr)	Flow (cfs)	Overland Flow (cfs)	Depth of flow (ft)	Roadway Surcharge (ft)	Spread (ft)	Travel Lane Spread (ft)
C.1.1	Augustine Ave westside	Spread	NA	NA	1835	1	0	8	2%	5.34	0.89	15	See note			3.04	14.45	0.00	0.00	0.00	0.00	0.00	4.18	19.87	12.77	0.33	0.33	16.46	8.46	5.84	27.76	27.76	0.44	0.44	22.00	Full
C.1.2	Augustine Ave eastside	Spread	NA	NA	1800	1	0	8	2%	95.56	0.54	20	2+	Yes	201.64	2.72	140.36	0.00	0.00	0.00	0.00	0.00	3.77	194.54	0.00	0.00	0.00	0.00	0.00	5.33	275.04	73.40	0.63	0.63	31.71	Full
C.1.3	Congress St southside	Spread	NA	NA	2600	2	0	10	1%	7.78	0.70	15	See note			3.04	16.56	0.00	0.00	0.00	0.00	0.00	4.18	22.76	22.76	0.47	0.47	23.25	Full	5.84	31.80	31.80	0.53	0.53	26.38	Full
C.1.4	Congress St northside	Spread	NA	NA	1500	1	0	10	1%	79.49	0.53	20	2+	Yes	141.68	2.72	114.59	0.00	0.00	0.00	0.00	0.00	3.77	158.83	17.15	0.42	0.42	20.92	Full	5.33	224.55	82.87	0.76	0.76	37.79	Full
C.1.5	George St eastside	Spread	NA	NA	2100	3	0	10	1%	9.83	0.44	15	3	Yes	5.72	3.04	13.15	7.43	0.31	0.31	15.29	5.29	4.18	18.08	12.36	0.37	0.37	18.50	8.50	5.84	25.26	19.54	0.44	0.44	21.96	Full
C.1.6	Mildred St eastside	Spread	NA	NA	1650	2	0	7	2%	4.76	0.36	10	2	Yes	7.64	3.72	6.37	0.00	0.00	0.00	0.00	0.00	5.07	8.69	1.05	0.13	0.13	6.46	0.00	7.03	12.05	4.41	0.22	0.22	11.04	4.04
C.1.7	Washington southside	Spread	NA	NA	2760	6	0.1	9	1%	29.68	0.46	20	See note			2.72	37.14	0.00	0.00	0.00	0.00	0.00	3.77	51.47	0.00	0.00	0.00	0.00	0.00	5.33	72.77	54.13	0.64	0.54	32.21	Full
C.1.8	Washington northside	Spread	NA	NA	2200	3	0.1	9	1%	43.69	0.54	20	2+	Yes	144.39	2.72	64.17	0.00	0.00	0.00	0.00	0.00	3.77	88.94	0.00	0.00	0.00	0.00	0.00	5.33	125.75	0.00	0.00	0.00	0.00	0.00
C.1.9	George St eastside	Spread	NA	NA	1530	2	0	8	1%	33.12	0.44	20	2+	Yes	87.55	2.72	39.64	0.00	0.00	0.00	0.00	0.00	3.77	54.94	0.00	0.00	0.00	0.00	0.00	5.33	77.67	0.00	0.00	0.00	0.00	0.00
C.1.10	Liberty St southside	Spread	NA	NA	2000	3	0	10	3%	14.71	0.32	20	2	Yes	1.11	2.72	12.80	11.69	0.30	0.30	14.75	4.75	3.77	17.75	16.64	0.34	0.34	16.83	6.83	5.33	25.09	23.98	0.39	0.39	19.33	9.33
C.1.11	Liberty St northside	Spread	NA	NA	1300	2	0	10	3%	1.46	0.37	10	0	No	0	3.72	2.01	2.01	0.15	0.15	7.63	0.00	5.07	2.74	2.74	0.17	0.17	8.58	0.00	7.03	3.80	3.80	0.19	0.19	9.67	0.00
C.1.12	Samuel St	Spread	NA	NA	1540	2	0	6	1%	9.10	0.37	15	0	No	0	3.04	10.24	10.24	0.35	0.35	17.25	Full	4.18	14.07	14.07	0.39	0.39	19.42	Full	5.84	19.66	19.66	0.44	0.44	22.04	Full

NOTES

C factors have been adjusted to 65% of their value for specified land uses other than the downtown/business land use to account for karst infiltration

For roadside ditches available depth is the approximated depth of the ditch outside the roadway, 0.1' is indicative of no defined roadside ditch

For spread comps available depth of 0' is indicative of no gutter pan and 0.1' is indicative of a gutter pan

For spread comps a negative available spread is indicative of a local depression that results in an initial spread for all storm events

Upstream Intersections within 500ft of the highpoint are excluded from the upstream intersection counts

Upstream road length is established based on upstream inlets, high points, expected road length impacts, and limited by any upstream channel comps to prevent redundancy

Available width is the approximated area available for spread outside an assumed 10ft travel lane

Roadway surcharge depth is the expected depth of water at the edge of pavement

Mannings n assumptions; ditch/channel = 0.025; road/gutter spread = .016

Road cross slopes assumed at 2%

Storm sewer capacity is only accounted for were either throat inlets or redundant grate inlets are present within the 100 year ponding area and utilizes the capacity of the pipe at the channel comp location

Where ditch and spread comps are performed on both sides of the street, the storm sewer capacity is alloted to the side of the street with a larger drainage shed and any remaining capacity is alloted to the adjacent analysis

Overland Relief Analysis (OLR)

Watershed 1

										10 Year									100 Year							
										10yr Karst Factor					1				100yr Karst Factor					1		
Identifier	Location	Description	Approximated Weir Elevation	Inlets Present	Throat Inlet or 2 Grates Present	Storm sewer capacity (cfs)	Drainage Area (Acre)	C Factor	Tc (Min)	Rainfall Intensity (in/hr)	OLR Flow (cfs)	Depth (ft)	Approximated WSE	Buildings Impacted	Local Roadway Inundation (ft)	Primary Route Inundation (ft)	Singular Access Point Impacts	Rainfall Intensity (in/hr)	OLR Flow (cfs)	Depth (ft)	Approximated WSE	Buildings Impacted	Local Roadway Inundation (ft)	Primary Route Inundation (ft)	Singular Access Point Impacts
O.1.1	Avis Street	Roadway, Building, Parking Lot	497.00	2+	Yes	76.33	92.68	0.55	20	3.77	115.84	1.70	498.70	1	160	0	No	5.33	195.36	1.99	498.99	2	170	0	No
O.1.2	Congress Street	Curb	499.50	2+	Yes	135.04	89.33	0.55	20	3.77	50.19	0.39	499.89	1	80	0	No	5.33	126.83	0.65	500.15	2	105	0	No
O.1.3	Washington Street	Roadway	504.10	2+	Yes	144.22	76.95	0.52	20	3.77	6.63	0.18	504.28	0	0	60	No	5.33	69.05	0.47	504.57	1	0	150	No
O.1.4	Liberty Street	Roadway	509.90	0	No	0.00	4.48	0.89	10	5.07	20.22	0.30	510.20	0	75	0	No	7.03	28.03	0.34	510.24	0	85	0	No
O.1.5	Liberty Street	Roadway/George St Intx	510.21	9	Yes	87.65	32.58	0.43	20	3.77	0.00	0.00	NA	0	0	0	No	5.33	0.00	0.00	NA	0	0	0	No
O.1.6	Court Street	Houses/Yards	537.90	5	Yes	6.14	6.96	0.25	15	4.18	1.13	0.12	538.02	1	0	0	No	5.84	4.02	0.20	538.10	1	25	0	No
O.1.7	Court Street	Houses/Yards	538.62	1	No	0.00	5.46	0.23	15	4.18	5.25	0.18	538.80	0	0	50	No	5.84	7.33	0.21	538.83	0	0	60	No

NOTES

Weir coefficient assumed as 3.27

C factors have been adjusted to 65% of their value for specified land uses other than the downtown/business land use to account for karst infiltration

OLR flow accounts for storm sewer capacity where redundant inlets are present to ensure drainage

Storm sewer capacity is only accounted for were either throat inlets or redundant grate inlets are present within the 100 year ponding area

Storm Sewer Pipe Analysis

Watershed 1

																									2 Year					10 Year				
																									2yr Karst Factor				1	10yr Karst Factor				1
Old Upstream Structure Name	Old Downstream Structure Name	Inlet/Structure Name	Downstream Structure	Structure Type	Inlet Size (in)	Inlet Profile	Approximate Top Elevation/Invert	Approximate Invert Up	Approximate Invert Down	Pipe Length (ft)	Pipe Material	Pipe Size (in)	Approximate Pipe Slope (%)	Pipe Mannings 'n'	Flow Area (ft^2)	Hydraulic Radius	Full Flow Box (cfs)	Full Flow Pipe (cfs)	Full Flow Capacity (cfs)	Inlet C Factor	Inlet Drainage Area (Acres)	Time to Inlet (min)	System C Factor	System Drainage Area (Acre)	System Time (Min)	Inlet Rainfall Intensity (in/hr)	Flow To Inlet (cfs)	System Rainfall Intensity (in/hr)	System Flow (cfs)	System Flow/Pipe Full Flow (%)	Inlet Rainfall Intensity (in/hr)	Flow To Inlet (cfs)	System Rainfall Intensity (in/hr)	System Flow (cfs)	System Flow/Pipe Full Flow (%)
		1.2.6	1.2.3	Grate	33 X 33	Sag	Private System, Not Evaluated																											
		1.2.5	1.2.4	Grate	33 X 33	Sag																												
NA		1.2.4	1.2.3	Grate	33 X 33	Sag																												
		1.2.3	1.2.2	Grate	33 X 33	Sag																												
		1.2.2	1.2.1	Grate	33 X 33	Sag																												
		1.2.1	1.2.0	Grate	33 X 33	Sag																												
		1.2.0		Outlet																														
NA		1.3.1	1.3.0	Culv Inlet	18 X 6	Sag	538.28	538.28	536.03	68	Concrete	18 X 6	3.3%	0.013	0.75	0.19	5.12	5.12	5.12	0.39	0.28	5	0.39	0.28	5	3.72	0.41	3.72	0.41	8%	5.07	0.55	5.07	0.55	11%
		1.3.0		Outlet			536.03										0.00	0.00																	
NA		1.4.3	Tee	Culv Inlet	6	Sag	539.40	539.40	539.211	14	PVC	6	1.3%	0.012	0.20	0.13	0.00	0.69	0.69	0.33	2.43	10	0.33	2.43	10	3.04	2.44	3.04	2.44	351%	4.18	3.35	4.18	3.35	483%
		1.4.2	Tee	Culv Inlet	12	Sag	538.33	538.33	538.329	14	Concrete	12	0.0%	0.013	0.79	0.25	0.00	1.13	1.13	0.33	0.27	5	0.33	0.27	5	3.72	0.33	3.72	0.33	29%	5.07	0.45	5.07	0.45	40%
		1.4.1	1.4.0	Culv Inlet	18 X 6	Sag	539.40	539.40	538.11	62	Concrete	12 X 6	2.1%	0.013	0.50	0.17	2.52	2.52	2.52	0.35	1.15	10	0.34	3.85	10	3.04	1.22	3.04	3.93	156%	4.18	1.68	4.18	5.41	215%
		1.4.0		Outlet			538.11																											
NA		1.5.1	1.5.0	Culv Inlet	15	Sag	518.48	518.48	516.46	67	CMP	15	3.0%	0.024	1.23	0.31	0.00	6.07	6.07	0.38	1.13	10	0.35	3.56	10	3.04	1.31	3.04	3.74	62%	4.18	1.79	4.18	5.15	85%
		1.5.0		Outlet			516.46																											
		1.6.3	Tee	Culv Inlet	15	Sag	521.70	521.70	518.92	12	Concrete	15	23.2%	0.013	1.23	0.31	0.00	31.18	31.18	0.44	0.88	5	0.44	0.88	5	3.72	1.44	3.72	1.44	5%	5.07	1.96	5.07	1.96	6%
NA		1.6.2	Tee	Grate	18 x 18	Sag	518.22	518.22	517.76	12	Terracotta	15	3.8%	0.013	1.23	0.31	0.00	12.62	12.62	0.38	0.17	5	0.38	0.17	5	3.72	0.24	3.72	0.24	2%	5.07	0.33	5.07	0.33	3%
		1.6.1	1.6.0	Culv Inlet	15	Sag	519.64	519.64	516.97	67	CMP	15	4.0%	0.024	1.23	0.31	0.00	7.01	7.01	0.32	13.32	20	0.33	14.37	20	3.36	14.32	3.36	15.84	226%	4.59	19.56	4.59	21.64	309%
		1.6.0		Outlet			516.97																											
NA		1.7.6	1.7.4	Grate/Curb Inlet	36 X 18	Grade	537.67	535.92	535.99	57	Terracotta	12	-0.1%	0.013	0.79	0.25	0.00	1.13	1.13	0.33	0.50	5	0.33	0.50	5	3.72	0.61	3.72	0.61	54%	5.07	0.84	5.07	0.84	74%
		1.7.5	1.7.4	Grate/Curb Inlet	36 X 18	Sag	537.54	536.02	535.99	46	CMP	12	0.1%	0.024	0.79	0.25	0.00	0.61	0.61	0.23	5.46	15	0.23	5.46	15	3.36	4.22	3.36	4.22	690%	4.59	5.76	4.59	5.76	942%
		1.7.2	Tee	Grate	36 X 18	Sag	537.70	535.87	535.50	40	Terracotta	12	0.9%	0.013	0.79	0.25	0.00	3.39	3.39	0.33	0.71	5	0.33	0.71	5	3.72	0.87	3.72	0.87	26%	5.07	1.19	5.07	1.19	35%
		1.7.4	1.7.3	Grate	24 X 24	Sag	537.77	535.99	535.92	23	CMP	15	0.3%	0.024	1.23	0.31	0.00	1.92	1.92	0.33	0.22	5	0.24	6.18	15	3.72	0.27	3.36	5.02	261%	5.07	0.37	4.59	6.85	357%
		1.7.3	1.7.1	Grate	24 X 24	Grade	537.22	535.92	535.00	111	CMP	15	0.8%	0.024	1.23	0.31	0.00	3.14	3.14	0.33	0.07	5	0.25	6.96	15	3.72	0.09	3.36	5.88	188%	5.07	0.12	4.59	8.04	256%
		1.7.1	1.7.0	Buried Structure or Bend			NA	535.00	533.00	221	Concrete	15	0.9%	0.013	1.23	0.31	0.00	6.14	6.14				0.25	6.96	15			3.36	5.88	96%			4.59	8.04	131%
		1.7.0		Outlet			533.00																											
NA		1.8.1	1.8.0	Grate	18 X 24	Grade	515.25	512.25	510.5	94	Concrete	12	1.9%	0.013	0.79	0.25	0.00	4.92	4.92	0.33	0.16	5	0.33	0.16	5	3.72	0.20	3.72	0.20	4%	5.07	0.27	5.07	0.27	5%
		1.8.0		Outlet			510.50																											
NA		1.9.1	1.9.0	Culv Inlet	12		Culvert not functioning - elevated inlet, water assumed to infiltrate into railroad ballast																													
		1.9.0		Outlet																																
NA		1.10.1	1.10.0	Culv Inlet	12		Culvert not functioning - elevated inlet, water assumed to infiltrate into railroad ballast																													
		1.10.0		Outlet																																
NA		1.11.2	1.11.1	Grate	33 X 33	Grade	515.40	514.00	514.00	42	CMP	12	0.0%	0.024	0.79	0.25	0.00	0.61	0.61	0.33	4.97	10	0.33	4.97	10	3.04	4.99	3.04	4.99	815%	4.18	6.86	4.18	6.86	1121%
		1.11.1	1.11.0	Grate	33 X 33	Grade	515.40	514.00	513.94	55	CMP	12	0.1%	0.024	0.79	0.25	0.00	0.61	0.61	0.33	1.22	10	0.33	6.19	15	3.04	1.22	3.36	6.86	1122%	4.18	1.68	4.59	9.38	1533%
		1.11.0		Grate	36 X 18	Grade	514.94	513.94																												
NA		1.12.1	1.12.0	Culv Inlet	12		Culvert not functioning - elevated inlet, water assumed to infiltrate into railroad ballast																													
		1.12.0		Outlet																																

NA		1.13.1	1.13.0	Culv Inlet		12			Culvert not functioning - elevated inlet, water assumed to infiltrate into railroad ballast																										
		1.13.0		Outlet																															
NA		1.14.1	1.14.0	Culv Inlet		12			Culvert not functioning - elevated inlet, water assumed to infiltrate into railroad ballast																										
		1.14.0		Outlet																															
NA		1.15.1	1.15.0	Culv Inlet		18		Sag	521.00	521.00	520.80	40	HDPE	18		0.5%	0.012	1.77	0.38	0.00	8.06	8.06	0.31	13.29	20	0.31	13.29	20	3.36	13.84	3.36	13.84	172%	4.59	18.91	4.59	18.91	234%
		1.15.0		Outlet					520.80																												
		1.1.84	Box Culvert	Grate																													0.00	0.00	0.00	16.43	
5	4	1.1.79	1.1.21	Grate	30	X	30	Sag	509.25	506.52	506.49	38.47	Concrete	22	X 34	0.32%	0.013	5.19	0.56	22.79	22.79	22.79	0.81	1.27	10	0.81	1.27	10	3.04	3.14	3.04	3.14	14%	4.18	4.31	4.18	4.31	19%
3A	3	1.1.78	1.1.20	Grate		30		Sag	509.35	507.12	506.7	38.00	HDPE	15		1.11%	0.012	1.23	0.31	0.00	7.39	7.39	0.90	0.39	5	0.90	0.39	5	3.72	1.32	3.72	1.32	18%	5.07	1.80	5.07	1.80	24%
1A	1	1.1.77	1.1.18	Grate		30		Sag	510.15	508.35	507.27	41.00	HDPE	12		2.60%	0.012	0.79	0.25	0.00	6.24	6.24	0.90	0.46	5	0.90	0.46	5	3.72	1.55	3.72	1.55	25%	5.07	2.12	5.07	2.12	34%
294	115.1	1.1.76	1.1.J73	Grate	48	X	18	Sag	511.22	509.37	506.5781	51.75	PVC	10		5.39%	0.012	0.55	0.21	0.00	5.53	5.51	0.90	0.47	5.00	0.90	0.47	5.00	4.75	2.01	4.75	2.01	36%	6.54	2.77	6.54	34.43	625%
312	312	1.1.83	1.1.82	Culvert Inlet		10		Sag	Direct Connection to 1.1.82																				4.75	1.77	4.75	1.77		6.54	2.43	6.54	2.43	
312	311	1.1.82	1.1.81	Grate	18	X	18	Grade	512.26	510.76	509.5	65.09	CMP	10		1.94%	0.024	0.55	0.21	0.00	1.66	1.65	0.60	0.62	5	0.60	0.62	5	4.75	1.77	4.75	1.77	107%	6.54	2.43	6.54	2.43	147%
311	4A	1.1.81	1.1.22	Grate		48		Sag	512.19	509.50	507.25	123.00	CMP	10		1.83%	0.024	0.55	0.21	0.00	1.61	1.61	0.90	0.69	5	0.90	0.69	5	4.75	2.95	4.67	1.77	110%	5.07	3.15	5.07	3.15	196%
6	4A	1.1.80	1.1.22	Grate		30		Sag	509.75	507.33	507.25	36.00	Concrete	24		0.25%	0.013	3.14	0.50	0.00	11.34	11.34	0.82	2.03	10	0.82	2.03	10	3.04	5.05	3.04	5.05	45%	4.18	6.95	4.18	6.95	61%
4A	4	1.1.22	1.1.21	Grate		30		Sag	509.84	507.25	506.49	34.52	Concrete	24		2.39%	0.013	3.14	0.50	0.00	22.62	24.34	0.64	2.69	10	0.64	2.69	10	3.04	5.24	3.04	5.24	22%	4.18	7.21	4.18	7.21	30%
4	3	1.1.21	1.1.20	Grate	30	X	30	Sag	509.50	506.49	506.49	129.65	Concrete	24	X 38	0.00%	0.013	6.33	0.61	0.00	16.28	17.09	0.90	0.24	5	0.90	0.24	5	3.72	0.82	3.72	0.82	5%	5.07	1.11	5.07	1.11	7%
3	2	1.1.20	1.1.19	Grate	30	X	30	Sag	509.22	506.49	506.49	65.72	Concrete	24	X 38	0.00%	0.013	6.33	0.61	0.00	16.29	17.09	0.90	0.03	5	0.90	0.03	5	3.72	0.09	3.72	0.09	1%	5.07	0.13	5.07	0.13	1%
2	1	1.1.19	1.1.18	Grate	60	x	60	Sag	509.12	506.49	506.49	82.57	Concrete	24	X 60	0.00%	0.013	10.00	0.71	33.78	33.78	42.59	0.90	0.09	5	0.90	0.09	5	3.72	0.31	3.72	0.31	1%	5.07	0.42	5.07	0.42	1%
1	00	1.1.18	1.1.17	Grate	30	X	30	Sag	509.64	506.49	505.97	51.39	Concrete	24	X 60	1.10%	0.013	10.00	0.71	33.77	33.77	42.59	0.90	0.13	5	0.90	0.13	5	3.72	0.45	3.72	0.45	1%	5.07	0.61	5.07	0.61	1%
00	F3	1.1.17	1.1.16	Grate	30	X	30	Grade	510.28	505.97	505.94	24.11	Concrete	33	X 47	0.10%	0.013	10.77	0.81	33.77	33.77	42.58	0.50	0.00		0.50	0.00											
291	115.12	1.1.73	Tee	Grate/Curb Inlet	36	X	18	Sag	510.99	509.17	508.9252	9.19	CMP	12		2.66%	0.024	0.79	0.25	0.00	3.16	3.15	0.90	0.20	5.00	0.90	0.20	5.00	4.75	0.86	4.75	0.86	27%	6.54	1.18	6.54	36.43	1157%
115.12	115.11	1.1.75	Box Culvert						510.85	508.94	508.7645	6.42	PVC	12		2.66%	0.012	0.79	0.25	0.00	6.31	6.29	0.00	0.00	0.00	0.90	0.20	5.04	0.00	0.00	4.75	0.85	14%	0.00	0.00	6.54	37.43	595%
292	115.13	1.1.74	Tee	Grate	24	X	18	Sag	511.92	510.45	508.54	26.38	PVC	8		7.24%	0.012	0.35	0.17	0.00	3.53	3.52	0.90	0.25	5.00	0.90	0.25	5.00	4.75	1.07	4.75	1.07	30%	6.54	1.47	6.54	39.43	1119%
293	115.13	1.1.75	1.1.73	Grate	48	X	18	Sag	511.87	510.56	508.54	15.03	PVC	10		13.44%	0.012	0.55	0.21	0.00	8.72	8.70	0.90	0.70	5.00	0.90	0.70	5.00	4.75	2.99	4.75	2.99	34%	6.54	4.12	6.54	41.43	476%
115.13	115.11	1.1.73	1.1.J73						512.00	508.54	508.7645	42.15	Terracotta	10			0.013	0.55	0.21	0.00	#VALUE!	1.60	0.00	0.00	0.00	0.90	0.95	5.05	0.00	0.00	4.75	4.04	253%	0.00	0.00	6.53	43.43	2716%
115.11	115.1	1.1.73	1.1.J73						510.75	508.76	507.5781	43.58	CMP	18		2.72%	0.024	1.77	0.38	0.00	9.41	9.39	0.00	0.00	0.00	0.90	1.15	5.06	0.00	0.00	4.74	4.86	52%	0.00	0.00	6.53	45.43	484%
115.1	115	1.1.17	1.1.16						510.54	506.58	506.46	17.57	Concrete	30		0.67%	0.013	4.91	0.63	0.00	33.70	33.62	0.00	0.00	0.00	0.78	10.05	10.56	0.00	0.00	3.65	33.98	101%	0.00	0.00	4.99	47.43	141%
115	114	1.1.16	1.1.15	Grate	24	X	24	Sag	509.79	506.47	505.76	105.64	Concrete	33	47	0.67%	0.013	10.77	0.81	87.78	0.00	87.55	0.90	0.09	5.00	0.78	10.14	10.60	4.75	0.38	3.65	34.20	39%	6.54	0.53	4.98	48.43	55%
114	114.2	1.1.15	1.1.13	Grate/Curb Inlet	36	X	18	Sag	509.12	505.76	505.51	33.42	Brick	33	47	0.75%	0.015	10.77	0.81	80.26	0.00	80.04	0.90	0.16	5.00	0.79	10.30	10.85	4.75	0.68	3.61	34.05	43%	6.54	0.94	4.93	49.43	62%
114.2	114.1	1.1.13	1.1.J72						509.00	505.51	505.4594	6.01	Brick	33	47	0.84%	0.015	10.77	0.81	85.18	0.00	84.95	0.00	0.00	0.00	0.79	10.30	10.93	0.00	0.00	3.59	33.80	40%	0.00	0.00	4.91	50.43	59%
281	114.1	1.1.72	1.1.J72	Grate/Curb Inlet	36	X	18	Sag	508.91	506.23	505.4594	10.68	PVC	12		7.21%	0.012	0.79	0.25	0.00	10.39	10.37	0.90	0.19	5.00	0.90	0.19	5.00	4.75	0.81	4.75	0.81	8%	6.54	1.12	6.54	52.43	506%
114.1	113.1	1.1.J72	1.1.J15						510.00	505.46	505.1107	45.70	Brick	33	47	0.76%	0.015	10.77	0.81	81.06	0.00	80.85	0.00	0.00	0.00	0.79	10.49	10.94	0.00	0.00	3.59	34.35	42%	0.00	0.00	4.91	54.43	67%
113.1	113	1.1.J15	1.1.14						508.75	505.11	504.66	56.45	Brick	37	54	0.80%	0.015	13.88	0.91	116.06	0.00	115.75	0.00	0.00	0.00	0.79	10.49	11.05	0.00	0.00	3.57	34.00	29%	0.00	0.00	4.89	55.43	48%
113	112	1.1.14	1.1.13						509.78	504.66	504.4708	17.82	Brick	37	54	1.06%	0.015	13.88	0.91	133.85	0.00	133.49	0.00	0.00	0.00	0.79	10.49	11.19	0.00	0.00	3.55	33.76	25%	0.00	0.00	4.86	56.43	42%
112	111.13	1.1.13	1.1.J66	Grate	36	X	18	Grade	508.33	504.30	504.2439	6.87	Brick	37	54	0.83%	0.015	13.88	0.91	118.20	0.00	117.88	0.85	0.00	10.00	0.79	10.49	11.23	3.74	0.00	3.54	33.67	29%	5.10	0.00	4.85	57.43	49%
111.13	111.12	1.1.13	1.1.J66						508.46	504.24	504.1176	15.25	Brick	37	54	0.83%	0.015	13.88	0.91	118.21	0.00	117.89	0.00	0.00	0.00	0.79	10.49	11.25	0.00	0.00	3.54	33.65	29%	0.00	0.00	4.85	58.43	50%
271	271.1	1.1.70	Tee	Grate/Curb Inlet	36	X	18	Grade	509.21	507.42	506.93	11.11	Concrete	8		4.41%	0.013	0.35	0.17	0.00	2.54	2.54	0.90	0.00	5.00	0.90	0.00	5.00	4.75	0.00	4.75	1.08	42%	6.54	0.00	6.54	60.43	2381%
272	271.1	1.1.71	1.1.70	Grate/Curb Inlet	36	X	18	Grade	510.01	508.14	506.93	10.82	PVC	12		11.18%	0.012	0.79	0.25	0.00	12.93	12.91	0.85	0.00	10.00	0.85	0.00	10.00	3.74	0.00	3.74	5.74	44%	5.10	0.00	5.10	62.43	484%
271.1	111.12	1.1.70	Box Culvert						509.70	506.93	504.1176	48.66	PVC	12		5.78%	0.012	0.79	0.25	0.00	9.30	9.28	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	3.74	6.82	73%	0.00	0.00	5.10	64.43	694%
111.12	111.11	1.1.13	1.1.J66						509.07	504.12	503.4902	75.77	Brick	37	54	0.83%	0.015	13.88	0.91	118.19	0.00	117.87	0.00	0.00	0.00	0.79	10.49	11.29	0.00	0.00	3.54	40.40	34%	0.00	0.00	4.84	66.43	56%
261	261	1.1.66	Tee	Grate	36	X	18	Sag	509.06	506.66	503.9595	10.33	CMP	18		26.14%	0.024	1.77	0.38	0.00	29.15	29.09	0.00	0.00	0.00	0.64	9.75	15.60	0.00	0.00	3.02	1.85	6%	0.00	0.00	4.15	68.43	235%
262	262	1.1.67	Tee	Grate/Curb Inlet	36	X	18	Grade	510.26	508.26	508.15	11.36	PVC	15		0.97%	0.012	1.23	0.31	0.00	6.90	6.89	0.00	0.00	0.00	0.64	9.75	15.56	0.00	0.00	3.02	7.01	102%	0.00	0.00	4.16	70.43	1023%
264	263	1.1.69	1.1.68	Grate	48	X	24	Grade	522.31	517.75	508.69	328.08	Terracotta	15		2.76%	0.013	1.23	0.31	0.00	10.76	10.73	0.52	6.24	15.00	0.52	6.24	15.00	3.07	9.96	3.07	3.14	29%	4.21	13.66	4.21	72.43	675%
263	111.11	1.1.68	1.1.J66	Grate	36	X	18	Grade	510.88	508.70	508	9.26	Terracotta	15		7.56%	0.013	1.23	0.31	0.00	17.80	17.76	0.85	3.51	10.00	0.64	9.75	15.55	3.74	11.16	3.02	2.62	15%	5.10	15.22	4.16	73.43	414%
262	261	1.1.67	1.1.66	Grate/Curb Inlet	36	X	18	Grade	510.50	508.00	503.9595	46.82	Terracotta	30		8.63%	0.013	4.91	0.63	0.00	120.76	120.50	0.00	0.00	0.00	0.64	9.75	15.56	0.00	0.00	3.02	9.60	8%	0.00	0.00	4.16	75.43	63%

261	111.11	1.1.66	1.1.J66	Grate	36	X	18	Sag	509.21	503.96	503.4902	56.68	Brick	48	48	0.83%	0.015	16.00	1.00	144.62	0.00	144.23	0.00	0.00	0.00	0.64	9.75	15.60	0.00	0.00	3.02	11.35	8%	0.00	0.00	4.15	77.43	54%
111.11	111.1	1.1.J66	1.1.64						509.45	503.49	501.0914	289.71	Brick	48	48	0.83%	0.015	16.00	1.00	144.62	0.00	144.23	0.00	0.00	0.00	0.72	20.24	15.76	0.00	0.00	3.00	46.32	32%	0.00	0.00	4.14	79.43	55%
254	111.1	1.1.64	1.1.J58	Grate/Curb Inlet	36	X	18	Sag	505.70	503.35	501.0914	4.86	PVC	15		46.45%	0.012	1.23	0.31	0.00	47.80	47.69	0.85	4.48	10.00	0.85	4.48	10.00	3.74	14.24	3.74	15.15	32%	5.10	19.42	5.10	81.43	171%
255	111.1	1.1.65	1.1.64	Grate/Curb Inlet	36	X	18	Grade	506.24	503.29	501.0914	12.39	CMP	18		17.74%	0.024	1.77	0.38	0.00	24.02	23.97	0.50	0.00	5.00	0.50	0.00	5.00	4.75	0.00	4.75	5.41	23%	6.54	0.00	6.54	83.43	348%
111.1	111.9	1.1.12	1.1.J66						506.50	501.09	500.854	28.67	Brick	48	48	0.83%	0.015	16.00	1.00	144.63	0.00	144.24	0.00	0.00	0.00	0.70	52.35	21.97	0.00	0.00	2.49	62.02	43%	0.00	0.00	3.53	85.43	59%
252	252.1	1.1.63	1.1.J58	Grate/Curb Inlet	36	X	18	Sag	506.41	504.47	503	11.29	Cast Iron	12		13.02%	0.015	0.79	0.25	0.00	11.17	11.14	0.85	0.00	10.00	0.85	0.00	10.00	3.74	0.00	3.74	0.00	0%	5.10	0.00	5.10	87.43	785%
253	252.1	1.1.62	1.1.J58	Grate/Curb Inlet	36	X	18	Sag	505.66	503.41	503	5.55	PVC	15		7.38%	0.012	1.23	0.31	0.00	19.06	19.01	0.85	0.00	10.00	0.85	0.00	10.00	3.74	0.00	3.74	0.00	0%	5.10	0.00	5.10	89.43	470%
252.1	111.9	1.1.63	1.1.J66						506.10	503.00	500.854	39.02	PVC	15		5.50%	0.012	1.23	0.31	0.00	16.45	16.41	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	3.74	0.00	0%	0.00	0.00	5.10	91.43	557%
111.9	111.8	1.1.J66	1.1.J58						506.00	500.85	500.7203	16.14	Brick	48	48	0.83%	0.015	16.00	1.00	144.64	0.00	144.25	0.00	0.00	0.00	0.74	24.72	16.43	0.00	0.00	2.93	61.93	43%	0.00	0.00	4.06	93.43	65%
251	251.1	1.1.61	1.1.J58	Grate/Curb Inlet	36	X	18	Grade	506.42	504.06	503	8.90	PVC	15		11.90%	0.012	1.23	0.31	0.00	24.20	24.15	0.85	0.00	10.00	0.85	0.00	10.00	3.74	0.00	3.74	0.00	0%	5.10	0.00	5.10	95.43	395%
251.1	111.8	1.1.61	1.1.J58						506.36	503.00	500.7203	34.92	PVC	15		6.53%	0.012	1.23	0.31	0.00	17.92	17.88	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	3.74	0.00	0%	0.00	0.00	5.10	96.43	539%
111.8	111.7	1.1.J66	1.1.J58						506.00	500.72	500.4734	29.82	Brick	48	48	0.83%	0.015	16.00	1.00	144.62	0.00	144.23	0.00	0.00	0.00	0.74	24.72	16.46	0.00	0.00	2.93	61.87	43%	0.00	0.00	4.06	98.43	68%
234	233	1.1.44	1.1.43	Curb Inlet		48		Sag	520.77	517.99	517.01	31.22	CMP	15		3.14%	0.024	1.23	0.31	0.00	6.21	6.20	0.62	2.92	10.00	0.62	2.92	10.00	3.74	6.77	3.74	1.32	21%	5.10	9.23	5.10	100.43	1620%
236	235.1	1.1.46	Tee	Grate	33	X	33	Grade	526.30	525.10	525.07	8.12	Terracotta	15		0.37%	0.013	1.23	0.31	0.00	3.94	3.93	0.50	0.00	5.00	0.50	0.00	5.00	4.75	0.00	4.75	3.24	82%	6.54	0.00	6.54	102.43	2608%
237	235.1	1.1.47	1.1.45	Curb Inlet		24		Sag	527.41	526.41	525.07	40.34	Concrete	12	12	3.32%	0.013	1.00	0.25	8.29	0.00	8.27	0.55	10.27	20.00	0.55	10.27	20.00	2.63	14.87	2.63	2.21	27%	3.68	20.77	3.68	104.43	1263%
235.1	235	1.1.46	1.1.45						526.30	525.07	519.62	164.09	Brick	4	8	3.32%	0.015	0.22	0.11	0.93	0.00	0.93	0.00	0.00	0.00	0.55	10.27	20.05	0.00	0.00	2.63	5.32	574%	0.00	0.00	3.67	106.43	######
235	233	1.1.45	1.1.43	Grate	24	X	18	Grade	521.29	519.62	517.19	178.25	Brick	4	8	1.36%	0.015	0.22	0.11	0.60	0.00	0.59	0.62	0.00	10.00	0.55	10.27	20.09	3.74	0.00	2.63	6.82	1148%	5.10	0.00	3.67	107.43	######
233	232	1.1.43	1.1.41	Grate	48	X	48	Sag	519.08	517.26	506.96	399.01	Terracotta	12		2.58%	0.013	0.79	0.25	0.00	5.74	5.72	0.50	0.00	5.00	0.57	13.19	20.13	4.75	0.00	2.62	19.36	338%	6.54	0.00	3.67	109.43	1912%
232	231.5	1.1.41	1.1.65	Grate	36	X	18	Grade	509.62	507.26	506.9	7.26	CMP	18		4.96%	0.024	1.77	0.38	0.00	12.69	12.67	0.85	2.59	10.00	0.61	15.78	20.40	3.74	8.23	2.60	18.56	147%	5.10	11.23	3.65	110.43	872%
256	231.5	1.1.42	1.1.41						509.41	507.41	506.9	40.06	CMP	18		1.27%	0.024	1.77	0.38	0.00	6.43	6.42	0.85	0.00	10.00	0.85	0.00	10.00	3.74	0.00	3.74	0.00	0%	5.10	0.00	5.10	112.43	1751%
231.5	231.4	1.1.41	1.1.60						509.80	506.90	503.12	252.47	PVC	18		1.50%	0.012	1.77	0.38	0.00	13.95	13.92	0.00	0.00	0.00	0.61	15.78	20.41	0.00	0.00	2.60	18.55	133%	0.00	0.00	3.65	114.43	822%
231.4	231.3	1.1.41	1.1.60						506.04	503.12	502.9952	17.84	PVC	18		0.68%	0.012	1.77	0.38	0.00	9.39	9.37	0.00	0.00	0.00	0.61	15.78	20.70	0.00	0.00	2.58	18.28	195%	0.00	0.00	3.63	115.43	1232%
231.3	231.2	1.1.41	1.1.60						506.71	503.00	502.7804	15.08	PVC	18		1.42%	0.012	1.77	0.38	0.00	13.61	13.58	0.00	0.00	0.00	0.61	15.78	20.72	0.00	0.00	2.58	18.26	134%	0.00	0.00	3.63	116.43	857%
231.2	231.1	1.1.41	1.1.60						505.75	502.78	502.6048	10.91	PVC	18		1.61%	0.012	1.77	0.38	0.00	14.47	14.44	0.00	0.00	0.00	0.61	15.78	20.74	0.00	0.00	2.58	18.24	126%	0.00	0.00	3.63	117.43	813%
231.1	231	1.1.41	1.1.60						505.85	502.60	502.84	2.95	PVC	18			0.012	1.77	0.38	0.00	#VALUE!	32.12	0.00	0.00	0.00	0.61	15.78	20.75	0.00	0.00	2.58	18.23	57%	0.00	0.00	3.63	118.43	369%
231	111.7	1.1.60	1.1.J58	Grate/Curb Inlet	36	X	18	Grade	505.76	502.84	500.4734	42.76	PVC	15		5.54%	0.012	1.23	0.31	0.00	16.50	16.46	0.85	0.00	10.00	0.61	15.78	20.75	3.74	0.00	2.58	18.23	111%	5.10	0.00	3.63	119.43	725%
111.7	111.6	1.1.J58	1.1.J52						506.00	500.47	497.821	320.35	Brick	48	48	0.83%	0.015	16.00	1.00	144.62	0.00	144.23	0.00	0.00	0.00	0.69	40.50	20.79	0.00	0.00	2.58	75.08	52%	0.00	0.00	3.63	121.43	84%
224	224.1	1.1.56	1.1.J52	Grate/Curb Inlet	36	X	18	Grade	503.63	502.01	500	8.72	PVC	10		23.05%	0.012	0.55	0.21	0.00	11.42	11.40	0.85	0.00	10.00	0.85	0.00	10.00	3.74	0.00	3.74	1.97	17%	5.10	0.00	5.10	123.43	1083%
225	224.1	1.1.57	1.1.J52	Grate/Curb Inlet	36	X	18	Grade	503.05	500.56	500	6.23	PVC	12		8.99%	0.012	0.79	0.25	0.00	11.60	11.57	0.85	1.54	10.00	0.85	1.54	10.00	3.74	4.90	3.74	4.42	38%	5.10	6.68	5.10	125.43	1084%
224.1	111.6	1.1.56	1.1.J52						504.00	500.00	497.821	30.02	PVC	15		7.26%	0.012	1.23	0.31	0.00	18.90	18.86	0.00	0.00	0.00	0.85	1.54	10.01	0.00	0.00	3.74	6.39	34%	0.00	0.00	5.10	127.43	676%
111.6	111.5	1.1.J58	1.1.J52						503.00	497.82	497.7555	7.91	Brick	48	48	0.83%	0.015	16.00	1.00	144.64	0.00	144.26	0.00	0.00	0.00	0.70	42.04	21.38	0.00	0.00	2.53	78.28	54%	0.00	0.00	3.58	129.43	90%
111.5	111.4	1.1.J58	1.1.J52						503.00	497.76	497.69	7.91	Brick	48	48	0.83%	0.015	16.00	1.00	144.64	0.00	144.26	0.00	0.00	0.00	0.70	42.04	21.40	0.00	0.00	2.53	78.23	54%	0.00	0.00	3.58	130.43	90%
221	111.4	1.1.53	1.1.J52	Grate/Curb Inlet	36	X	18	Sag	503.28	499.97	497.69	33.30	Terracotta	15		6.85%	0.013	1.23	0.31	0.00	16.94	16.90	0.50	0.00	5.00	0.50	0.00	5.00	4.75	0.00	4.75	0.00	0%	6.54	0.00	6.54	132.43	784%
222	222.1	1.1.54	1.1.J52	Grate/Curb Inlet	36	X	18	Sag	504.28	502.94	502.5	9.18	PVC	12		4.79%	0.012	0.79	0.25	0.00	8.47	8.45	0.50	0.00	5.00	0.50	0.00	5.00	4.75	0.00	4.75	0.00	0%	6.54	0.00	6.54	134.43	1591%
223	222.1	1.1.55	1.1.J52	Grate/Curb Inlet	36	X	18	Grade	504.52	502.94	502.5	9.52	PVC	12		4.62%	0.012	0.79	0.25	0.00	8.32	8.30	0.85	2.88	10.00	0.85	2.88	10.00	3.74	9.16	3.74	7.18	87%	5.10	12.48	5.10	136.43	1644%
222.1	111.4	1.1.54	1.1.J52						504.89	502.50	497.69	46.35	PVC	15		10.38%	0.012	1.23	0.31	0.00	22.59	22.54	0.00	0.00	0.00	0.85	2.88	10.01	0.00	0.00	3.75	7.21	32%	0.00	0.00	5.10	138.43	614%
226	226.1	1.1.52	1.1.J52	Grate/Curb Inlet	36	X	18	Grade	504.00	500.64	500	5.79	PVC	15		11.06%	0.012	1.23	0.31	0.00	23.33	23.27	0.85	0.00	10.00	0.85	0.00	10.00	3.74	0.00	3.74	0.49	2%	5.10	0.00	5.10	140.43	603%
226.1	111.4	1.1.52	1.1.J52						503.50	500.00	497.69	18.35	PVC	15		12.59%	0.012	1.23	0.31	0.00	24.89	24.83	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	3.74	0.49	2%	0.00	0.00	5.10	141.43	570%
111.4	111.3	1.1.J52	1.1.J33						503.00	497.69	495.1803	303.41	Brick	48	48	0.83%	0.015	16.00	1.00	144.61	0.00	144.22	0.00	0.00	0.00	0.71	44.92	21.41	0.00	0.00	2.53	82.77	57%	0.00	0.00	3.57	143.43	99%
213	111.3	1.1.36	1.1.J33	Curb Inlet		120		Sag	501.31	497.17	495.1803	23.04	Cast Iron	15		8.64%	0.015	1.23	0.31	0.00	16.49	16.45	0.66	0.00	15.00	0.66	0.00	15.00	3.07	0.00	3.07	2.50	15%	4.21	0.00	4.21	145.43	884%

111.3	111.2	1.1.J52	1.1.J33						502.00	495.18	495.17	1.24	Brick	48	48	0.83%	0.015	16.00	1.00	144.77	0.00	144.39	0.00	0.00	0.00	0.71	44.92	21.96	0.00	0.00	2.49	83.84	58%	0.00	0.00	3.53	147.43	102%
217	216	1.1.40	1.1.39	Grate	33	X	33	Sag	512.91	509.56	504.12	112.97	PVC	12		4.82%	0.012	0.79	0.25	0.00	8.49	8.47	0.90	0.21	5.00	0.90	0.21	5.00	4.75	0.90	4.75	0.90	11%	6.54	1.24	6.54	149.43	1764%
216	215	1.1.39	1.1.38						510.49	503.89	500.41	158.21	PVC	12		2.20%	0.012	0.79	0.25	0.00	5.74	5.72	0.00	0.00	0.00	0.90	0.21	5.27	0.00	0.00	4.69	0.86	15%	0.00	0.00	6.45	150.43	2628%
215	214	1.1.38	1.1.37						503.05	500.36	500	18.06	PVC	12		1.99%	0.012	0.79	0.25	0.00	5.46	5.45	0.00	0.00	0.00	0.90	0.21	5.77	0.00	0.00	4.56	0.84	15%	0.00	0.00	6.28	151.43	2779%
214	111.2	1.1.37	1.1.J33	Curb Inlet		120		Sag	502.10	497.00	495.17	40.18	Terracotta	15		4.55%	0.013	1.23	0.31	0.00	13.82	13.79	0.66	7.22	15.00	0.67	7.43	15.00	3.07	14.63	3.07	3.43	25%	4.21	20.06	4.21	152.43	1106%
111.2	111.1	1.1.J52	1.1.J33						502.00	495.17	495.1153	6.37	Brick	48	48	0.86%	0.015	16.00	1.00	147.31	0.00	146.91	0.00	0.00	0.00	0.70	52.35	21.96	0.00	0.00	2.49	84.14	57%	0.00	0.00	3.53	154.43	105%
212	111.1	1.1.35	1.1.J33	Curb Inlet		120		Sag	501.04	497.30	495.1153	19.04	Terracotta	15		11.48%	0.013	1.23	0.31	0.00	21.93	21.88	0.66	0.00	15.00	0.66	0.00	15.00	3.07	0.00	3.07	3.29	15%	4.21	0.00	4.21	156.43	715%
111.1	111	1.1.J52	1.1.12						502.00	495.12	495.09	3.05	Brick	48	48	0.83%	0.015	16.00	1.00	144.70	0.00	144.31	0.00	0.00	0.00	0.70	52.35	21.97	0.00	0.00	2.49	78.11	54%	0.00	0.00	3.53	158.43	110%
111	110.5	1.1.12	1.1.J33						501.50	495.08	495.05	4.24	Brick	48	48	0.71%	0.015	16.00	1.00	133.64	0.00	133.28	0.00	0.00	0.00	0.70	52.35	21.97	0.00	0.00	2.49	78.09	59%	0.00	0.00	3.53	159.43	120%
211	110.5	1.1.34	1.1.J33	Curb Inlet		120		Sag	501.57	497.47	495.05	21.20	Terracotta	15		11.42%	0.013	1.23	0.31	0.00	21.87	21.83	0.66	0.00	15.00	0.66	0.00	15.00	3.07	0.00	3.07	0.00	0%	4.21	0.00	4.21	161.43	740%
110.5	110.4	1.1.J52	1.1.11						501.50	495.05	494.93	14.90	Brick	48	48	0.81%	0.015	16.00	1.00	142.61	0.00	142.23	0.00	0.00	0.00	0.70	52.35	21.98	0.00	0.00	2.49	78.07	55%	0.00	0.00	3.53	163.43	115%
110.4	110.3	1.1.J52	1.1.11						501.00	494.93	493.6889	152.11	Brick	48	48	0.82%	0.015	16.00	1.00	143.56	0.00	143.18	0.00	0.00	0.00	0.70	52.35	22.01	0.00	0.00	2.49	77.98	54%	0.00	0.00	3.53	164.43	115%
110.3	110.2	1.1.J52	1.1.11						500.00	493.69	493.66	2.89	Brick	48	48	1.04%	0.015	16.00	1.00	161.83	0.00	161.39	0.00	0.00	0.00	0.70	52.35	22.28	0.00	0.00	2.47	76.97	48%	0.00	0.00	3.51	165.43	103%
205	110.2	1.1.33	1.1.J33	Grate	28	X	28	Sag	499.46	497.26	493.66	27.35	Terracotta	15		13.16%	0.013	1.23	0.31	0.00	23.49	23.44	0.85	2.09	10.00	0.85	2.09	10.00	3.74	6.64	3.74	21.91	93%	5.10	9.06	5.10	167.43	714%
110.2	110.1								500.00	493.66	493.59	8.83	Brick	48	48	0.79%	0.015	16.00	1.00	141.51	0.00	141.13	0.00	0.00	0.00	0.71	54.44	22.28	0.00	0.00	2.47	96.48	68%	0.00	0.00	3.50	169.43	120%
110.1	110	1.1.J33	1.1.11						500.00	493.59	493.52	8.76	Brick	48	48	0.80%	0.015	16.00	1.00	142.06	0.00	141.68	0.00	0.00	0.00	0.71	54.44	22.30	0.00	0.00	2.47	96.42	68%	0.00	0.00	3.50	170.43	120%
110	109.3	1.1.11	1.1.10	Grate	24	X	18	Sag	499.04	493.48	493.459	2.96	Brick	48	48	0.73%	0.015	16.00	1.00	135.41	0.00	135.04	0.00	0.00	5.00	0.71	54.44	22.31	4.75	0.00	2.47	96.36	71%	6.54	0.00	3.50	171.43	127%
109.3	109.2	1.1.11	1.1.10						499.04	493.46	491.4802	272.86	Brick	48	48	0.73%	0.015	16.00	1.00	135.35	0.00	134.98	0.00	0.00	0.00	0.71	54.44	22.32	0.00	0.00	2.47	96.34	71%	0.00	0.00	3.50	172.43	128%
109.2	109.1	1.1.11	1.1.10						498.94	491.48	491.4326	6.72	Brick	48	48	0.71%	0.015	16.00	1.00	133.73	0.00	133.37	0.00	0.00	0.00	0.71	54.44	22.81	0.00	0.00	2.44	94.59	71%	0.00	0.00	3.46	173.43	130%
109.1	109	1.1.11	1.1.10						499.10	491.43	491.4148	2.44	Brick	48	48	0.73%	0.015	16.00	1.00	135.87	0.00	135.50	0.00	0.00	0.00	0.71	54.44	22.83	0.00	0.00	2.44	94.54	70%	0.00	0.00	3.46	174.43	129%
109	108.2	1.1.10	1.1.9						499.06	491.41	491.3623	7.24	Concrete	48		0.73%	0.013	12.56	1.00	0.00	122.62	122.35	0.00	0.00	0.00	0.71	54.44	22.83	0.00	0.00	2.44	94.53	77%	0.00	0.00	3.46	175.43	143%
108.2	108.1	1.1.10	1.1.9						499.12	491.36	491.2912	9.81	Concrete	48	48	0.72%	0.013	16.00	1.00	156.12	0.00	155.70	0.00	0.00	0.00	0.71	54.44	22.84	0.00	0.00	2.44	94.49	61%	0.00	0.00	3.46	176.43	113%
108.1	108	1.1.10	1.1.9						499.36	491.29	490.64	89.82	Concrete	48		0.72%	0.013	12.56	1.00	0.00	122.57	122.31	0.00	0.00	0.00	0.71	54.44	22.86	0.00	0.00	2.44	94.42	77%	0.00	0.00	3.46	177.43	145%
108	107.1	1.1.9	1.1.7	Grate	28	X	28	Sag	496.65	490.57	490.3519	77.23	Concrete	48		0.28%	0.013	12.56	1.00	0.00	76.50	76.33	0.45	3.35	10.00	0.69	57.79	23.00	3.74	5.64	2.43	97.49	128%	5.10	7.69	3.45	178.43	234%
204	203	1.1.32	1.1.32		36	X	18	Grade	497.51	495.51	495.14	5.05	Brick	18	18	7.33%	0.015	2.25	0.38	31.47	0.00	31.39	0.62	2.00	10.00	0.62	2.00	10.00	3.74	4.64	3.74	4.22	13%	5.10	6.32	5.10	180.43	575%
203	107.1	1.1.31	1.1.8						498.18	492.68	490.3519	18.99	Concrete	12		12.26%	0.013	0.79	0.25	0.00	12.50	12.47	0.00	0.00	0.00	0.62	2.00	10.01	0.00	0.00	3.74	4.22	34%	0.00	0.00	5.10	181.43	1455%
107.1	107	1.1.8	1.1.7						497.92	490.35	490.24	39.95	Concrete	48	48	0.28%	0.013	16.00	1.00	97.05	0.00	96.79	0.00	0.00	0.00	0.69	59.79	23.16	0.00	0.00	2.42	99.57	103%	0.00	0.00	3.44	183.43	190%
107	106.6	1.1.7	1.1.6	Grate/Curb Inlet	36	X	18	Grade	496.02	490.37	490.1293	31.32	Brick	51	51	0.77%	0.015	18.06	1.06	163.79	0.00	163.35	0.85	0.00	10.00	0.69	59.79	23.27	3.74	0.00	2.41	99.73	61%	5.10	0.00	3.43	184.43	113%
106.6	106.5	1.1.7	1.1.6						496.00	490.13	489.8856	31.32	Brick	51	51	0.78%	0.015	18.06	1.06	164.81	0.00	164.36	0.00	0.00	0.00	0.69	59.79	23.33	0.00	0.00	2.41	99.59	61%	0.00	0.00	3.43	185.43	113%
106.5	106.4	1.1.7	1.1.6						496.00	489.89	489.5557	42.40	Brick	51	51	0.78%	0.015	18.06	1.06	164.79	0.00	164.34	0.00	0.00	0.00	0.69	59.79	23.38	0.00	0.00	2.40	99.46	61%	0.00	0.00	3.42	186.43	113%
202	202.1	1.1.31	Box Culvert	Grate/Curb Inlet	36	X	18	Sag	495.65	493.54	493.2193	27.69	Concrete	15		1.16%	0.013	1.23	0.31	0.00	6.96	6.95	0.52	1.56	10.00	0.52	1.56	10.00	3.74	3.03	3.74	3.03	44%	5.10	4.14	5.10	188.43	2713%
202.1	106.4	1.1.31	Box Culvert						496.10	493.22	489.5557	57.04	Concrete	15		6.42%	0.013	1.23	0.31	0.00	16.41	16.37	0.00	0.00	0.00	0.52	1.56	10.08	0.00	0.00	3.74	3.03	18%	0.00	0.00	5.10	189.43	1157%
106.4	106.3	1.1.7	1.1.6						496.00	489.56	489.4528	13.59	Brick	51	51	0.76%	0.015	18.06	1.06	162.55	0.00	162.11	0.00	0.00	0.00	0.68	61.35	23.46	0.00	0.00	2.40	101.16	62%	0.00	0.00	3.42	191.43	118%
106.3	106.2	1.1.7	1.1.6						496.00	489.45	489.2257	29.19	Brick	51	51	0.78%	0.015	18.06	1.06	164.78	0.00	164.34	0.00	0.00	0.00	0.68	61.35	23.48	0.00	0.00	2.40	101.10	62%	0.00	0.00	3.42	192.43	117%
106.2	106.1	1.1.6	1.1.5						495.14	489.23	488.9986	29.19	Brick	51	51	0.78%	0.015	18.06	1.06	164.78	0.00	164.34	0.00	0.00	0.00	0.68	61.35	23.53	0.00	0.00	2.39	100.97	61%	0.00	0.00	3.41	193.43	118%
106.1	106	1.1.6	1.1.5						494.21	489.00	488.42	70.52	Brick	51	51	0.82%	0.008	18.06	1.06	317.29	0.00	316.44	0.00	0.00	0.00	0.68	61.35	23.58	0.00	0.00	2.39	100.85	32%	0.00	0.00	3.41	194.43	61%
106	105	1.1.5	1.1.4						494.01	488.42	487.76	92.72	Brick	51	51	0.71%	0.015	18.06	1.06	157.62	0.00	157.19	0.00	0.00	0.00	0.68	61.35	23.66	0.00	0.00	2.39	100.66	64%	0.00	0.00	3.40	195.43	124%
105	104	1.1.4	1.1.3						493.02	487.76	486.27	223.86	Brick	51	51	0.67%	0.015	18.06	1.06	152.42	0.00	152.01	0.00	0.00	0.00	0.68	61.35	23.82	0.00	0.00	2.38	100.26	66%	0.00	0.00	3.39	196.43	129%
104	103	1.1.3	1.1.2						491.81	486.27	485.68	100.80	Brick	51	51	0.59%	0.015	18.06	1.06	142.93	0.00	142.54	0.00	0.00	0.00	0.68	61.35	24.24	0.00	0.00	2.35	99.23	70%	0.00	0.00	3.36	197.43	139%
103	102	1.1.2	1.1.1						490.86	485.68	483.21	117.36	Brick	51	51	2.10%	0.015	18.06	1.06	271.03	0.00	270.30	0.00	0.00	0.00	0.68	61.35	24.44	0.00	0.00	2.34	98.78	37%	0.00	0.00	3.35	198.43	73%
201	102	1.1.30	1.1.1	Grate/Curb Inlet	36	X	18	Grade	486.92	484.11	483.18	34.77	Concrete	18		2.67%	0.013	1.77	0.38	0.00	17.22	17.18	0.85	0.79	5.00	0.85	0.79	5.00	4.75	3.19	4.75	3.07	18%	6.54	4.39	6.54	200.43	1167%
102	101.1	1.1.1	1.1.0	Grate/Curb Inlet	36	X	18	Grade	486.81	483.29	476.72	327.83	Concrete	48		2.00%	0.013	12.56	1.00	0.00	203.79	203.35	0.85	2.98	10.00	0.69	65.12	24.58	3.74	9.47	2.33	103.20	51%	5.10	12.92	3.34	202.43	100%
101.1	101	1.1.1	1.1.0						480.72	476.72	476.53	9.64	Concrete	48		1.97%	0.013	12.56	1.00	0.00	202.08	201.64	0.00	0.00	0.00	0.69	65.12	24.91	0.00	0.00	2.31	102.37	51%	0.00	0.00	3.32	203.43	101%
		1.1.0	Outlet																	0.00	0.00															

NOTES

System 1 analysis per Stormwater Runoff Evaluation report dated December 22, 2020

Systems 1.2-1.14 C factors have been adjusted to 65% of their value for specified land uses other than the downtown/business land use to account for karst infiltration

Structures assumed to be 3' deep unless direct field observations indicate significant difference

Negative pipe slopes are assumed to have the capacity equivalent to a slope of 0.1%

Structure 2.1.2 recieves runoff from a low area with no outfall. The karst factor for this drainage area has been doubled to account for detention and infiltration in this area.

Appendix-Watershed 2

Watershed 2 consists of areas discharging to Evitts Run. The dominating swale in the center of the watershed appears to be a karst swale that has had significant development over the years. System 2.1 is the primary discharge point of the watershed into Evitts Run. No suspected stormwater management facilities were identified within watershed 2.

Storm Sewer and Culverts

Three storm sewer systems were identified within watershed 2.

System 2.1 provides drainage across Mordington Avenue and Washington Apartments. The system was not evaluated within the area considered private and contained in the Washington Apartments complex.

System 2.2 consists of an inlet and discharge location found along Ann Street.

System 2.3 is the second largest system identified with the study. It provides drainage at the low points of Samuel and George Streets. The system has many stretches of terracotta pipe that are beginning to degrade and should be replaced. Improvements to this system could mitigate many of the identified issues within watershed 2.

Channel/Roadway Spread Analysis

Roadway spread was assessed at four points within the watershed. These points communicate spread issues at the analyses point and upstream areas. A table of the analyses points is provided below.

Identifier	Location	Description
C.2.1	Mordington Ave northside	Roadside ditch
C.2.2	Samuel Street westside	Spread
C.2.3	Samuel Street eastside	Spread
C.2.4	Charles Street eastside	Roadside ditch

Depressions

D2.1 was the only major depression identified within watershed 2. The depression receives discharges from systems 2.2 and 2.3. No storm sewer is present within the depression and it must fill with water before beginning to discharge across the Washington Apartments parking lot and entering storm sewer system 2.1. Only one inlet (2.1.2) is present to facilitate the runoff

crossing Mordington Avenue. Some level of infiltration is expected to take place within this depression. Additional analyses utilizing techniques outlined in HEC 22 and infiltration testing could be performed to assess the actual discharges from the depression. Karst factors have been doubled for the drainage area coming to this depression for all downstream analyses.

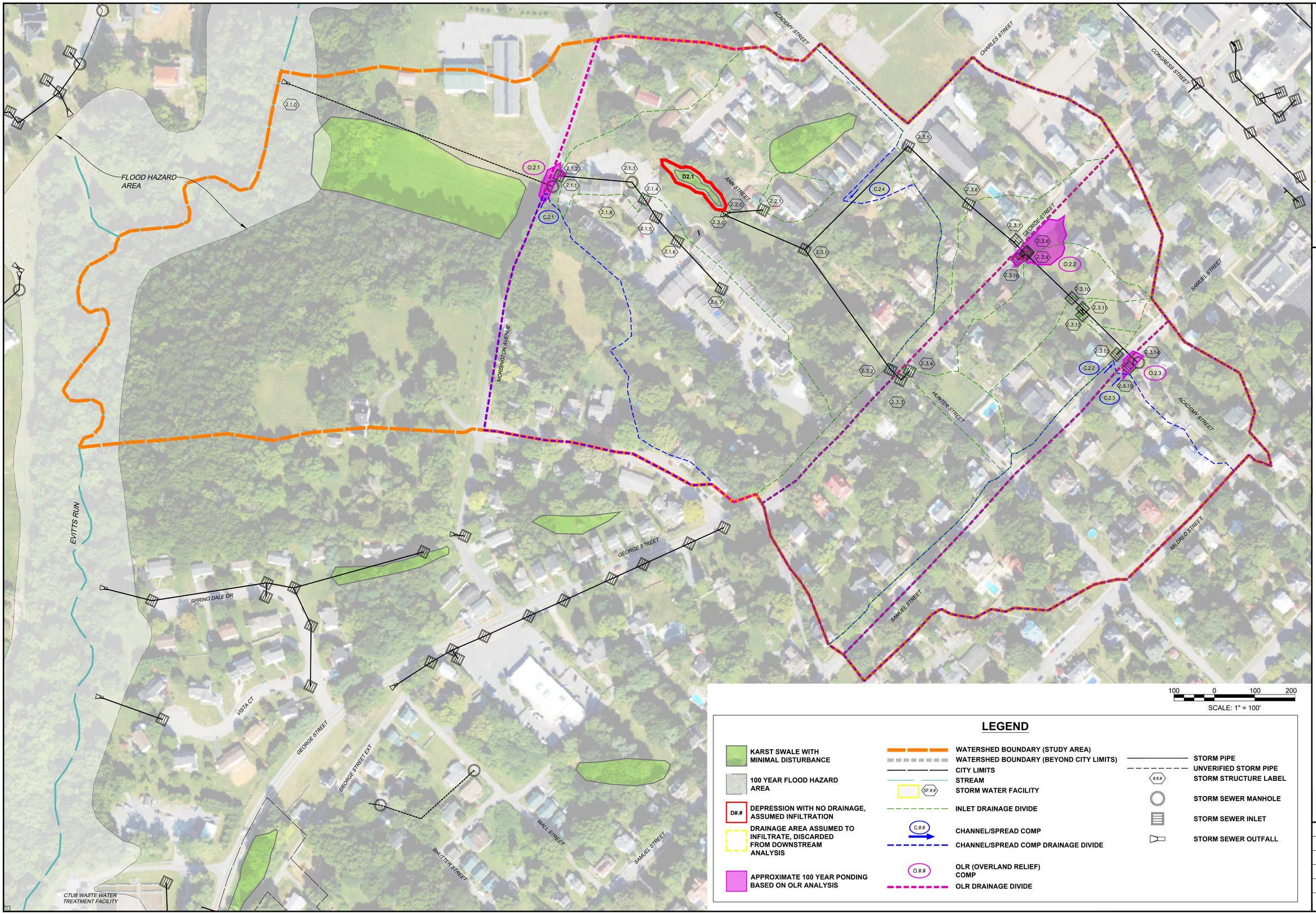
Overland Relief

Three locations were assessed for ponding within watershed 2.

O.2.1 assesses drainage across Mordington Avenue. Runoff must pond until it can cross the crown of the street and continue downstream to Evitts Run.

O.2.2 evaluates ponding at the low point in George Street. Water must pond until it can traverse the crown of the street and continue down Academy Street.

O.2.3 evaluates the ponding at the low point along Samuel Street. The crown of the street must be overtopped before the runoff continues down Academy Street.



100 0 100 200

SCALE: 1" = 100'

LEGEND

- KARST SWALE WITH MINIMAL DISTURBANCE
- 100 YEAR FLOOD HAZARD AREA
- D#.# DEPRESSION WITH NO DRAINAGE, ASSUMED INFILTRATION
- DRAINAGE AREA ASSUMED TO INFILTRATE, DISCARDED FROM DOWNSTREAM ANALYSIS
- APPROXIMATE 100 YEAR PONDING BASED ON OLR ANALYSIS
- WATERSHED BOUNDARY (STUDY AREA)
- WATERSHED BOUNDARY (BEYOND CITY LIMITS)
- CITY LIMITS
- STREAM
- SF.## STORM WATER FACILITY
- INLET DRAINAGE DIVIDE
- C.## CHANNEL/SPREAD COMP
- CHANNEL/SPREAD COMP DRAINAGE DIVIDE
- O.## OLR (OVERLAND RELIEF) COMP
- OLR DRAINAGE DIVIDE
- STORM PIPE
- UNVERIFIED STORM PIPE
- ### STORM STRUCTURE LABEL
- STORM SEWER MANHOLE
- STORM SEWER INLET
- STORM SEWER OUTFALL

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CITY OF CHARLES TOWN WATERSHEDS

WATERSHED 2 H&H ANALYSIS EXHIBIT

CITY OF CHARLES TOWN - JEFFERSON COUNTY, WEST VIRGINIA

Date:	04/08/2026
Scale:	1" = 100'
Designed By:	ZJ/RLK/ZS
File No.	7037
Sheet	1 Of 1

Roadside Ditch and Roadway Spread Analysis

Watershed 2

															2 Year							10 Year							100 Year						
															2yr Karst Factor	0.51						10yr Karst Factor	0.62						100yr Karst Factor	0.71					
Identifier	Location	Description	Side Slope 1 (H ft:1 ft)	Side Slope 2 (H ft:1 ft)	Upstream Road Length(ft)	Upstream Intersections	Available Depth for Ditch/Gutter(ft)	Available Width for Spread (ft)	Approximate Running Slope (%)	Drainage Area (Acre)	C Factor	Tc (Min)	Inlets Present	Throat Inlet or 2 Grates Present	Storm sewer capacity (cfs)	Rainfall Intensity (in/hr)	Flow (cfs)	Overland Flow (cfs)	Depth of flow (ft)	Roadway Surcharge (ft)	Spread (ft)	Travel Lane Spread (ft)	Rainfall Intensity (in/hr)	Flow (cfs)	Overland Flow (cfs)	Depth of flow (ft)	Roadway Surcharge (ft)	Spread (ft)	Travel Lane Spread (ft)	Rainfall Intensity (in/hr)	Flow (cfs)	Overland Flow (cfs)	Depth of flow (ft)	Roadway Surcharge (ft)	Spread (ft)	Travel Lane Spread (ft)
C.2.1	Mordington Ave northside	Roadside ditch	2	40	1100	1	0.25	2.5	2%	3.82	0.50	10	0	No	0	3.72	3.62	3.62	0.28	0.03	1.50	0.00	5.07	6.00	6.00	0.34	0.09	4.50	2.00	7.03	9.53	9.53	0.40	0.15	7.50	5.00
C.2.2	Samuel Street westside	Spread	NA	NA	1015	1	0	3	2%	0.74	0.50	5	0	No	0	4.73	0.89	0.89	0.12	0.12	6.04	3.04	6.52	1.50	1.50	0.15	0.15	7.38	4.38	9.23	2.42	2.42	0.18	0.18	8.83	5.83
C.2.3	Samuel Street eastside	Spread	NA	NA	1360	1	0	3	2%	5.87	0.50	15	0	No	0	3.04	4.55	4.55	0.22	0.22	11.17	8.17	4.18	7.61	7.61	0.27	0.27	13.54	Full	5.84	12.17	12.17	0.32	0.32	16.17	Full
C.2.4	Charles Street eastside	Roadside ditch	50	25	1200	1	0.1	1.5	2%	23.11	0.52	20	2+	Yes	7.93	2.72	16.67	8.74	0.31	0.21	10.50	9.00	3.77	28.09	20.16	0.42	0.32	16.00	Full	5.33	45.48	37.55	0.54	0.44	22.00	Full

NOTES

For roadside ditches available depth is the approximated depth of the ditch outside the roadway, 0.1' is indicative of no defined roadside ditch

For spread comps available depth of 0' is indicative of no gutter pan and 0.1' is indicative of a gutter pan

For spread comps a negative available spread is indicative of a local depression that results in an initial spread for all storm events

Upstream Intersections within 500ft of the highpoint are excluded from the upstream intersection counts

Available width is the approximated area available for spread outside an assumed 10ft travel lane

Roadway surcharge depth is the expected depth of water at the edge of pavement

Mannings n assumptions; ditch/channel = 0.025; road/gutter spread = .016

Road cross slopes assumed at 2%

Overland Relief Analysis (OLR)

Watershed 2

										10 Year								100 Year							
										10yr Karst Factor	0.62							100yr Karst Factor	0.71						
Identifier	Location	Constraint Description	Approximated Weir Elevation	Inlets Present	Throat Inlet or 2 Grates Present	Storm sewer capacity (cfs)	Drainage Area (Acre)	C Factor	Tc (Min)	Rainfall Intensity (in/hr)	OLR Flow (cfs)	Depth (ft)	Approximated WSE	Buildings Impacted	Local Roadway Inundation (ft)	Primary Route Inundation (ft)	Singular Access Point Impacts	Rainfall Intensity (in/hr)	OLR Flow (cfs)	Depth (ft)	Approximated WSE	Buildings Impacted	Local Roadway Inundation (ft)	Primary Route Inundation (ft)	Singular Access Point Impacts
O.2.1	Mordington Ave	Roadway	494.25	2	Yes	7.04	44.43	0.52	20	3.77	26.44	0.36	494.61	0	65	0	No	5.33	55.04	0.49	494.74	0	85	0	No
O.2.2	George St and Academy St	Roadway	526.25	3	Yes	12.95	18.40	0.50	20	3.77	8.55	0.09	526.34	0	0	135	No	5.33	21.87	0.17	526.42	0	0	135	No
O.2.3	Samuel St and Academy St	Roadway	537.00	1	No	0.00	7.38	0.50	15	4.18	9.56	0.23	537.23	0	40	0	No	5.84	15.30	0.29	537.29	0	50	0	No

NOTES

Weir coefficient assumed as 3.27

OLR flow accounts for storm sewer capacity where redundant inlets are present to ensure drainage

Storm sewer capacity is only accounted for were either throat inlets or redundant grate inlets are present within the 100 year ponding area

O.2.1 recieves runoff from a low area with no outfall. The karst factor for this drainage area has been doubled to account for detention and infiltration in this area.

Storm Sewer Pipe Analysis

Watershed 2

																						2 Year					10 Year				
																						2yr Karst Factor				0.51	10yr Karst Factor				0.62
Inlet/Structure Name	Downstream Structure	Structure Type	Inlet Size (in)	Inlet Profile	Approximate Top Elevation/Invert	Approximate Invert Up	Approximate Invert Down	Pipe Length (ft)	Pipe Material	Pipe Size (in)	Approximate Pipe Slope (%)	Pipe Mannings 'n'	Flow Area (ft^2)	Hydraulic Radius	Full Flow Capacity (cfs)	Inlet C Factor	Inlet Drainage Area (Acres)	Time to Inlet (min)	System C Factor	System Drainage Area (Acre)	System Time (Min)	Inlet Rainfall Intensity (in/hr)	Flow To Inlet (cfs)	System Rainfall Intensity (in/hr)	System Flow (cfs)	System Flow/Pipe Full Flow (%)	Inlet Rainfall Intensity (in/hr)	Flow To Inlet (cfs)	System Rainfall Intensity (in/hr)	System Flow (cfs)	System Flow/Pipe Full Flow (%)
2.1.7	2.1.6	Grate	24 X 24	Sag	Private System, Not Evaluated																										
2.1.6	2.1.5	Grate	30 X 30	Sag																											
2.1.5	2.1.4	Grate	24 X 24	Sag																											
2.1.4	2.1.3	Grate	30 X 30	Sag																											
2.1.3	2.1.2	MH																													
2.1.2	2.1.1	Grate	24 X 18	Sag	494.00	491.00	491	706	CMP	30	0.0%	0.024	4.91	0.63	7.04	0.53	33.15	20	0.53	38.99	20	3.36	15.35	3.36	20.48	291%	4.59	31.00	4.59	39.47	561%
2.1.1	2.1.0	MH			494.00	491.00	474.39	706	CMP	30	2.4%	0.024	4.91	0.63	34.49				0.53	38.99	20			3.36	20.48	59%			4.59	39.47	114%
2.1.0		Outlet			474.39														0.00	0.00											
2.2.1	2.2.0	Grate	30 X 30		504.00	501.00	498	86	HDPE	18	3.5%	0.012	1.77	0.38	21.34	0.66	0.36	5	0.66	0.36	5	3.72	0.45	3.72	0.45	2%	5.07	0.75	5.07	0.75	4%
2.2.0		Outlet			498.00														0.00	0.00											
2.3.15	2.3.14	Grate	24 X 48	Grade	536.60	533.60	533.6	20	Concrete	15	0.0%	0.013	1.23	0.31	2.05	0.50	7.38	15	0.50	7.38	15	3.36	6.32	3.36	6.32	309%	4.59	10.50	4.59	10.50	513%
2.3.14	2.3.13	Metal Lid			536.60	533.60	531.54	50	Concrete	15	4.1%	0.013	1.23	0.31	13.11				0.50	7.38	15			3.36	6.32	48%			4.59	10.50	80%
2.3.13	2.3.11	Grate	24 X 24	Grade	534.54	531.54	526.25	140	Brick	15 15	3.8%	0.015	1.56	0.31	13.93	0.50	0.91	5	0.50	8.29	15	3.72	0.86	3.36	7.10	51%	5.07	1.43	4.59	11.80	85%
2.3.12	2.3.11	Grate	30 X 30	Grade	529.80	526.80	526.25	20	Concrete	18	2.7%	0.013	1.77	0.38	17.30	0.50	0.09	5	0.50	0.09	5	3.72	0.09	3.72	0.09	0%	5.07	0.14	5.07	0.14	1%
2.3.11	2.3.10	Grate	30 X 30	Grade	529.25	526.25	525.94	35	Brick	15 15	0.9%	0.015	1.56	0.31	6.78	0.50	0.23	5	0.50	8.61	15	3.72	0.22	3.36	7.38	109%	5.07	0.36	4.59	12.25	181%
2.3.10	2.3.9	Grate	18 X 18	Grade	528.94	525.94	522.28	155	Terracotta	18	2.4%	0.013	1.77	0.38	16.31	0.50	1.31	10	0.50	9.92	15	3.04	1.02	3.36	8.50	52%	4.18	1.70	4.59	14.12	87%
2.3.9	2.3.8	Grate	18 X 18	Sag	525.28	522.28	522.31	Interconnected W/2.3.8								0.50	1.54	10	0.50	11.46	20	3.04	1.19	3.36	9.82		4.18	2.00	4.59	16.31	
2.3.16	2.3.8	Grate	12 X 60	Sag	525.78	522.78	522.31	25	CMP	12	1.9%	0.024	0.79	0.25	2.67	0.50	0.57	5	0.50	0.57	5	3.72	0.54	3.72	0.54	20%	5.07	0.90	5.07	0.90	34%
2.3.8	2.3.7	Grate	18 X 18	Sag	525.31	522.31	522.12	40.5	Brick	15 15	0.5%	0.015	1.56	0.31	5.05	0.50	1.35	10	0.50	13.38	20	3.04	1.05	3.36	11.46	227%	4.18	1.75	4.59	19.04	377%
2.3.7	2.3.6	Curb Inlet	48	Grade	525.12	522.12	516.23	148	Terracotta	15	4.0%	0.013	1.23	0.31	12.95	0.50	0.04	5	0.50	13.42	20	3.72	0.04	3.36	11.50	89%	5.07	0.06	4.59	19.10	147%
2.3.6	2.3.5	Grate	18 X 36	Grade	519.23	516.23	514.41	205	Terracotta	15	0.9%	0.013	1.23	0.31	6.14	0.52	1.17	10	0.50	14.59	20	3.04	0.94	3.36	12.54	204%	4.18	1.58	4.59	20.83	339%
2.3.5	2.3.1	Grate	24 X 36	Grade	517.41	514.41	512	397	CMP	18	0.6%	0.024	1.77	0.38	4.42	0.62	3.24	10	0.52	17.83	20	3.04	3.11	3.36	15.98	362%	4.18	5.21	4.59	26.54	601%
2.3.4	2.3.3	Grate	18 X 30	Grade	534.54	531.54	531.91	30	CMP	15	0.5%	0.024	1.23	0.31	2.48	0.50	0.62	5	0.50	0.62	5	3.72	0.59	3.72	0.59	24%	5.07	0.97	5.07	0.97	39%
2.3.3	2.3.2	Grate	24 X 30	Grade	534.91	531.91	531.54	38	CMP	15	1.0%	0.024	1.23	0.31	3.51	0.50	4.49	10	0.50	5.11	15	3.04	3.48	3.36	4.38	125%	4.18	5.82	4.59	7.27	207%
2.3.2	2.3.1	Grate	15 X 15	Grade	534.54	531.54	512	365	Concrete	15	5.4%	0.013	1.23	0.31	15.04	0.50	0.34	5	0.50	5.45	15	3.72	0.32	3.36	4.67	31%	5.07	0.53	4.59	7.75	52%
2.3.1	2.3.0	Grate	24 X 24	Grade	515.00	512.00	498	215	CMP	18	6.5%	0.024	1.77	0.38	14.54	0.00	0.00		0.52	23.28	20			3.36	20.65	142%			4.59	34.30	236%
2.3.0		Outlet			498.00																										

NOTES

Structures assumed to be 3' deep unless direct field observations indicate significant difference

Negative pipe slopes are assumed to have the capacity equivalent to a slope of 0.1%

Structure 2.1.2 recieves runoff from a low area with no outfall. The karst factor for this drainage area has been doubled to account for detention and infiltration in this area.

Appendix-Watershed 3

Watershed 3 consists of areas draining to Evitts Run around and through the CTUB wastewater treatment plan. Small portions of the watershed drain as sheet flow directly adjacent to the stream and majority of the drainage shed concentrates at the culvert inlet adjacent to the treatment plant across George Street (3.1.1). It was noted that two houses have been constructed within the past five years in a location with significant drainage implications. These are described further in relation to the overland relief analysis. No suspected stormwater management facilities were identified within watershed 3.

Storm Sewer and Culverts

The storm sewer and culvert infrastructure within watershed 3 consists of five individual storm sewer systems/culverts.

System 1 provides drainage around the CTUB wastewater treatment plant. This system is not analyzed as the only impacts due to lack of capacity would be wholly within the CTUB property. It is expected that the system has an engineered design, although the only documents provided by CTUB consist of a layout showing the storm system. The system discharges directly to Evitts Run.

System 2 consists of a culvert across George Street. The outfall for this culvert appears to have been buried and/or collapsed. Little evidence of overtopping of George Street exists due to this collapse exists.

System 3 is the culvert providing drainage across South George Street Extension. The culvert is severely undersized for the drainage area.

System 4 consists of grate inlets along Wall Street and Shutter Street. The outfall for this system is buried and during rain events the system discharges through the grate inlet on Shutter Street.

System 5 provides drainage along George Street and was installed with construction of the municipal building housing CTUB and the Charles Town Police Department. This system was not analyzed as it was installed per an engineered design.

Channel/Roadway Spread Analysis

No significant open space channels were identified within watershed 3 other than the two karst swales and the channel between George Street and George Street Extension. These were not analyzed as they all appear to have significant infiltration and/or capacity.

Two locations were analyzed for their potential issues resulting from channel flow. The table below lists the issues.

Identifier	Location	Description
C.3.1	George Street Ext	Roadside ditch
C.3.2	Samuel Street	Spread

Depressions

One significant infiltration depression was identified within watershed 3. D3.1 does have a previously installed outlet which is the culvert under George Street(3.2). The outfall for the culvert appears to be buried. Little evidence of significant overtopping of George Street or erosion of its roadside ditch seems to indicate this low-lying area infiltrates significantly through natural process and through the buried outfall 3.2.0.

Overland Relief

The majority of watershed 3's issues were analyzed utilizing overland relief analyses.

The issue associated with O.3.1 was created by the construction of two houses at 815 and 817 George Street Extension. The houses were constructed within a drainage swale with little to no consideration for functional drainage. Over 10 acres drained through the swale that was cut off by the construction. A depression now exists both within the lot of the more upstream of the new houses and the neighboring lot that had an existing residence. The depression must fill before spilling into the street. The foundation of 813 George Street Extension is inundated by this ponding even during smaller events.

O.3.2 and O.3.3 are associated with potential impacts to local roadways and several residences. O3.3 has an inlet and storm sewer, but the routing from 3.4.2 to 3.3.1 is unclear and the original outfall seems to have been buried. The system discharges through the grate at 3.3.1. 3.4.2 is also located outside the true low point resulting in inundation even during smaller events.

CITY OF CHARLES TOWN WATERSHEDS

WATERSHED 3 H&H ANALYSIS EXHIBIT

CITY OF CHARLES TOWN - JEFFERSON COUNTY, WEST VIRGINIA

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GREENWAY ENGINEERING
PROUDLY SERVING WEST VIRGINIA & VIRGINIA
OFFICES IN: MARTINSBURG, WV WINCHESTER, VA & ASHBURN, VA

Date:	04/08/2026
Scale:	1" = 100'
Designed By:	ZJ/RLK/ZS
File No.	7037
Sheet	1 Of 1

100 0 100 200

SCALE: 1" = 100'

LEGEND

- KARST SWALE WITH MINIMAL DISTURBANCE
- 100 YEAR FLOOD HAZARD AREA
- D#.# — DEPRESSION WITH NO DRAINAGE, ASSUMED INFILTRATION
- DRAINAGE AREA ASSUMED TO INFILTRATE, DISCARDED FROM DOWNSTREAM ANALYSIS
- APPROXIMATE 100 YEAR PONDING BASED ON OLR ANALYSIS
- WATERSHED BOUNDARY (STUDY AREA)
- WATERSHED BOUNDARY (BEYOND CITY LIMITS)
- CITY LIMITS
- STREAM
- SF.## — STORM WATER FACILITY
- INLET DRAINAGE DIVIDE
- C.## — CHANNEL/SPREAD COMP
- CHANNEL/SPREAD COMP DRAINAGE DIVIDE
- O.## — OLR (OVERLAND RELIEF) COMP
- OLR DRAINAGE DIVIDE
- STORM PIPE
- UNVERIFIED STORM PIPE
- ### — STORM STRUCTURE LABEL
- STORM SEWER MANHOLE
- STORM SEWER INLET
- STORM SEWER OUTFALL

Roadside Ditch and Roadway Spread Analysis

Watershed 3

												2 Year						10 Year						100 Year					
												2yr Karst Factor			0.69			10yr Karst Factor			0.77			100yr Karst Factor			0.83		
Identifier	Location	Description	Side Slope 1 (H ft:1 ft)	Side Slope 2 (H ft:1 ft)	Upstream Road Length(ft)	Upstream Intersections	Available Depth for Ditch/Gutter(ft)	Available Width for Spread (ft)	Approximate Running Slope (%)	Drainage Area (Acre)	C Factor	Tc (Min)	Rainfall Intensity (in/hr)	Flow (cfs)	Depth of flow (ft)	Roadway Surcharge (ft)	Spread (ft)	Travel Lane Spread (ft)	Rainfall Intensity (in/hr)	Flow (cfs)	Depth of flow (ft)	Roadway Surcharge (ft)	Spread (ft)	Travel Lane Spread (ft)	Rainfall Intensity (in/hr)	Flow (cfs)	Depth of flow (ft)	Roadway Surcharge (ft)	Spread (ft)	Travel Lane Spread (ft)
C.3.1	George Street Ext	Roadside ditch	20	3	550	0	0.25	0	4%	11.48	0.58	20	2.72	12.50	0.49	0.24	12.00	Full	3.77	19.33	0.57	0.32	16.00	Full	5.33	29.46	0.67	0.42	21.00	Full
C.3.2	Samuel Street	Spread	NA	NA	1000	2	0	3	2%	0.83	0.49	5	4.73	1.33	0.14	0.14	7.04	5.04	6.52	2.05	0.17	0.17	8.29	6.29	9.23	3.12	0.19	0.19	9.71	7.71

NOTES

For roadside ditches available depth is the approximated depth of the ditch outside the roadway, 0.1' is indicative of no defined roadside ditch

For spread comps available depth of 0' is indicative of no gutter pan and 0.1' is indicative of a gutter pan

For spread comps a negative available spread is indicative of a local depression that results in an initial spread for all storm events

Upstream Intersections within 500ft of the highpoint are excluded from the upstream intersection counts

Available width is the approximated area available for spread outside an assumed 10ft travel lane

Roadway surcharge depth is the expected depth of water at the edge of pavement

Mannings n assumptions; ditch/channel = 0.025; road/gutter spread = .016

Road cross slopes assumed at 2%

Overland Relief Analysis (OLR)

Watershed 3

										10 Year								100 Year							
										10yr Karst Factor					0.77			100yr Karst Factor					0.83		
Identifier	Location	Constraint Description	Approximated Weir Elevation	Inlets Present	Throat Inlet or 2 Grates Present	Storm sewer capacity (cfs)	Drainage Area (Acre)	C Factor	Tc (Min)	Rainfall Intensity (in/hr)	OLR Flow (cfs)	Depth (ft)	Approximated WSE	Buildings Impacted	Local Roadway Inundation (ft)	Primary Route Inundation (ft)	Singular Access Point Impacts	Rainfall Intensity (in/hr)	OLR Flow (cfs)	Depth (ft)	Approximated WSE	Buildings Impacted	Local Roadway Inundation (ft)	Primary Route Inundation (ft)	Singular Access Point Impacts
O.3.1	George Street Ext	Houses/Yards	493.00	0	No	0.00	10.28	0.58	20	3.77	17.31	0.69	493.69	2	0	0	No	5.33	26.38	0.80	493.80	2	0	0	No
O.3.2	Shutter Street	Roadway	501.00	1	No	0.00	9.35	0.59	15	4.18	17.76	0.21	501.21	1	50	0	No	5.84	26.74	0.27	501.27	1	75	0	No
O.3.3	Wall Street	Houses/Yards	512.10	1	No	0.00	7.63	0.58	15	4.18	14.24	0.41	512.51	2	220	0	No	5.84	21.45	0.64	512.74	2	240	0	No

NOTES

Weir coefficient assumed as 3.27

OLR flow accounts for storm sewer capacity where redundant inlets are present to ensure drainage

Storm sewer capacity is only accounted for were either throat inlets or redundant grate inlets are present within the 100 year ponding area

Storm Sewer Pipe Analysis

Watershed 3

																						2 Year					10 Year				
																						2yr Karst Factor				0.69	10yr Karst Factor				0.77
Inlet/Structure Name	**Downstream Structure**	**Structure Type**	**Inlet Size (in)**	**Inlet Profile**	**Approximate Top Elevation/Invert**	**Approximate Invert Up**	**Approximate Invert Down**	**Pipe Length (ft)**	**Pipe Material**	**Pipe Size (in)**	**Approximate Pipe Slope (%)**	**Pipe Mannings 'n'**	**Flow Area (ft^2)**	**Hydraulic Radius**	**Full Flow Capacity (cfs)**	**Inlet C Factor**	**Inlet Drainage Area (Acres)**	**Time to Inlet (min)**	**System C Factor**	**System Drainage Area (Acre)**	**System Time (Min)**	**Inlet Rainfall Intensity (in/hr)**	**Flow To Inlet (cfs)**	**System Rainfall Intensity (in/hr)**	**System Flow (cfs)**	**System Flow/Pipe Full Flow (%)**	**Inlet Rainfall Intensity (in/hr)**	**Flow To Inlet (cfs)**	**System Rainfall Intensity (in/hr)**	**System Flow (cfs)**	**System Flow/Pipe Full Flow (%)**
3.1.14	3.1.3	Grate	24 x 24	Private System, Engineered Design, Not Evaluated																											
3.1.13	3.1.12	Grate	24 x 24																												
3.1.12	3.1.11	Grate	24 x 24																												
3.1.11	3.1.10	MH																													
3.1.10	3.1.9	MH																													
3.1.9	3.1.8	Grate	24 x 24																												
3.1.8	3.1.7	Grate	24 x 24																												
3.1.7	3.1.6	Grate	24 x 24																												
3.1.6	3.1.5	Grate	24 x 24																												
3.1.5	3.1.4	Grate	24 x 24																												
3.1.4	3.1.3	Grate	24 x 24																												
3.1.3	3.1.2	Grate	24 x 24																												
3.1.2	3.1.1	Grate	24 x 24																												
3.1.1	3.1.0	Grate	24 x 24																												
3.1.0		Outlet																													
3.2.1	3.2.0	Culvert Inv		Sag	480.00	480.00			Concrete	24						0.55	24.08	20	0.55	24.08	20	3.36	30.70	3.36	30.70		4.59	46.81	4.59	46.81	
3.2.0		Outlet			Buried																										
3.3.1	3.3.0	Culvert Inv		Sag	481.28	481.28	480.25	24	Concrete	15	4.3%	0.013	1.23	0.31	13.42	0.55	17.18	20	0.55	17.18	20	3.36	21.91	3.36	21.91	163%	4.59	33.40	4.59	33.40	249%
3.3.0		Outlet			480.25																										
3.4.2	3.4.1	Grate	30 x 30	Sag	505.05	502.05	497	283	PVC	12	1.8%	0.012	0.79	0.25	5.19	0.58	7.63	15	0.58	7.63	15	3.36	10.26	3.36	10.26	198%	4.59	15.64	4.59	15.64	301%
3.4.1	3.4.0	Grate	24 x 24	Sag	500.00	497.00										0.65	1.72	10	0.59	9.35	15	3.04	2.35	3.36	12.85		4.18	3.60	4.59	19.59	
3.4.0		Outlet			Buried																										
3.5.10	3.5.2	Grate	18 x 18	Engineered Design, Not Evaluated																											
3.5.9	3.5.8	Curb Inlet	48																												
3.5.8	3.5.7	Curb Inlet	48																												
3.5.7	3.5.6	Curb Inlet	48																												
3.5.6	3.5.5	Curb Inlet	48																												
3.5.5	3.5.4	Curb Inlet	48																												
3.5.4	3.5.3	Curb Inlet	48																												
3.5.3	3.5.2	Curb Inlet	48																												
3.5.2	3.5.1	Curb Inlet	48																												
3.5.1	3.5.0	Curb Inlet	48																												
3.5.0		Outlet																													

NOTES

Structures assumed to be 3' deep unless direct field observations indicate significant difference

Negative pipe slopes are assumed to have the capacity equivalent to a slope of 0.1%

Appendix-Watershed 4

Watershed 4 consists of areas draining to Evitts Run southwest of George Street west of the CTUB wastewater treatment plant. This watershed has two concentrated discharges from storm sewer systems 4.2 and 4.1. No suspected stormwater management facilities were identified within watershed 4.

Storm Sewer and Culverts

Three storm sewer systems were identified within the watershed.

Systems 4.1 and 4.2 were installed with Evitts Run Estates which only has plat documents available in city files based on documents provided by City planning staff. System 4.2 appears to have been extended to provide drainage to the residential lot downstream of Mordington Avenue (4.2.7).

System 4.3 provides roadway drainage for the low point along Mordington Avenue and discharges towards system 4.2.

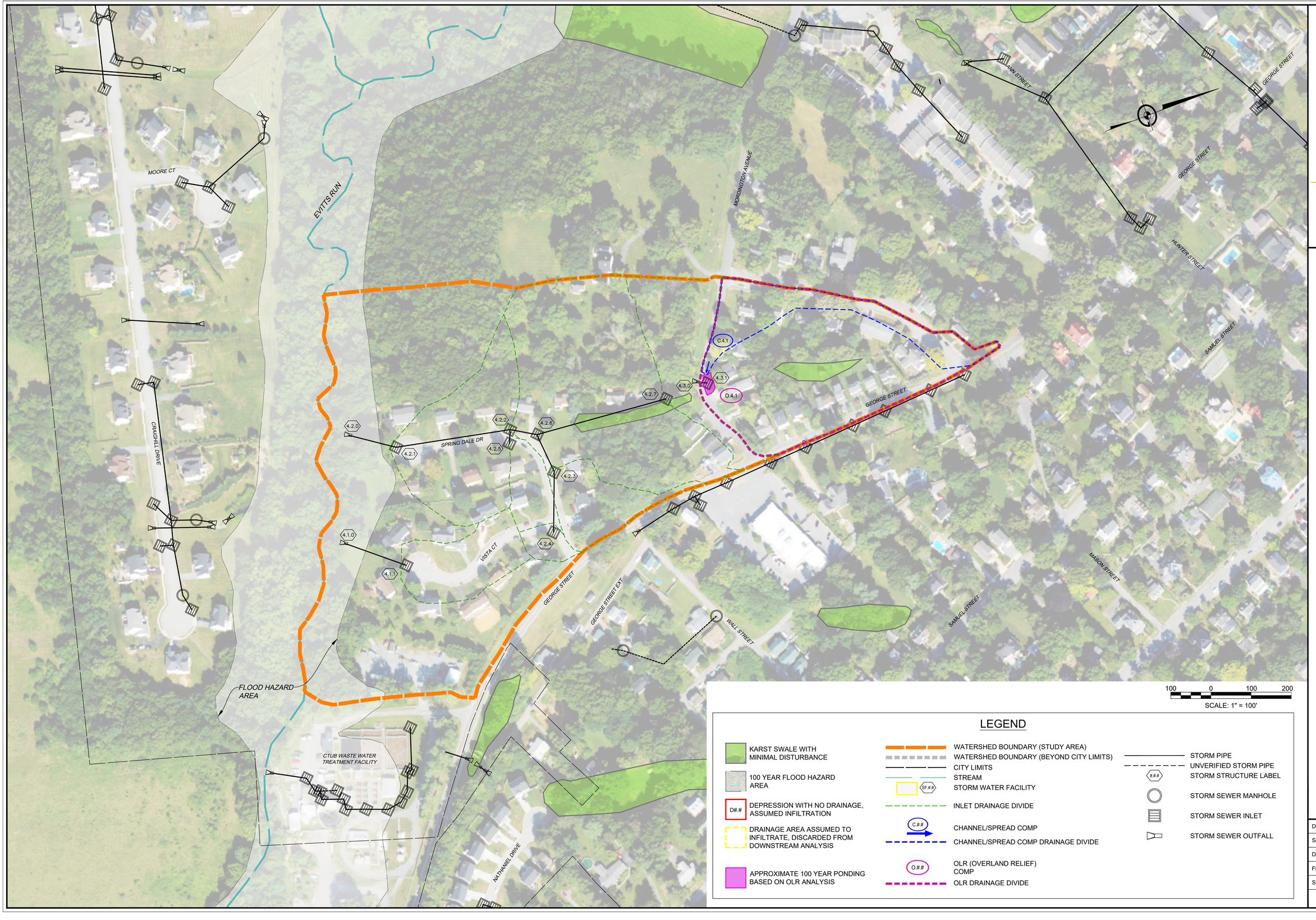
Channel/Roadway Spread Analysis

One location was identified for channel analysis within watershed 4. C.4.1 evaluates spread along Mordington Avenue leading to the low point on the street. Other areas appear to have sufficient inlets, storm sewer and roadside ditches to minimize spread.

Identifier	Location	Description
C.4.1	Mordington north side	Roadside ditch

Overland Relief

Overland relief was analyzed at the low point along Mordington Avenue (O.4.1) and evaluated the ponding resulting from runoff needing to overtop the crown of Mordington Avenue.



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CITY OF CHARLES TOWN WATERSHEDS

WATERSHED 4 H&H ANALYSIS EXHIBIT

CITY OF CHARLES TOWN - JEFFERSON COUNTY, WEST VIRGINIA

Date:	04/08/2026
Scale:	1" = 100'
Designed By:	ZJ/RLK/ZS
File No.	7037
Sheet	1 Of 1

Roadside Ditch and Roadway Spread Analysis

Watershed 4

													2 Year						10 Year						100 Year					
													2yr Karst Factor			0.55			10yr Karst Factor			0.66			100yr Karst Factor			0.74		
Identifier	**Location**	**Description**	**Side Slope 1 (H ft:1 ft)**	**Side Slope 2 (H ft:1 ft)**	**Upstream Road Length(ft)**	**Upstream Intersections**	**Available Depth for Ditch/Gutter(ft)**	**Available Width for Spread (ft)**	**Approximate Running Slope (%)**	**Drainage Area (Acre)**	**C Factor**	**Tc (Min)**	**Rainfall Intensity (in/hr)**	**Flow (cfs)**	**Depth of flow (ft)**	**Roadway Surcharge (ft)**	**Spread (ft)**	**Travel Lane Spread (ft)**	**Rainfall Intensity (in/hr)**	**Flow (cfs)**	**Depth of flow (ft)**	**Roadway Surcharge (ft)**	**Spread (ft)**	**Travel Lane Spread (ft)**	**Rainfall Intensity (in/hr)**	**Flow (cfs)**	**Depth of flow (ft)**	**Roadway Surcharge (ft)**	**Spread (ft)**	**Travel Lane Spread (ft)**
C.4.1	Mordington north side	Roadside ditch	40	5	800	1	0.1	0	3%	1.17	0.50	10	3.72	1.20	0.17	0.07	3.50	3.50	5.07	1.96	0.23	0.13	6.50	6.50	7.03	3.04	0.20	0.10	5.00	5.00

NOTES

For roadside ditches available depth is the approximated depth of the ditch outside the roadway, 0.1' is indicative of no defined roadside ditch

For spread comps available depth of 0' is indicative of no gutter pan and 0.1' is indicative of a gutter pan

For spread comps a negative available spread is indicative of a local depression that results in an initial spread for all storm events

Upstream Intersections within 500ft of the highpoint are excluded from the upstream intersection counts

Available width is the approximated area available for spread outside an assumed 10ft travel lane

Roadway surcharge depth is the expected depth of water at the edge of pavement

Mannings n assumptions; ditch/channel = 0.025; road/gutter spread = .016

Road cross slopes assumed at 2%

Overland Relief Analysis (OLR)

Watershed 4

										10 Year								100 Year							
										10yr Karst Factor					0.66			100yr Karst Factor					0.74		
Identifier	**Location**	**Constraint Description**	**Approximated Weir Elevation**	**Inlets Present**	**Throat Inlet or 2 Grates Present**	**Storm sewer capacity (cfs)**	**Drainage Area (Acre)**	**C Factor**	**Tc (Min)**	**Rainfall Intensity (in/hr)**	**OLR Flow (cfs)**	**Depth (ft)**	**Approximated WSE**	**Buildings Impacted**	**Local Roadway Inundation (ft)**	**Primary Route Inundation (ft)**	**Singular Access Point Impacts**	**Rainfall Intensity (in/hr)**	**OLR Flow (cfs)**	**Depth (ft)**	**Approximated WSE**	**Buildings Impacted**	**Local Roadway Inundation (ft)**	**Primary Route Inundation (ft)**	**Singular Access Point Impacts**
O.4.1	Mordington Ave	Roadway	511.50	1	No	0.00	4.43	0.59	10	5.07	8.75	0.16	511.66	0	25	0	No	7.03	13.60	0.20	511.70	2	58	0	No

NOTES

Weir coefficient assumed as 3.27

OLR flow accounts for storm sewer capacity where redundant inlets are present to ensure drainage

Storm sewer capacity is only accounted for were either throat inlets or redundant grate inlets are present within the 100 year ponding area

Storm Sewer Pipe Analysis

Watershed 4

																					2 Year					10 Year				
																							2yr Karst Factor		0.55			10yr Karst Factor		0.66	
Inlet/Structure Name	Downstream Structure	Structure Type	Inlet Size (in)	Inlet Profile	Approximate Top Elevation/Invert	Approximate Invert Up	Approximate Invert Down	Pipe Length (ft)	Pipe Material	Pipe Size (in)	Approximate Pipe Slope (%)	Pipe Mannings 'n'	Flow Area (ft^2)	Hydraulic Radius	Full Flow Capacity (cfs)	Inlet C Factor	Inlet Drainage Area (Acres)	Time to Inlet (min)	System C Factor	System Drainage Area (Acre)	System Time (Min)	Inlet Rainfall Intensity (in/hr)	Flow To Inlet (cfs)	System Rainfall Intensity (in/hr)	System Flow (cfs)	System Flow/Pipe Full Flow (%)	Inlet Rainfall Intensity (in/hr)	Flow To Inlet (cfs)	System Rainfall Intensity (in/hr)	System Flow (cfs)	System Flow/Pipe Full Flow (%)
4.1.1	4.1.0	Grate	24 X 24	Sag	489.93	486.93	470.87	160	CMP	15	10.0%	0.024	1.23	0.31	11.09	0.5	1.05	10	0.50	1.05	10	3.04	0.88	3.04	0.88	8%	4.18	1.45	4.18	1.45	13%
4.1.0		Outlet			470.87																										
4.2.4	4.2.3	Grate	24 X 24	Grade	505.05	502.05	495.48	150	CMP	15	4.4%	0.024	1.23	0.31	7.36	0.50	0.21	5	0.50	0.21	5	3.72	0.21	3.72	0.21	3%	5.07	0.35	5.07	0.35	5%
4.2.3	4.2.6	Curb	96	Grade	498.48	495.48	490.08	101	CMP	15	5.3%	0.024	1.23	0.31	8.07	0.50	0.84	5	0.50	1.05	10	3.72	0.86	3.04	0.88	11%	5.07	1.41	4.18	1.45	18%
4.2.7	4.2.6	Grate	30 X 30	Grade	504.00	501.00	490.08	324	CMP	15	3.4%	0.024	1.23	0.31	6.47	0.57	5.83	15	0.57	5.83	15	3.36	6.14	3.36	6.14	95%	4.59	10.07	4.59	10.07	156%
4.2.6	4.2.2	Grate	30 X 30	Grade	493.08	490.08	486.97	64	CMP	24	4.9%	0.024	3.14	0.50	27.18	NA Buried			0.56	6.88	15	NA Buried		3.36	7.11	26%	NA Buried		4.59	11.66	43%
4.2.5	4.2.2	Curb	120		489.69	486.69	486.97	35	CMP	15	-0.8%	0.024	1.23	0.31	1.11	0.5	0.47	5	0.50	0.47	5	3.72	0.48	3.72	0.48	43%	5.07	0.79	5.07	0.79	71%
4.2.2	4.2.1	Curb	120		489.97	486.97	475.51	287	CMP	30	4.0%	0.024	4.91	0.63	44.53	0.5	4.35	10	0.53	11.70	20	3.04	3.64	3.36	11.56	26%	4.18	6.00	4.59	18.96	43%
4.2.1	4.2.0	Grate	24 X 24		478.51	475.51	472	125	CMP	36	2.8%	0.024	7.07	0.75	60.59	0.47	2.14	10	0.52	13.84	20	3.04	1.68	3.36	13.42	22%	4.18	2.77	4.59	22.01	36%
4.2.0		Outlet			472.00	469.00																									
4.3.1	4.3.0	Grate	24 X 24		510.94	509.50	509.2	30	Concrete	6 x 12	1.0%	0.013	0.50	0.17	1.74	0.59	4.43	10	0.59	4.43	10	3.04	4.37	3.04	4.37	252%	4.18	7.21	4.18	7.21	415%
4.3.0		Outlet			509.20																										

NOTES

Structures assumed to be 3' deep unless direct field observations indicate significant difference

Negative pipe slopes are assumed to have the capacity equivalent to a slope of 0.1%

Appendix-Watershed 5

Watershed 5 consisted of areas discharging to Evitts Run. The area lies to the south of Evitts run and is primarily made up of the development known as Craighill Estates which was designed by a professional surveying firm. Three stormwater facilities were identified that are associated with this development (SF5.1-3). An additional stormwater facility was identified in watershed 5 and seems to be associated with a private parking lot (SF5.4).

Storm Sewer and Culverts

Ten storm sewer networks were identified within watershed 5.

Networks 1-2 and 4-9 were all associated with the Craighill Estates development and were not evaluated as they were constructed per an engineered design plan.

System 3 consists of a culvert under Augustine Avenue and was not evaluated as it serves a DOH road and the upstream end where issues would be likely to occur is within Jefferson County.

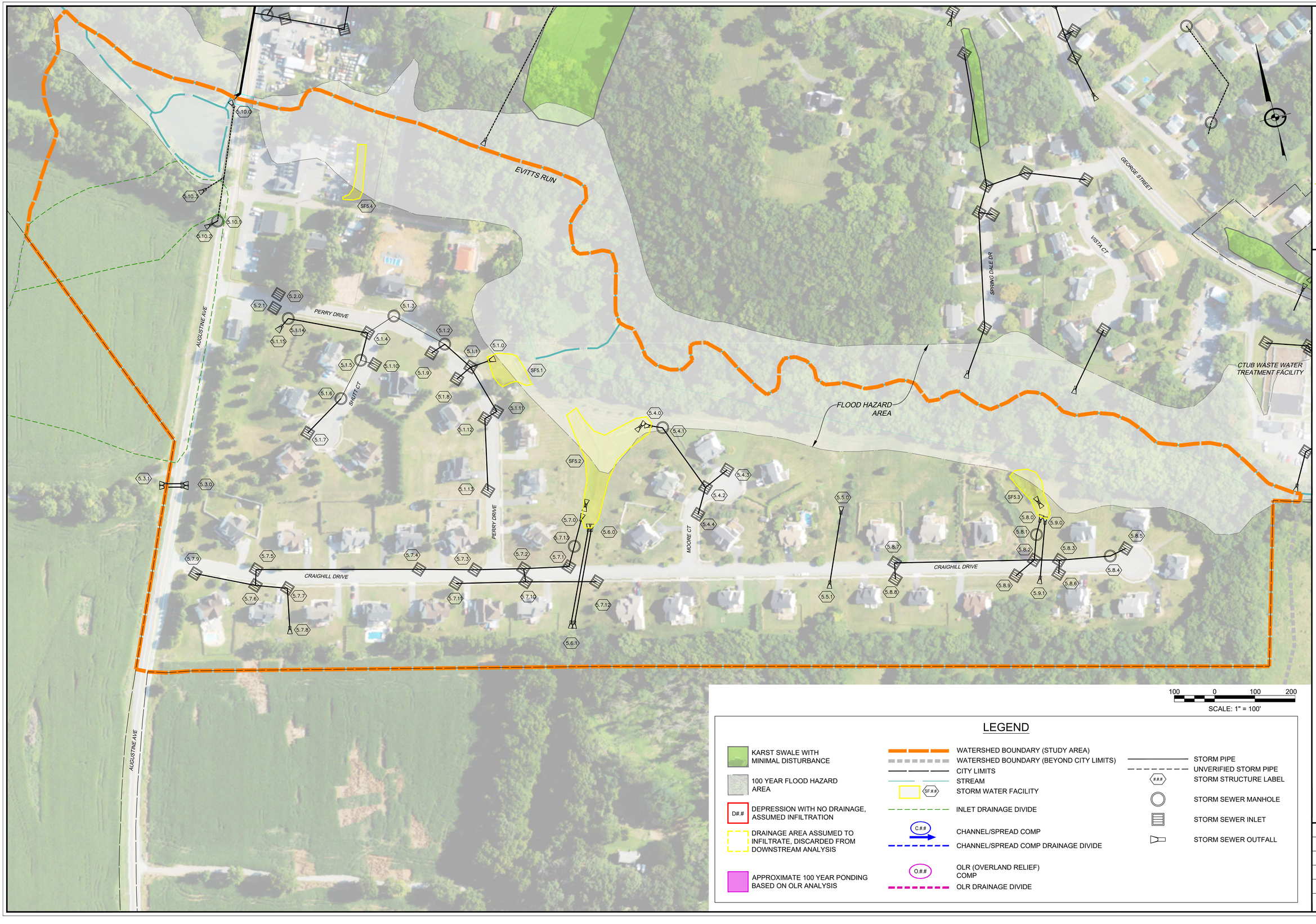
System 10 provides drainage along Augustine Avenue and is most likely under DOH's jurisdiction but was evaluated.

Channel/Roadway Spread Analysis

No potential roadway spread issues or major open channels were identified within the watershed for analysis.

Overland Relief

No concerning areas for overland relief analysis were identified within watershed 5.



100 0 100 200

SCALE: 1" = 100'

LEGEND

- KARST SWALE WITH MINIMAL DISTURBANCE
- 100 YEAR FLOOD HAZARD AREA
- D#.# — DEPRESSION WITH NO DRAINAGE, ASSUMED INFILTRATION
- DRAINAGE AREA ASSUMED TO INFILTRATE, DISCARDED FROM DOWNSTREAM ANALYSIS
- APPROXIMATE 100 YEAR PONDING BASED ON OLR ANALYSIS
- WATERSHED BOUNDARY (STUDY AREA)
- WATERSHED BOUNDARY (BEYOND CITY LIMITS)
- CITY LIMITS
- STREAM
- SF.## — STORM WATER FACILITY
- INLET DRAINAGE DIVIDE
- C.## — CHANNEL/SPREAD COMP
- CHANNEL/SPREAD COMP DRAINAGE DIVIDE
- O.## — OLR (OVERLAND RELIEF) COMP
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WATERSHED 5 H&H ANALYSIS EXHIBIT

CITY OF CHARLES TOWN WATERSHEDS

CITY OF CHARLES TOWN - JEFFERSON COUNTY, WEST VIRGINIA

Date:	04/08/2026
Scale:	1" = 100'
Designed By:	ZJ/RLK/ZS
File No.	7037
Sheet	1 Of 1

Storm Sewer Pipe Analysis

Watershed 5

																							2 Year					10 Year				
																									2yr Karst Factor			0.43		10yr Karst Factor			0.55
Inlet/Structure Name	Downstream Structure	Structure Type	Inlet Size (in)			Inlet Profile	Approximate Top Elevation/Invert	Approximate Invert Up	Approximate Invert Down	Pipe Length (ft)	Pipe Material	Pipe Size (in)	Approximate Pipe Slope (%)	Pipe Mannings 'n'	Flow Area (ft^2)	Hydraulic Radius	Full Flow Capacity (cfs)	Inlet C Factor	Inlet Drainage Area (Acres)	Time to Inlet (min)	System C Factor	System Drainage Area (Acre)	System Time (Min)	Inlet Rainfall Intensity (in/hr)	Flow To Inlet (cfs)	System Rainfall Intensity (in/hr)	System Flow (cfs)	System Flow/Pipe Full Flow (%)	Inlet Rainfall Intensity (in/hr)	Flow To Inlet (cfs)	System Rainfall Intensity (in/hr)	System Flow (cfs)	System Flow/Pipe Full Flow (%)
5.1.15	5.1.14	End Section		48		Engineered Design, Not Evaluated																										
5.1.14	5.1.4	Manhole																														
5.1.13	5.1.12	Curb Inlet		144																												
5.1.12	5.1.11	Curb Inlet		120																												
5.1.11	5.1.1	Curb Inlet		120																												
5.1.10	5.1.5	Curb Inlet		120																												
5.1.9	5.1.2	Curb Inlet		120																												
5.1.8	5.1.1	Curb Inlet		120																												
5.1.7	5.1.6	Curb Inlet		48																												
5.1.6	5.1.5	Manhole																														
5.1.5	5.1.4	Manhole																														
5.1.4	5.1.3	Curb Inlet		120																												
5.1.3	5.1.2	Manhole																														
5.1.2	5.1.1	Manhole																														
5.1.1	5.1.0	Curb Inlet		48																												
5.1.0		Outfall																														
5.2.1	5.2.0	Curb Inlet		48		Engineered Design, Not Evaluated, Pass Through Structures-No Pipe																												
5.2.0		Curb Inlet		48																												
5.3.1	5.3.0	End Wall		24		DOH Culvert, Jefferson County Jurisdiction Upstream																												
5.3.0		End Section																														
5.4.4	5.4.2	Curb Inlet		144		Engineered Design, Not Evaluated																												
5.4.3	5.4.2	Curb Inlet		72																												
5.4.2	5.4.1	Curb Inlet		120																												
5.4.1	5.4.0	Manhole																														
5.4.0		End Section																														
5.5.1	5.5.0	End Section		24		Engineered Design, Not Evaluated																												
5.5.0		End Section																														
5.6.1	5.6.0	End Section		*48*		Engineered Design, Not Evaluated																												
5.6.0		End Section																														
5.7.13	5.7.0	Manhole				Engineered Design, Not Evaluated																												
5.7.12	5.7.1	Curb Inlet		144																												
5.7.11	5.7.3	Curb Inlet		120																												
5.7.10	5.7.2	Curb Inlet		48																												
5.7.9	5.7.6	Curb Inlet		120																												
5.7.8	5.7.7	End Section		30																												
5.7.7	5.7.6	Curb Inlet		72																												
5.7.6	5.7.5	Curb Inlet		96																												
5.7.5	5.7.4	Curb Inlet		48																												
5.7.4	5.7.3	Curb Inlet		120																												
5.7.3	5.7.2	Curb Inlet		144																												
5.7.2	5.7.1	Curb Inlet		48																												
5.7.1	5.7.13	Curb Inlet		72																												
5.7.0		End Section																														
5.8.9	5.8.2	Curb Inlet		144		Engineered Design, Not Evaluated																												
5.8.8	5.8.7	Curb Inlet		168																												
5.8.7	5.8.2	Curb Inlet		120																												
5.8.6	5.8.3	Curb Inlet		96																												
5.8.5	5.8.4	Curb Inlet		48																												
5.8.4	5.8.3	Manhole																														
5.8.3	5.8.2	Curb Inlet		48																												
5.8.2	5.8.1	Curb Inlet		120																												
5.8.1	5.8.0	Manhole																														
5.8.0		End Section																														
5.9.1	5.9.0	End Section		24		Engineered Design, Not Evaluated																												
5.9.0		End Section																														
5.10.3	5.10.0	Culvert Inlet		24		SAG	482.00	482.00	479.2	60	Concrete		24		4.7%	0.013	3.14	0.50	49.15	0.15	2.15	10	0.15	2.15	10	3.04	0.18	3.04	1.33	3%	4.18	0.41	4.18	2.42	5%
5.10.2	5.10.1	End Wall		24		SAG	481.00	481.00	480.75	22	Concrete		24		1.1%	0.013	3.14	0.50	23.78	0.15	5.32	15	0.15	7.47	15	3.36	0.50	3.36	1.76	7%	4.59	1.11	4.59	3.32	14%
5.10.1	5.10.0	Manhole					483.75	480.75	476.5	280	Concrete		24		1.5%	0.013	3.14	0.50	27.77																
5.10.0		Outfall					476.53				Concrete																								

NOTES

Structures assumed to be 3' deep unless direct field observations indicate significant difference

Negative pipe slopes are assumed to have the capacity equivalent to a slope of 0.1%

Appendix-Watershed 6

Watershed 6 consists of the area draining to Evitts Run in the north western portion of the City. No direct concentrated discharges to Evitts Run were identified in this watershed except the discharges of the sags at road crossings.

Storm Sewer and Culverts

Six individual storm networks were identified within watershed 6.

System 2 consists of two grate inlets on either side of MLK Jr Avenue and a discharge into a private parking lot along Washington Street.

Systems 1, 3, and 4 consist of one grate inlet and discharge point serving locations along Liberty and Park Streets.

System 5 consists of one suspected storm sewer inlet. The structure has a metal lid and is filled with sediment. No outfall location was located.

System 6 consists of one grate inlet that discharges to the bridge structure crossing Evitts Run under Washington Street.

Channel/Roadway Spread Analysis

Channel analysis for watershed 6 evaluated flows along four streets. The locations are listed in the table below.

Identifier	Location	Description
C.6.1	Washington St northside	Spread
C.6.2	Eagle Ave westside & MLK Intx	Roadside Ditch
C.6.3	Water St southwest side	Roadside Ditch
C.6.4	Liberty St northside	Spread

Overland Relief

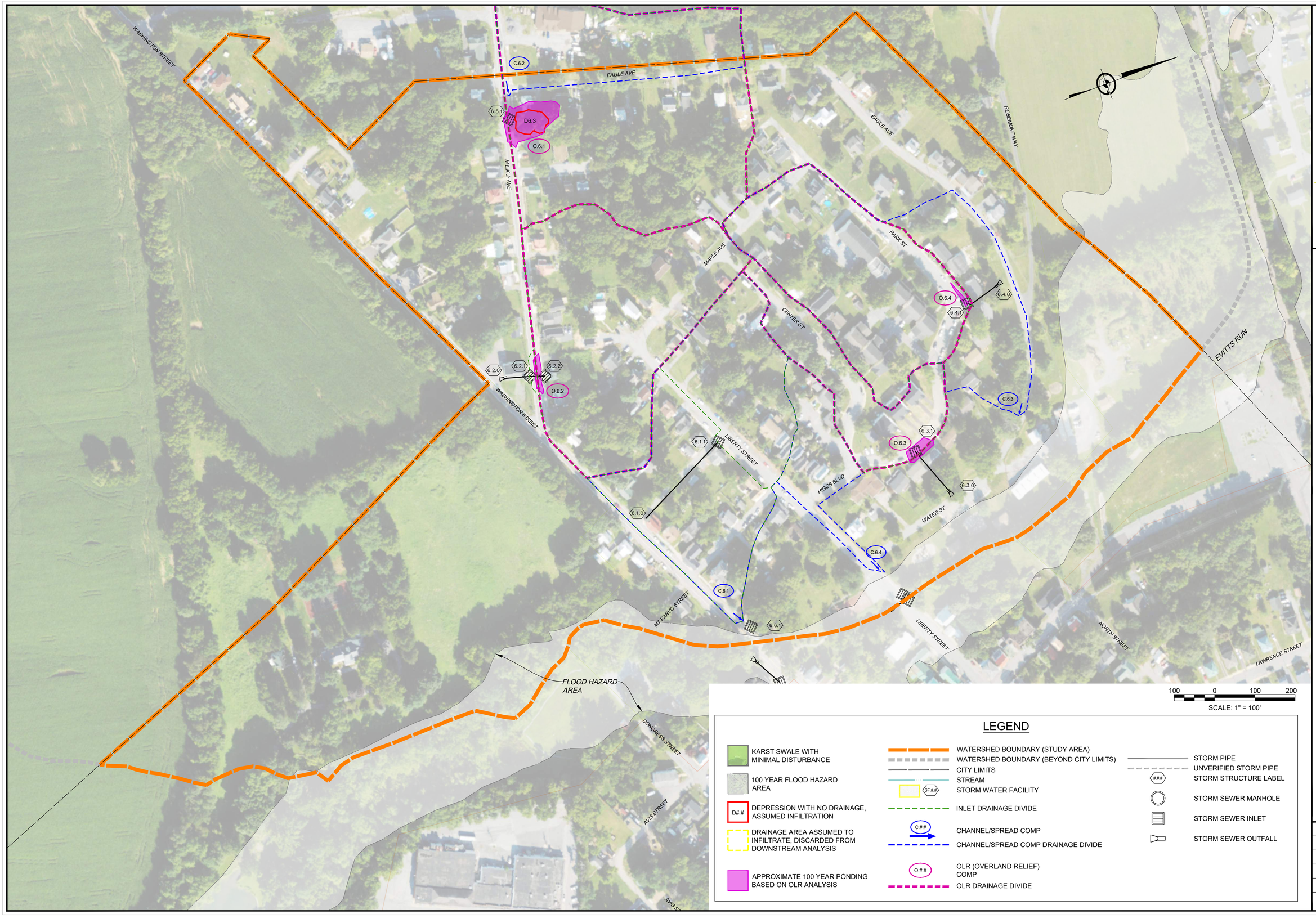
Four locations were evaluated for potential ponding. None of the locations had redundant grate inlets or throat inlets and no storm sewer capacity was deducted from the overland flow rates.

O.6.1 evaluated ponding were runoff must overtop the crown of MLK Jr Avenue. Structure 6.5.1 is believed to have provided drainage for the uphill side of MLK Jr Avenue and is currently filled with sediment and potentially has a buried outfall.

O.6.2 evaluates another location were runoff must cross the crown of MLK Jr Avenue near its intersection with Washington Street and has a grate inlet serving the low point uphill of the road.

O.6.3 evaluates the ponding resulting from runoff needing to overtop the curb and flow between houses along Higgs Boulevard.

O.6.4 evaluates the ponding resulting from runoff needing to overtop the curb and flow between houses along Park Street near its intersection with Higgs Boulevard.



100 0 100 200

SCALE: 1" = 100'

LEGEND

- KARST SWALE WITH MINIMAL DISTURBANCE
- 100 YEAR FLOOD HAZARD AREA
- D#.# — DEPRESSION WITH NO DRAINAGE, ASSUMED INFILTRATION
- DRAINAGE AREA ASSUMED TO INFILTRATE, DISCARDED FROM DOWNSTREAM ANALYSIS
- APPROXIMATE 100 YEAR PONDING BASED ON OLR ANALYSIS
- WATERSHED BOUNDARY (STUDY AREA)
- WATERSHED BOUNDARY (BEYOND CITY LIMITS)
- CITY LIMITS
- STREAM
- SF.## — STORM WATER FACILITY
- INLET DRAINAGE DIVIDE
- C.## — CHANNEL/SPREAD COMP
- CHANNEL/SPREAD COMP DRAINAGE DIVIDE
- O.## — OLR (OVERLAND RELIEF) COMP
- OLR DRAINAGE DIVIDE
- STORM PIPE
- UNVERIFIED STORM PIPE
- ### — STORM STRUCTURE LABEL
- STORM SEWER MANHOLE
- STORM SEWER INLET
- STORM SEWER OUTFALL

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CITY OF CHARLES TOWN WATERSHEDS

WATERSHED 6 H&H ANALYSIS EXHIBIT

CITY OF CHARLES TOWN - JEFFERSON COUNTY, WEST VIRGINIA

Date:	04/08/2026
Scale:	1" = 100'
Designed By:	ZJ/RLK/ZS
File No.	7037
Sheet	1 Of 1

Roadside Ditch and Roadway Spread Analysis

Watershed 6

												2 Year						10 Year						100 Year					
												2yr Karst Factor			0.47			10yr Karst Factor			0.58			100yr Karst Factor			0.68		
Identifier	Location	Description	Side Slope 1 (H ft:1 ft)	Side Slope 2 (H ft:1 ft)	Upstream Road Length(ft)	Upstream Intersections	Available Depth for Ditch/Gutter(ft)	Available Width for Spread (ft)	Approximate Running Slope (%)	Drainage Area (Acre)	C Factor	Tc (Min)	Rainfall Intensity (in/hr)	Flow (cfs)	Depth of flow (ft)	Roadway Surcharge (ft)	Spread (ft)	Travel Lane Spread (ft)	Rainfall Intensity (in/hr)	Flow (cfs)	Depth of flow (ft)	Roadway Surcharge (ft)	Spread (ft)	Travel Lane Spread (ft)	Rainfall Intensity (in/hr)	Flow (cfs)	Depth of flow (ft)	Roadway Surcharge (ft)	Spread (ft)	Travel Lane Spread (ft)
C.6.1	Washington St northside	Spread	NA	NA	500	1	0	10	6%	5.09	0.50	15	3.04	3.64	0.17	0.17	8.38	0.00	4.18	6.17	0.20	0.20	10.21	0.21	5.84	10.11	0.25	0.25	12.25	2.25
C.6.2	Eagle Ave westside & MLK Intx	Roadside Ditch	0.1	40	590	1	0.1	0	1%	2.55	0.50	10	3.72	2.23	0.27	0.17	8.50	8.50	5.07	3.75	0.33	0.23	11.50	Full	7.03	6.10	0.39	0.29	14.50	Full
C.6.3	Water St southwest side	Roadside Ditch	2	40	600	0	0.2	0.5	1%	6.20	0.50	15	3.04	4.43	0.34	0.14	7.00	6.50	4.18	7.52	0.42	0.22	11.00	Full	5.84	12.31	0.50	0.30	15.00	Full
C.6.4	Liberty St northside	Spread	NA	NA	480	1	0.1	4	5%	1.15	0.50	10	3.72	1.01	0.11	0.01	5.35	1.35	5.07	1.69	0.13	0.03	6.50	2.50	7.03	2.75	0.16	0.06	7.79	3.79

NOTES

For roadside ditches available depth is the approximated depth of the ditch outside the roadway, 0.1' is indicative of no defined roadside ditch

For spread comps available depth of 0' is indicative of no gutter pan and 0.1' is indicative of a gutter pan

For spread comps a negative available spread is indicative of a local depression that results in an initial spread for all storm events

Upstream Intersections within 500ft of the highpoint are excluded from the upstream intersection counts

Available width is the approximated area available for spread outside an assumed 10ft travel lane

Roadway surcharge depth is the expected depth of water at the edge of pavement

Mannings n assumptions; ditch/channel = 0.025; road/gutter spread = .016

Road cross slopes assumed at 2%

Overland Relief Analysis (OLR)

Watershed 6

										10 Year								100 Year							
										10yr Karst Factor	0.58							100yr Karst Factor	0.68						
Identifier	Location	Constraint Description	Approximated Weir Elevation	Inlets Present	Throat Inlet or 2 Grates Present	Storm sewer capacity (cfs)	Drainage Area (Acre)	C Factor	Tc (Min)	Rainfall Intensity (in/hr)	OLR Flow (cfs)	Depth (ft)	Approximated WSE	Buildings Impacted	Local Roadway Inundation (ft)	Primary Route Inundation (ft)	Singular Access Point Impacts	Rainfall Intensity (in/hr)	OLR Flow (cfs)	Depth (ft)	Approximated WSE	Buildings Impacted	Local Roadway Inundation (ft)	Primary Route Inundation (ft)	Singular Access Point Impacts
O.6.1	MLK Jr Ave	Roadway	513.50	0	No	0.00	7.22	0.50	15	4.18	8.75	0.21	513.71	2	0	50	No	5.84	14.34	0.26	513.76	3	0	75	No
O.6.2	MLK Jr Ave	Roadway	513.70	1	No	0.00	5.38	0.50	15	4.18	6.52	0.18	513.88	1	0	40	No	5.84	10.68	0.22	513.92	2	0	85	No
O.6.3	Higgs Blvd	Curb/Yards/Houses	529.00	1	No	0.00	1.86	0.50	10	5.07	2.73	0.05	529.05	0	70	0	No	7.03	4.45	0.07	529.07	0	80	0	No
O.6.4	Park St	Curb/Yards/Houses	519.00	1	No	0.00	4.16	0.50	10	5.07	6.12	0.12	519.12	0	0	0	No	7.03	9.94	0.17	519.17	0	0	0	No

NOTES

Weir coefficient assumed as 3.27

OLR flow accounts for storm sewer capacity where redundant inlets are present to ensure drainage

Storm sewer capacity is only accounted for were either throat inlets or redundant grate inlets are present within the 100 year ponding area

Storm Sewer Pipe Analysis

Watershed 6

																					2 Year					10 Year				
																							2yr Karst Factor		0.47			10yr Karst Factor		0.58	
Inlet/Structure Name	Downstream Structure	Structure Type	Inlet Size (in)	Inlet Profile	Approximate Top Elevation/Invert	Approximate Invert Up	Approximate Invert Down	Pipe Length (ft)	Pipe Material	Pipe Size (in)	Approximate Pipe Slope (%)	Pipe Mannings 'n'	Flow Area (ft^2)	Hydraulic Radius	Full Flow Capacity (cfs)	Inlet C Factor	Inlet Drainage Area (Acres)	Time to Inlet (min)	System C Factor	System Drainage Area (Acre)	System Time (Min)	Inlet Rainfall Intensity (in/hr)	Flow To Inlet (cfs)	System Rainfall Intensity (in/hr)	System Flow (cfs)	System Flow/Pipe Full Flow (%)	Inlet Rainfall Intensity (in/hr)	Flow To Inlet (cfs)	System Rainfall Intensity (in/hr)	System Flow (cfs)	System Flow/Pipe Full Flow (%)
6.1.1	6.1.0	Curb Inlet	24	Sag	520.03	517.03	494	259	PVC	12	8.9%	0.012	0.79	0.25	11.54	0.50	2.22	10	0.50	2.22	10	3.04	1.59	3.04	1.59	14%	4.18	2.69	4.18	2.69	23%
6.1.0		Outlet			494.00																										
6.2.2	6.2.1	Grate	24 x 24	Sag	514.00	511.00	510	40	CMP	15	2.5%	0.024	1.23	0.31	5.54	0.50	5.38	15	0.50	5.38	15	3.36	4.25	3.36	4.25	77%	4.59	7.16	4.59	7.16	129%
6.2.1	6.2.0	Grate	24 x 24	Sag	513.00	510.00	505.5	70	CMP	15	6.4%	0.024	1.23	0.31	8.87	0.50	0.04	5	0.50	5.42	15	3.72	0.03	3.36	4.28	48%	5.07	0.06	4.59	7.21	81%
6.2.0		Outlet			505.50																										
6.3.1	6.3.0	Grate	30 x 30	Sag	526.71	523.71	497.87	131	PVC	6	19.7%	0.012	0.20	0.13	2.70	0.50	1.86	10	0.50	1.86	10	3.04	1.33	3.04	1.33	49%	4.18	2.25	4.18	2.25	83%
6.3.0		Outlet			497.87																										
6.4.1	6.4.0	Grate	30 x 30	Sag	518.67	515.67	505.25	90	CMP	10	11.6%	0.024	0.55	0.21	4.05	0.50	4.16	10	0.50	6.02	15	3.04	2.97	3.36	4.75	117%	4.18	5.04	4.59	8.01	198%
6.4.0		Outlet			505.25																										
6.5.1				Sag	Suspected structure, filled with sediment, no outfall located											0.50	7.22	15				3.36	5.70				4.59	9.61			
6.6.1	6.6.0	Grate	30 x 30	Sag	522.91	520.03	511.73	260	PVC	15	3.2%	0.012	1.23	0.31	12.55	0.50	5.09	15	0.50	5.09	15	3.36	4.02	3.36	4.02	32%	4.59	6.78	4.59	6.78	54%
6.6.0		Outlet			511.73																										

NOTES

Structures assumed to be 3' deep unless direct field observations indicate significant difference

Negative pipe slopes are assumed to have the capacity equivalent to a slope of 0.1%

Appendix-Watershed 7

Watershed 7 consists of northern portions of the City that drain directly to Evitts Run along its eastern bank. No direct concentrated discharges to Evitts Run were identified in this watershed except the discharges of the low points at road crossings. Two potential stormwater facilities were identified within watershed 7. Both SF7.1 and SF7.2 appear to be associated with the American Public University System buildings as well as a third facility outside City limits noted as SF7.X on the watershed 7 H&H analysis exhibit.

Storm Sewer and Culverts

Eight storm systems were identified in watershed 7

System 1 and 2 consists of a private systems on the American Public University System facilty.

System 3 has two grate inlets at the George Street Railroad crossing. At least one additional inlet was located at this low point in the roadway near 7.3.2 and has been paved over.

System 4 consists of pipes that appear to be installed crossing North Street at its intersection with Lawrence Street. It is suspected these were originally culverts under North Street that were modified with expansion of the roadway and installation of sidewalks.

System 5 consists of a structure with a metal lid that is full of sediment. It may or may not be a storm sewer structure and may have provided drainage across the intersection of Liberty and Lawrence Streets at one time.

System 6 consists of an inlet and discharge point along Washington Street nears its crossing of Evitts Run.

System 7 is made up of two grate inlets draining the low point in Liberty Street at its crossing of Evitts Run. Grate 7.7.2 drains areas that are classified as watershed 6, however it is included as one system with 7.7.1 due to their similarities and proximity.

System 8 is a culvert under Lawrence Street at its crossing of the CSX Railroad.

Channel/Roadway Spread Analysis

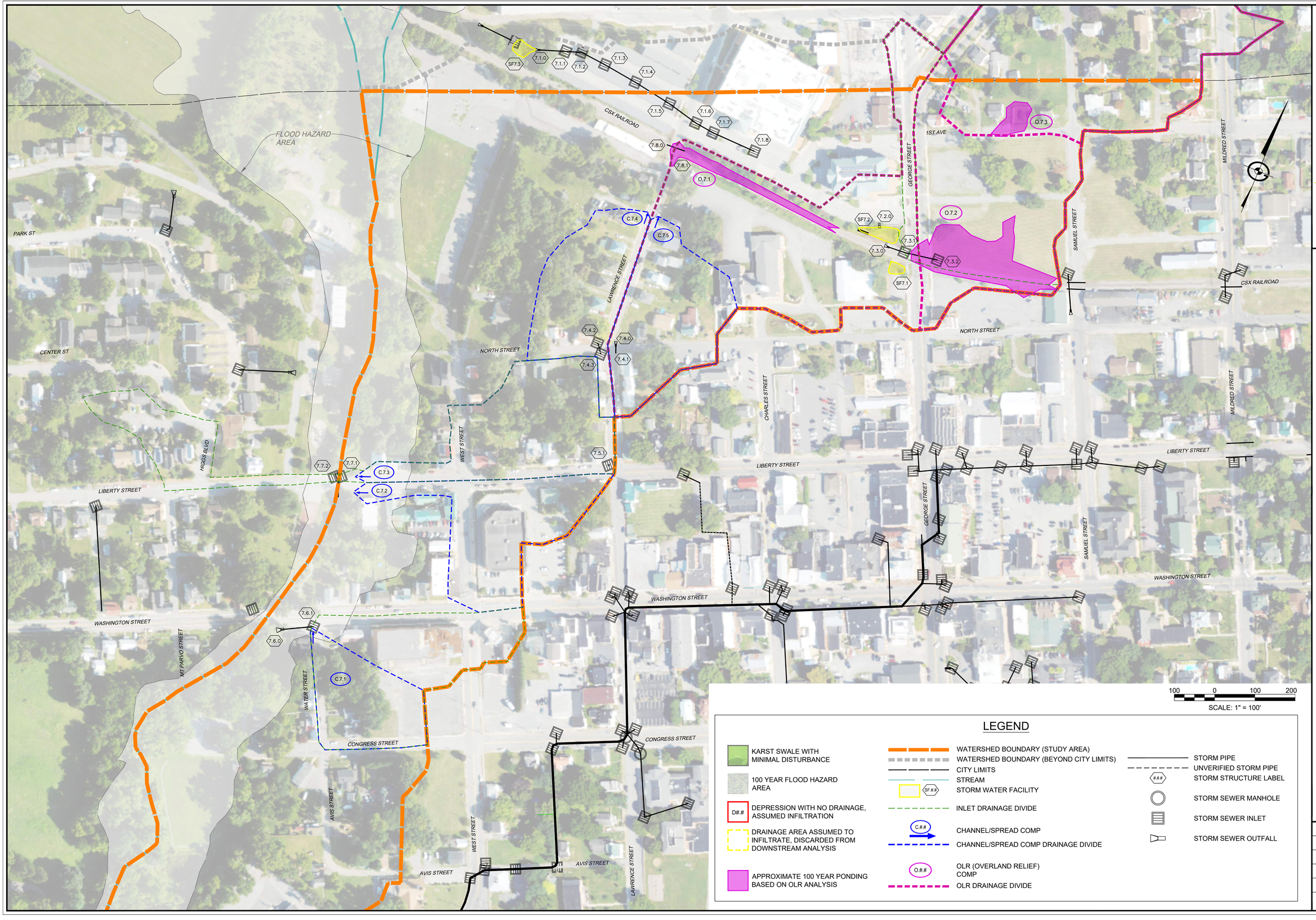
Five locations were evaluated for roadway spread within watershed 7 and a listed below.

Overland Relief

Three locations were evaluated for ponding in watershed 7.

Although O.7.1 and O.7.2 were evaluated, they were not considered as a primary issue as much of the runoff is likely conveyed through the ballast underlying the railroad as well as potentially having jurisdictional implications associated with the roadway. The analysis presented ignores this flow capacity and verified the low probability of significant impacts to buildings.

O.7.3 evaluates flow across 1ST Avenues crown and associated ponding.



LEGEND

- KARST SWALE WITH MINIMAL DISTURBANCE
- 100 YEAR FLOOD HAZARD AREA
- D#.# — DEPRESSION WITH NO DRAINAGE, ASSUMED INFILTRATION
- DRAINAGE AREA ASSUMED TO INFILTRATE, DISCARDED FROM DOWNSTREAM ANALYSIS
- APPROXIMATE 100 YEAR PONDING BASED ON OLR ANALYSIS
- WATERSHED BOUNDARY (STUDY AREA)
- WATERSHED BOUNDARY (BEYOND CITY LIMITS)
- CITY LIMITS
- STREAM
- SF.## — STORM WATER FACILITY
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WATERSHED 7 H&H ANALYSIS EXHIBIT

CITY OF CHARLES TOWN WATERSHEDS

CITY OF CHARLES TOWN - JEFFERSON COUNTY, WEST VIRGINIA

Date:	04/08/2026
Scale:	1" = 100'
Designed By:	ZJ/RLK/ZS
File No.	7037
Sheet	1 Of 1

Roadside Ditch and Roadway Spread Analysis

Watershed 7

												2 Year						10 Year						100 Year					
												2yr Karst Factor			0.69			10yr Karst Factor			0.77			100yr Karst Factor			0.83		
Identifier	Location	Description	Side Slope 1 (H ft:1 ft)	Side Slope 2 (H ft:1 ft)	Upstream Road Length(ft)	Upstream Intersections	Available Depth for Ditch/Gutter(ft)	Available Width for Spread (ft)	Approximate Running Slope (%)	Drainage Area (Acre)	C Factor	Tc (Min)	Rainfall Intensity (in/hr)	Flow (cfs)	Depth of flow (ft)	Roadway Surcharge (ft)	Spread (ft)	Travel Lane Spread (ft)	Rainfall Intensity (in/hr)	Flow (cfs)	Depth of flow (ft)	Roadway Surcharge (ft)	Spread (ft)	Travel Lane Spread (ft)	Rainfall Intensity (in/hr)	Flow (cfs)	Depth of flow (ft)	Roadway Surcharge (ft)	Spread (ft)	Travel Lane Spread (ft)
C.7.1	Water St westside	Spread	NA	NA	530	0	0	0	5%	1.36	0.87	10	3.72	3.04	0.16	0.16	8.08	8.08	5.07	4.62	0.19	0.19	9.46	9.46	7.03	6.90	0.25	0.25	12.33	Full
C.7.2	Liberty St southside	Roadside Ditch	20	50	1030	1	0	10	2%	2.14	0.50	10	3.72	2.75	0.21	0.21	10.50	0.50	5.07	4.18	0.24	0.24	12.00	2.00	7.03	6.24	0.29	0.29	14.50	4.50
C.7.3	Liberty St northside	Spread	NA	NA	900	1	0	10	2%	2.53	0.50	10	3.72	3.25	0.20	0.20	9.83	0.00	5.07	4.94	0.23	0.23	11.54	1.54	7.03	7.38	0.27	0.27	13.42	3.42
C.7.4	Lawrence St westside	Spread	NA	NA	680	0	0	4	0.5%	1.82	0.50	10	3.72	2.34	0.23	0.23	11.29	7.29	5.07	3.55	0.26	0.26	13.21	9.21	7.03	5.31	0.31	0.31	15.38	Full
C.7.5	Lawrence St eastside	Spread	NA	NA	750	0	0	4	0.5%	2.12	0.63	10	3.72	3.43	0.26	0.26	13.04	9.04	5.07	5.21	0.31	0.31	15.25	Full	7.03	7.79	0.35	0.35	17.71	Full

NOTES

For roadside ditches available depth is the approximated depth of the ditch outside the roadway, 0.1' is indicative of no defined roadside ditch

For spread comps available depth of 0' is indicative of no gutter pan and 0.1' is indicative of a gutter pan

For spread comps a negative available spread is indicative of a local depression that results in an initial spread for all storm events

Upstream Intersections within 500ft of the highpoint are excluded from the upstream intersection counts

Available width is the approximated area available for spread outside an assumed 10ft travel lane

Roadway surcharge depth is the expected depth of water at the edge of pavement

Mannings n assumptions; ditch/channel = 0.025; road/gutter spread = .016

Road cross slopes assumed at 2%

Overland Relief Analysis (OLR)

Watershed 7

										10 Year								100 Year							
										10yr Karst Factor	0.77							100yr Karst Factor	0.83						
Identifier	**Location**	**Constraint Description**	**Approximated Weir Elevation**	**Inlets Present**	**Culv, Throat Inlet or 2 Grates Present**	**Storm sewer capacity (cfs)**	**Drainage Area (Acre)**	**C Factor**	**Tc (Min)**	**Rainfall Intensity (in/hr)**	**OLR Flow (cfs)**	**Depth (ft)**	**Approximated WSE**	**Buildings Impacted**	**Local Roadway Inundation (ft)**	**Primary Route Inundation (ft)**	**Singular Access Point Impacts**	**Rainfall Intensity (in/hr)**	**OLR Flow (cfs)**	**Depth (ft)**	**Approximated WSE**	**Buildings Impacted**	**Local Roadway Inundation (ft)**	**Primary Route Inundation (ft)**	**Singular Access Point Impacts**
O.7.1	Lawrence St and CSX RR	Roadway	511.00	1	Yes	3.84	19.42	0.63	20	3.77	31.68	0.71	511.71	0	45	0	No	5.33	50.28	0.85	511.85	0	60	0	No
O.7.2	George St and CSX RR	Roadway	514.10	1	No	0.00	12.18	0.53	20	3.77	18.74	0.47	514.57	0	0	45	No	5.33	28.56	0.56	514.66	0	0	55	No
O.7.3	1st Ave	Roadway	516.50	0	No	0.00	8.39	0.50	15	4.18	13.50	0.32	516.82	0	40	0	No	5.84	20.33	0.38	516.88	0	50	0	No

NOTES

Weir coefficient assumed as 3.27

OLR flow accounts for storm sewer capacity where redundant inlets are present to ensure drainage

Storm sewer capacity is only accounted for were either throat inlets or redundant grate inlets are present within the 100 year ponding area

Storm Sewer Pipe Analysis

Watershed 7

																					2 Year					10 Year				
																							2yr Karst Factor		0.69			10yr Karst Factor		0.77
Inlet/Structure Name	Downstream Structure	Structure Type	Inlet Size (in)	Inlet Profile	Approximate Top Elevation/Invert	Approximate Invert Up	Approximate Invert Down	Pipe Length (ft)	Pipe Material	Pipe Size (in)	Approximate Pipe Slope (%)	Pipe Mannings 'n'	Flow Area (ft^2)	Hydraulic Radius	Full Flow Capacity (cfs)	Inlet C Factor	Inlet Drainage Area (Acres)	Time to Inlet (min)	System C Factor	System Drainage Area (Acre)	System Time (Min)	Inlet Rainfall Intensity (in/hr)	Flow To Inlet (cfs)	System Rainfall Intensity (in/hr)	System Flow (cfs)	System Flow/Pipe Full Flow (%)	Inlet Rainfall Intensity (in/hr)	Flow To Inlet (cfs)	System Rainfall Intensity (in/hr)	System Flow (cfs)	System Flow/Pipe Full Flow (%)
7.1.8	7.1.7	Grate	30 x 30	Private system. Partially outside city limits. Not evaluated.																												
7.1.7	7.1.6	Grate	30 x 30																													
7.1.6	7.1.5	Grate	30 x 30																													
7.1.5	7.1.4	Grate	30 x 30																													
7.1.4	7.1.3	Grate	30 x 30																													
7.1.3	7.1.2	Grate	30 x 30																													
7.1.2	7.1.1	Grate	30 x 30																													
7.1.1	7.1.0	Grate	30 x 30																													
7.1.0		Outlet																														
7.2.0		Outlet		Private system. Suspected roof drain outfall.																												
7.3.2	7.3.1	Grate	12 x 18	Sag	514.00	512.00	512	80	CMP	15	0.0%	0.024	1.23	0.31	1.11	0.52	11.74	20	0.52	11.74	20	3.36	14.15	3.36	14.15	1276%	4.59	21.58	4.59	21.58	1946%
7.3.1	7.3.0	Grate	18 x 72	Sag	514.00	512.00	512	50	CMP	15	0.0%	0.024	1.23	0.31	1.11	0.90	0.74	5	0.54	12.48	20	3.72	1.71	3.36	15.70	1416%	5.07	2.60	4.59	23.93	2158%
7.3.0		Outlet			513.00																											
7.4.3	UNK	Grate	24 x 30	Non functioning, assumed to provide drainage across intersection only, potential historical culverts that were renovated with sidewalk installation.																												
7.4.2	UNK	Metal Lid																														
7.4.1	7.4.0	SW Opening																														
7.4.0		Outlet																														
7.5.1		Metal Lid			Function unclear, sedimented																											
7.6.1	7.6.0	Grate	18 x 24	Grade	489.00	486.00	484.54	75	PVC	10	1.9%	0.012	0.55	0.21	3.28	0.89	2.90	10	0.89	2.90	10	3.04	5.41	3.04	5.41	165%	4.18	8.31	4.18	8.31	253%
7.6.0		Outlet			484.54																											
7.7.1	Bridge	Grate	30 x 30	Sag	489.00	Outfalls under bridge/boxculvert										0.50	2.56	10				3.04	2.68				4.18	4.12			
7.7.2	Bridge	Grate	30 x 30	Sag	484.54											0.50	1.15	10				3.04	1.21				4.18	1.85			
7.8.1	7.8.0	Culv Inlet			510.00	510.00	509.75	75	HDPE	15	0.3%	0.012	1.23	0.31	3.84	0.63	19.42	20	0.63	19.42	20	3.36	28.36	3.36	28.36	738%	4.59	43.24	4.59	43.24	1126%
7.8.0		Outlet			509.75																											

NOTES

Structures assumed to be 3' deep unless direct field observations indicate significant difference

Negative pipe slopes are assumed to have the capacity equivalent to a slope of 0.1%

Appendix-Watershed 8

Watershed 8 appears to ultimately drain to Flowing Springs Run. The drainage area is made up of a northeast portion of the City containing the eastern terminal end of 1st Avenue, North and Liberty Streets.

Storm Sewer and Culverts

System 8.1 is the only identified storm sewer with watershed 8 and its outfall location was never fully verified. A resident provided input that the outfall was suspected to lie behind their garage under a wood pile.

Channel/Roadway Spread Analysis

Only one location was evaluated for roadway spread within watershed 8. O.8.1 analyzed flow along North Street prior to its intersection with Church Street.

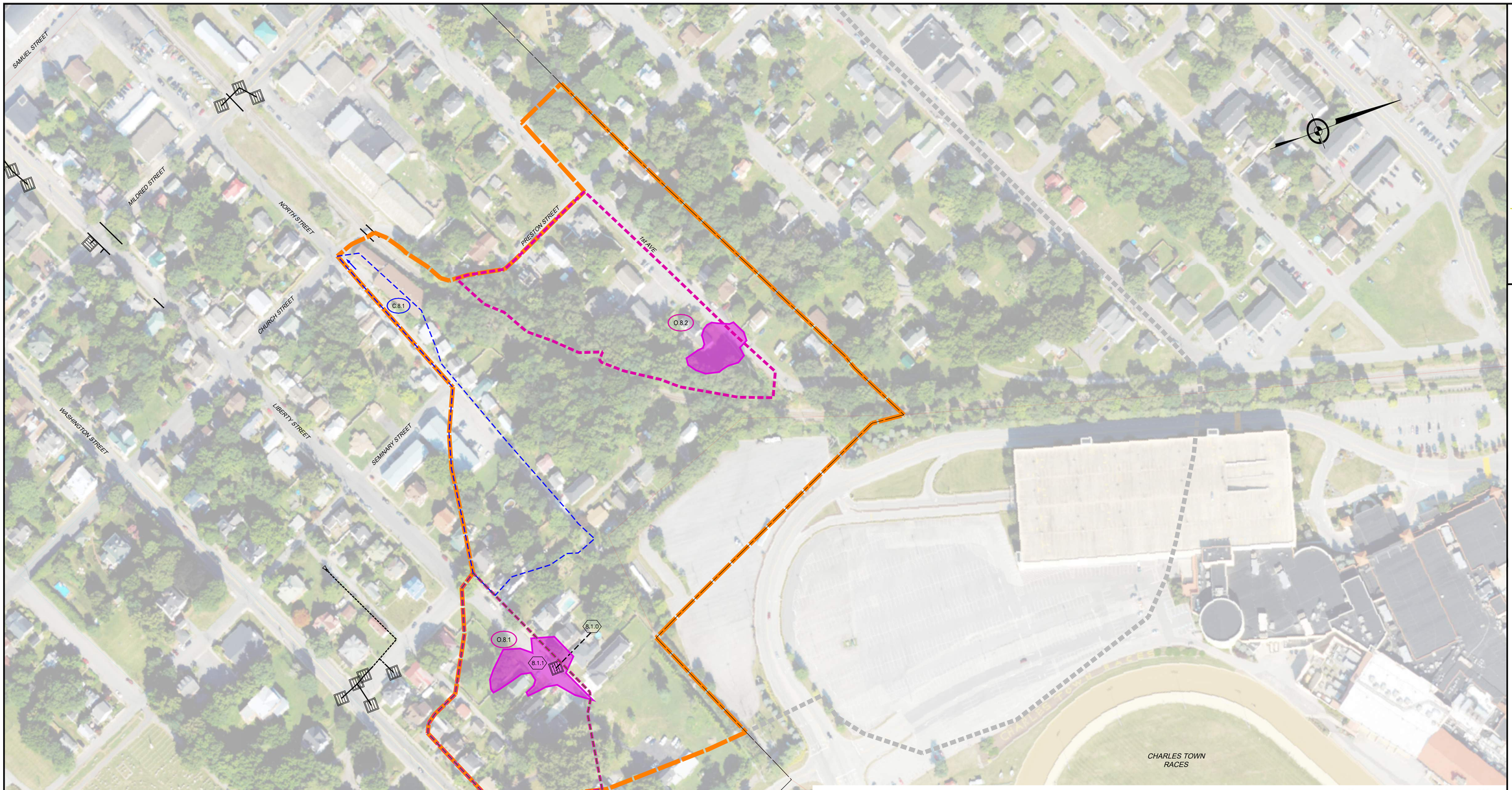
Identifier	Location	Description
C.8.1	North St northside	Spread

Overland Relief

Two locations were identified for ponding/overland relief analysis.

O.8.1 assesses the potential ponding within Liberty Street near its eastern terminal end. This condition appears to have been potentially worsened by the construction of a home at 548 Liberty Street. The construction efforts for the residence seem to have included additional sidewalk and pavement along Liberty Street that may have raised the ground surface and reduced flow capacity previously present at the terminal end of the road.

O8.2 evaluated flow depth across the crown of 1st Avenue and associated ponding.



100 0 100 200

SCALE: 1" = 100'

LEGEND

- KARST SWALE WITH MINIMAL DISTURBANCE
- 100 YEAR FLOOD HAZARD AREA
- D#.# DEPRESSION WITH NO DRAINAGE, ASSUMED INFILTRATION
- DRAINAGE AREA ASSUMED TO INFILTRATE, DISCARDED FROM DOWNSTREAM ANALYSIS
- APPROXIMATE 100 YEAR PONDING BASED ON OLR ANALYSIS
- WATERSHED BOUNDARY (STUDY AREA)
- WATERSHED BOUNDARY (BEYOND CITY LIMITS)
- CITY LIMITS
- STREAM
- SF.## STORM WATER FACILITY
- INLET DRAINAGE DIVIDE
- C.## CHANNEL/SPREAD COMP
- CHANNEL/SPREAD COMP DRAINAGE DIVIDE
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- OLR DRAINAGE DIVIDE
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- ### STORM STRUCTURE LABEL
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WATERSHED 8 H&H ANALYSIS EXHIBIT

CITY OF CHARLES TOWN WATERSHEDS

CITY OF CHARLES TOWN - JEFFERSON COUNTY, WEST VIRGINIA

Date:	04/08/2026
Scale:	1" = 100'
Designed By:	ZJ/RLK/ZS
File No.	7037
Sheet	1 Of 1

Roadside Ditch and Roadway Spread Analysis

Watershed 8

												2 Year						10 Year						100 Year					
												2yr Karst Factor			0.60			10yr Karst Factor			0.70			100yr Karst Factor			0.77		
Identifier	Location	Description	Side Slope 1 (H ft:1 ft)	Side Slope 2 (H ft:1 ft)	Upstream Road Length(ft)	Upstream Intersections	Available Depth for Ditch/Gutter(ft)	Available Width for Spread (ft)	Approximate Running Slope (%)	Drainage Area (Acre)	C Factor	Tc (Min)	Rainfall Intensity (in/hr)	Flow (cfs)	Depth of flow (ft)	Roadway Surcharge (ft)	Spread (ft)	Travel Lane Spread (ft)	Rainfall Intensity (in/hr)	Flow (cfs)	Depth of flow (ft)	Roadway Surcharge (ft)	Spread (ft)	Travel Lane Spread (ft)	Rainfall Intensity (in/hr)	Flow (cfs)	Depth of flow (ft)	Roadway Surcharge (ft)	Spread (ft)	Travel Lane Spread (ft)
C.8.1	North St northside	Spread	NA	NA	800	0	0	0	1%	1.90	0.52	10	3.72	2.21	0.19	0.19	9.71	9.71	5.07	3.51	0.23	0.23	11.54	Full	7.03	5.35	0.27	0.27	13.54	Full

NOTES

For roadside ditches available depth is the approximated depth of the ditch outside the roadway, 0.1' is indicative of no defined roadside ditch

For spread comps available depth of 0' is indicative of no gutter pan and 0.1' is indicative of a gutter pan

For spread comps a negative available spread is indicative of a local depression that results in an initial spread for all storm events

Upstream Intersections within 500ft of the highpoint are excluded from the upstream intersection counts

Available width is the approximated area available for spread outside an assumed 10ft travel lane

Roadway surcharge depth is the expected depth of water at the edge of pavement

Mannings n assumptions; ditch/channel = 0.025; road/gutter spread = .016

Road cross slopes assumed at 2%

Overland Relief Analysis (OLR)

Watershed 8

										10 Year								100 Year							
										10yr Karst Factor	0.70							100yr Karst Factor	0.77						
Identifier	Location	Constraint Description	Approximated Weir Elevation	Inlets Present	Throat Inlet or 2 Grates Present	Storm sewer capacity (cfs)	Drainage Area (Acre)	C Factor	Tc (Min)	Rainfall Intensity (in/hr)	OLR Flow (cfs)	Depth (ft)	Approximated WSE	Buildings Impacted	Local Roadway Inundation (ft)	Primary Route Inundation (ft)	Singular Access Point Impacts	Rainfall Intensity (in/hr)	OLR Flow (cfs)	Depth (ft)	Approximated WSE	Buildings Impacted	Local Roadway Inundation (ft)	Primary Route Inundation (ft)	Singular Access Point Impacts
O.8.1	Liberty Street	Curb/Yards	538.40	1	No	0.00	3.14	0.50	10	5.07	5.57	0.09	538.49	3	130	0	Yes	7.03	8.50	0.12	538.52	3	160	0	Yes
O.8.2	1st Ave	Roadway	518.40	0	No	0.00	3.08	0.50	10	5.07	5.47	0.21	518.61	1	40	0	No	7.03	8.34	0.25	518.65	1	50	0	No

NOTES

Weir coefficient assumed as 3.27

Storm sewer capacity is only accounted for were culvert inlets, throat inlets or redundant grate inlets are present within the 100 year ponding area

Storm Sewer Pipe Analysis

Watershed 8

																					2 Year					10 Year				
																							2yr Karst Factor		0.60			10yr Karst Factor		0.70	
Inlet/Structure Name	**Downstream Structure**	**Structure Type**	**Inlet Size (in)**	**Inlet Profile**	**Approximate Top Elevation/Invert**	**Approximate Invert Up**	**Approximate Invert Down**	**Pipe Length (ft)**	**Pipe Material**	**Pipe Size (in)**	**Approximate Pipe Slope (%)**	**Pipe Mannings 'n'**	**Flow Area (ft^2)**	**Hydraulic Radius**	**Full Flow Capacity (cfs)**	**Inlet C Factor**	**Inlet Drainage Area (Acres)**	**Time to Inlet (min)**	**System C Factor**	**System Drainage Area (Acre)**	**System Time (Min)**	**Inlet Rainfall Intensity (in/hr)**	**Flow To Inlet (cfs)**	**System Rainfall Intensity (in/hr)**	**System Flow (cfs)**	**System Flow/Pipe Full Flow (%)**	**Inlet Rainfall Intensity (in/hr)**	**Flow To Inlet (cfs)**	**System Rainfall Intensity (in/hr)**	**System Flow (cfs)**	**System Flow/Pipe Full Flow (%)**
8.1.1	8.1.0	Grate	12 x 18	Sag	537.90	No pipe indentified, structure has cinder block openings towards suspected outfall										0.50	2.22	10	0.50	2.22	10	3.04	1.21	3.04	6.54		4.18	2.27	4.18	10.82	
8.1.0		Outfall suspected to be buried																							6.54					10.82	

NOTES

Structures assumed to be 3' deep unless direct field observations indicate significant difference

Negative pipe slopes are assumed to have the capacity equivalent to a slope of 0.1%

Appendix-Watershed 9

Watershed 9 is made up of a northeastern contiguous portion of the City expected to ultimately drain to Flowing Springs Run. Majority of the watershed is occupied by Edge Hill Cemetery. A portion of the commercial area associated with George Street between the historic area of town and the Route 9/340 interchange.

Two private stormwater facilities were identified in this watershed. SF9.1 is a newly installed underground detention system and SF9.2 lies both within the City and Jefferson County, SF9.2 is suspected to be previously installed water gardens / bioretention cells but a review of available documentation by City planning staff for design documents associated with this facility did not yield any results.

Storm Sewer and Culverts

Two storm sewer systems were identified within watershed 9.

System 1 consists of a private drainage system and stormwater facility installed with recent development along Alla Willa Drive.

System 2 is storm sewer associated with a private business and discharges directly into the public roadway.

Additional storm sewer was identified just outside the study area along George Street and is reflected in the developed exhibits.

Channel/Roadway Spread Analysis

Two adjacent locations along George Street were analyzed for potential roadway spread.

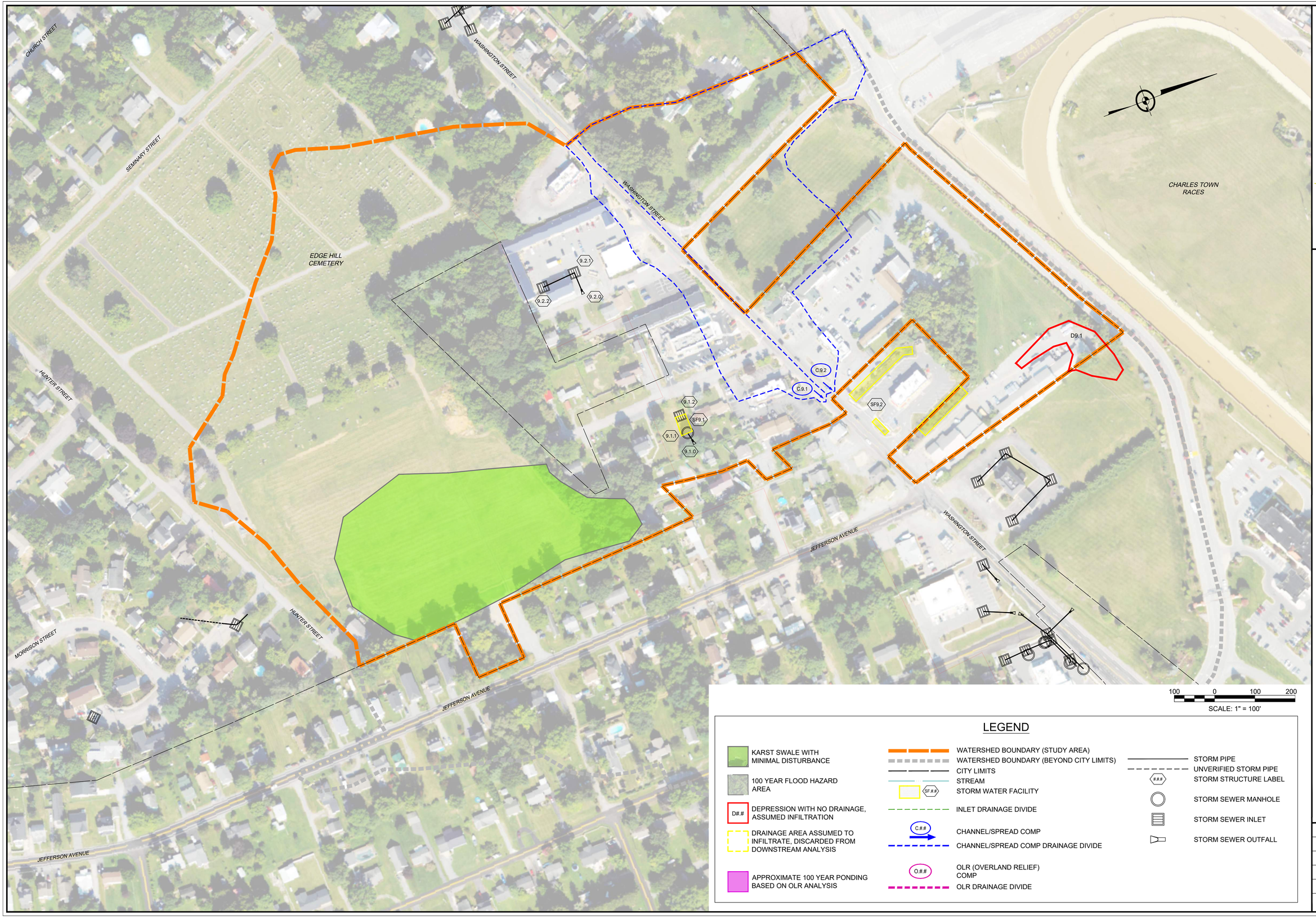
Identifier	Location	Description
C.9.1	Washington St southside	Spread
C.9.2	Washington St northside	Spread

Depressions

One depression was noted within watershed 9 based on resident feedback. D9.1 represents the low-lying area located on private property associated with 8335 East Washington Street and occupied by the TireVille business. Ponding occurs here and is likely worsened runoff from Washington Street. The inundation is primarily due to building elevations and lack of proper drainage within private property but is likely worsened by runoff from Washington Street.

Overland Relief

No locations were identified for overland relief analysis in watershed 9.



LEGEND

- KARST SWALE WITH MINIMAL DISTURBANCE
- 100 YEAR FLOOD HAZARD AREA
- D#.# — DEPRESSION WITH NO DRAINAGE, ASSUMED INFILTRATION
- DRAINAGE AREA ASSUMED TO INFILTRATE, DISCARDED FROM DOWNSTREAM ANALYSIS
- APPROXIMATE 100 YEAR PONDING BASED ON OLR ANALYSIS
- WATERSHED BOUNDARY (STUDY AREA)
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CITY OF CHARLES TOWN WATERSHEDS

WATERSHED 9 H&H ANALYSIS EXHIBIT

CITY OF CHARLES TOWN - JEFFERSON COUNTY, WEST VIRGINIA

Date:	04/08/2026
Scale:	1" = 100'
Designed By:	ZJ/RLK/ZS
File No.	7037
Sheet	1 Of 1

Roadside Ditch and Roadway Spread Analysis

Watershed 9

												2 Year						10 Year						100 Year					
												2yr Karst Factor			0.51			10yr Karst Factor			0.62			100yr Karst Factor			0.71		
Identifier	Location	Description	Side Slope 1 (H ft:1 ft)	Side Slope 2 (H ft:1 ft)	Upstream Road Length(ft)	Upstream Intersections	Available Depth for Ditch/Gutter(ft)	Available Width for Spread (ft)	Approximate Running Slope (%)	Drainage Area (Acre)	C Factor	Tc (Min)	Rainfall Intensity (in/hr)	Flow (cfs)	Depth of flow (ft)	Roadway Surcharge (ft)	Spread (ft)	Travel Lane Spread (ft)	Rainfall Intensity (in/hr)	Flow (cfs)	Depth of flow (ft)	Roadway Surcharge (ft)	Spread (ft)	Travel Lane Spread (ft)	Rainfall Intensity (in/hr)	Flow (cfs)	Depth of flow (ft)	Roadway Surcharge (ft)	Spread (ft)	Travel Lane Spread (ft)
C.9.1	Washington St southside	Spread	NA	NA	1490	1	0.1	8	2%	6.32	0.50	15	3.04	4.90	0.23	0.13	11.50	3.50	4.18	8.19	0.28	0.18	13.92	5.92	5.84	13.10	0.33	0.23	16.63	8.63
C.9.2	Washington St northside	Spread	NA	NA	1000	1	0.1	8	2%	1.76	0.88	10	3.72	2.94	0.19	0.09	9.50	1.50	5.07	4.87	0.23	0.13	11.46	3.46	7.03	7.73	0.27	0.17	13.38	5.38

NOTES

For roadside ditches available depth is the approximated depth of the ditch outside the roadway, 0.1' is indicative of no defined roadside ditch

For spread comps available depth of 0' is indicative of no gutter pan and 0.1' is indicative of a gutter pan

For spread comps a negative available spread is indicative of a local depression that results in an initial spread for all storm events

Upstream Intersections within 500ft of the highpoint are excluded from the upstream intersection counts

Available width is the approximated area available for spread outside an assumed 10ft travel lane

Roadway surcharge depth is the expected depth of water at the edge of pavement

Mannings n assumptions; ditch/channel = 0.025; road/gutter spread = .016

Road cross slopes assumed at 2%

Storm Sewer Pipe Analysis

Watershed 9

																					2 Year					10 Year				
																							2yr Karst Factor		0.51			10yr Karst Factor		0.62	
Inlet/Structure Name	**Downstream Structure**	**Structure Type**	**Inlet Size (in)**	**Inlet Profile**	**Approximate Top Elevation/Invert**	**Approximate Invert Up**	**Approximate Invert Down**	**Pipe Length (ft)**	**Pipe Material**	**Pipe Size (in)**	**Approximate Pipe Slope (%)**	**Pipe Mannings 'n'**	**Flow Area (ft^2)**	**Hydraulic Radius**	**Full Flow Capacity (cfs)**	**Inlet C Factor**	**Inlet Drainage Area (Acres)**	**Time to Inlet (min)**	**System C Factor**	**System Drainage Area (Acre)**	**System Time (Min)**	**Inlet Rainfall Intensity (in/hr)**	**Flow To Inlet (cfs)**	**System Rainfall Intensity (in/hr)**	**System Flow (cfs)**	**System Flow/Pipe Full Flow (%)**	**Inlet Rainfall Intensity (in/hr)**	**Flow To Inlet (cfs)**	**System Rainfall Intensity (in/hr)**	**System Flow (cfs)**	**System Flow/Pipe Full Flow (%)**
9.1.2	9.1.1	Grate	20 x 20	Sag	Undergound SWM/Private System, Not Evaluated																										
9.1.1	9.1.0	MH																													
9.1.0		Outlet																													
9.2.2	9.2.1	Grate	24 x 24	Sag	Private System, Not Evaluated																										
9.2.1	9.2.0	Grate	18																												
9.2.0		Outlet																													

NOTES

Structures assumed to be 3' deep unless direct field observations indicate significant difference

Negative pipe slopes are assumed to have the capacity equivalent to a slope of 0.1%

Appendix-Watershed 10

Watershed 10 consists of areas draining to Evitts Run across George Street in the vicinity of its intersections with Samuel Street and Jefferson Avenue. The watershed is dominated by a karst swale, much of which has prudently been preserved as Jefferson Memorial Park. Areas draining to this karst swale were assumed to infiltrate for analysis performed downstream.

Storm Sewer and Culverts

The storm sewer and culvert infrastructure within watershed 10 is minimal and consists of seven individual storm sewer systems/culverts.

System 1 provides drainage around 1189 S George Street and conveys the water across George Street. This is the only direct pipe discharge to the Evitts Run riparian area in the watershed.

System 2 consists of a culvert across Nathaniel Drive and is not included in the evaluation as it was constructed utilizing an engineered design and is assumed to function appropriately.

System 3 consists of roadway drainage for Nathaniel Drive and is not included in the evaluation as it was constructed utilizing an engineered design and is assumed to function appropriately.

System 4 consists of a roadside grate inlet along Forrest Avenue and is expected to discharge within Jefferson Memorial Park. A suspected buried outfall location has been identified that shows evidence of surface discharge.

System 5 provides drainage for the sag at the intersection of Brooke Street and Morrison Street utilizing a curb inlet. The discharge could not be located and is expected to be a subterranean infiltration outfall due to its location within a karst swale.

System 6 consists of a grate inlet on 4th Street and has one connected pipe evident with significant sedimentation within the structure. The identified pipe appears to be discharging into the structure, and it is assumed that the outfall pipe is either buried, both within the structure and at its discharge point, or that the structure itself was installed as an infiltration point.

System 7 consists of a pass-through curb inlet and is located at the cul-de-sac on 4th Street.

Channel/Roadway Spread Analysis

No significant open space channels were identified with watershed 10 other than the karst swale dominating the watershed. This swale was not analyzed as the water infiltrates within the swale and results in little overland flow.

The roadways within watershed 10 have many identified inundation concerns. While the southern portion of Morrison Street lacks a roadside ditch along the eastern side, this was not

included in the evaluation as much of the runoff crosses the street as sheet flow at various points and discharges to Jefferson Memorial Park. The roadside ditches and roadway spreads that were analyzed are listed in the table below.

Identifier	Location	Description
C.10.1	Samuel St eastside	Roadside ditch
C.10.2	Samuel St westside	Roadside ditch
C.10.3	Samuel St eastside	Spread
C.10.4	Forrest Ave northside	Roadside ditch
C.10.5	Mildred St eastside	Spread
C.10.6	Mildred St westside	Spread
C.10.7	Church St westside	Spread
C.10.8	Seminary St westside	Spread
C.10.9	Seminary St eastside	Roadside ditch
C.10.10	Brooke St westside	Spread
C.10.10	Morrison St eastside	Spread
C.10.12	Morrison St westside	Spread

Depressions

Watershed 10 contains two major depressions and two minor depressions with no available discharge. These depressions lie within the identified historical karst swale allowing for significant infiltration. As there was no observable evidence of overtopping downstream of these depressions, the drainage areas to these depressions were assumed to infiltrate during all storms and discarded for analysis performed downstream.

Both major depressions appear to have been historically created by the construction of roads that occurred prior to 1978. These depressions could be further evaluated utilizing methodology described in FHWA HEC 22 and infiltration testing to confirm the validity of the infiltration assumption for larger storm events.

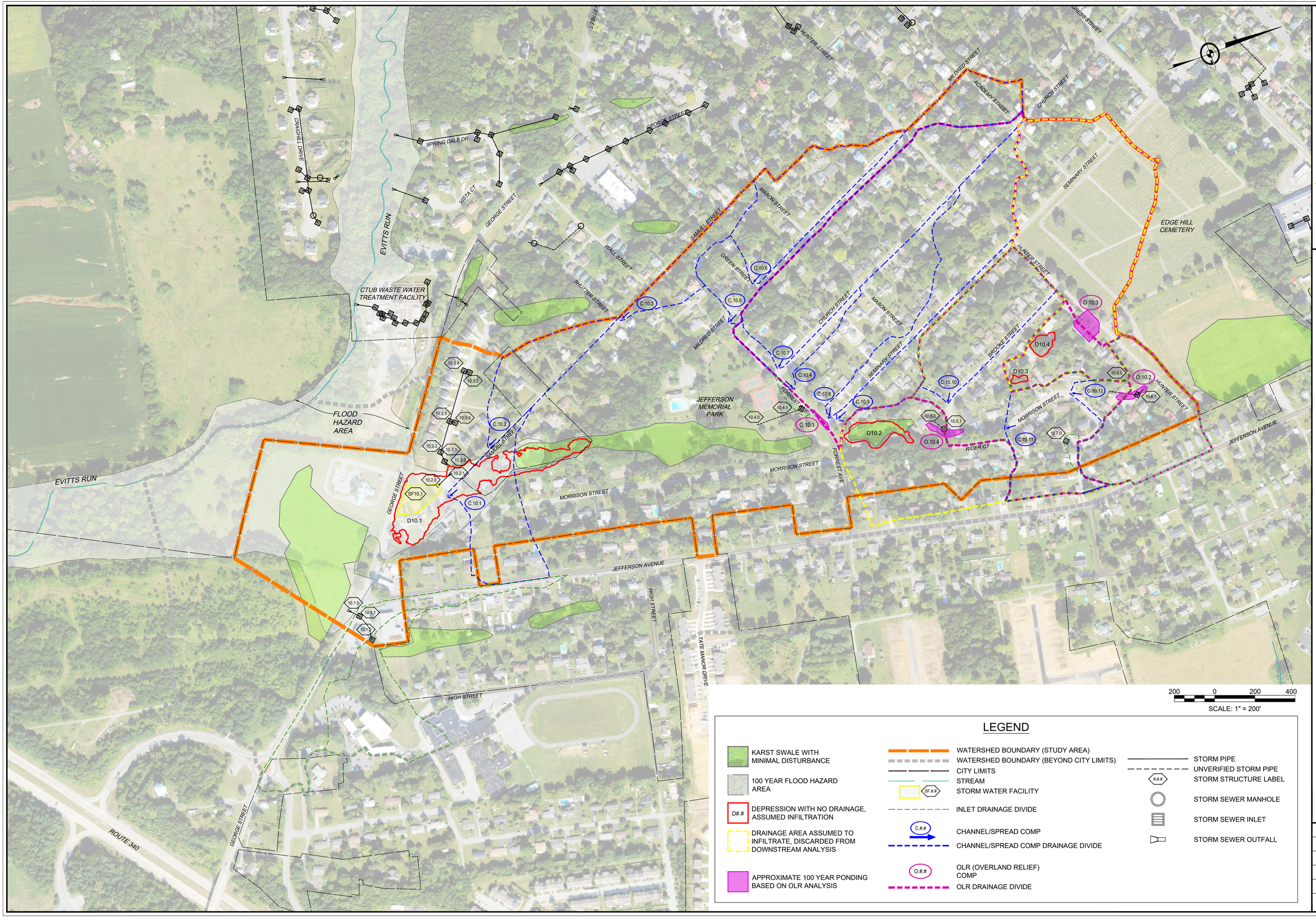
The detention pond identified as SF10.1 was designed as an infiltration pond and has no outfall; this is identified as depression D10.1. Should the infiltration capacity of the pond be exhausted during a severe storm the water must discharge across George Street resulting in inundation of the major route. Based on the topography data, two residences appear to have potential flooding concerns should infiltration capacity be overwhelmed. Current standards require pond liners in karst prone areas and discourage infiltration practices due to the increased risk of sinkholes. It is known that at least one detention pond constructed prior to current standards in the local area has recurring sinkhole formation requiring ongoing mitigation. Due to the ponds close proximity to a primary route further geotechnical investigation would be prudent.

The depression identified as S.10.2 consists of a depression above Forrest Avenue. Three houses and Forrest Avenue are threatened by resulting inundation if the infiltration capacity is overwhelmed based on the topography data.

The two minor depressions lie in the backyards of the residences along Brooke and Morrison Streets. D10.3 and D10.4 are utilized to identify them. These depressions have the potential to impact three residences based on review of the topography data. The depressions were classified as minor due to the small scale and imperviousness of the respective drainage areas, as well as their minimal relative depth.

Overland Relief

Four points were identified for overland relief analysis. O.10.1 analyzes potential flow across Forrest Avenue and the analysis ignores the drainage area upstream of D10.2. O.10.2 analyzes runoff and potential resulting inundation on 4th Street near its terminus at Hunter Street. One inlet (10.6.1) provides drainage for this point of concentration and the outfall point was not located. The resulting ponding from the analyses indicates two residences and 4th Street would be impacted during the 100-year storm event. O.10.3 addresses the flows crossing Hunter Street from Edge Hill Cemetery which must pass between the houses fronting Hunter Street. The potential inundation would threaten two residences and inundate Hunter Street. O10.4 analyzes where runoff concentrates at the intersection of Brooke and Morrison Street. Inlet 10.5.1 provides drainage for the area, but no outfall was located for the structure. The resulting 100-year inundation per the analyses would threaten one residence and inundate the intersection.



200 0 200 400

SCALE: 1" = 200'

LEGEND

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- 100 YEAR FLOOD HAZARD AREA
- D#.# — DEPRESSION WITH NO DRAINAGE, ASSUMED INFILTRATION
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Scale:	1" = 200'
Designed By:	ZJ/RLK/ZS
File No.	7037
Sheet	1 Of 1

Roadside Ditch and Roadway Spread Analysis

Watershed 10

												2 Year						10 Year						100 Year					
												2yr Karst Factor	0.47					10yr Karst Factor	0.58					100yr Karst Factor	0.68				
Identifier	Location	Description	Side Slope 1 (H ft:1 ft)	Side Slope 2 (H ft:1 ft)	Upstream Road Length(ft)	Upstream Intersections	Available Depth for Ditch/Gutter(ft)	Available Width for Spread (ft)	Approximate Running Slope (%)	Drainage Area (Acre)	C Factor	Tc (Min)	Rainfall Intensity (in/hr)	Flow (cfs)	Depth of flow (ft)	Roadway Surcharge (ft)	Spread (ft)	Travel Lane Spread (ft)	Rainfall Intensity (in/hr)	Flow (cfs)	Depth of flow (ft)	Roadway Surcharge (ft)	Spread (ft)	Travel Lane Spread (ft)	Rainfall Intensity (in/hr)	Flow (cfs)	Depth of flow (ft)	Roadway Surcharge (ft)	Spread (ft)	Travel Lane Spread (ft)
C.10.1	Samuel St eastside	Roadside ditch	50	10	600	0	0.1	1	1%	4.67	0.50	10	3.72	4.08	0.24	0.14	7.00	6.00	5.07	6.87	0.30	0.20	10.00	9.00	7.03	11.16	0.36	0.26	13.00	Full
C.10.2	Samuel St westside	Roadside ditch	4	50	900	0	0.1	1	3%	3.47	0.40	10	3.72	2.43	0.19	0.09	4.50	3.50	5.07	4.08	0.24	0.14	7.00	6.00	7.03	6.64	0.34	0.24	12.00	Full
C.10.3	Samuel St eastside	Spread	NA	NA	950	0	0	4	2%	2.17	0.43	10	3.72	1.63	0.15	0.15	7.63	3.63	5.07	2.74	0.19	0.19	9.25	5.25	7.03	4.46	0.22	0.22	11.08	7.08
C.10.4	Forrest Ave northside	Roadside ditch	50	40	975	1	0.3	2	2%	13.11	0.50	20	2.72	8.38	0.31	0.01	0.50	0.00	3.77	14.33	0.38	0.08	4.00	2.00	5.33	23.76	0.45	0.15	7.50	5.50
C.10.5	Mildred St eastside	Spread	NA	NA	1994	2	0	6	5%	10.34	0.49	20	2.72	6.48	0.23	0.23	11.63	5.63	3.77	11.08	0.28	0.28	14.00	8.00	5.33	18.36	0.34	0.34	16.96	Full
C.10.6	Mildred St westside	Spread	NA	NA	1425	1	0	5	2%	5.51	0.50	15	3.04	3.94	0.21	0.21	10.58	5.58	4.18	6.68	0.26	0.26	12.88	7.88	5.84	10.94	0.31	0.31	15.54	Full
C.10.7	Church St westside	Spread	NA	NA	1700	0	0	8	2%	11.97	0.50	20	2.72	7.65	0.29	0.29	14.58	6.58	3.77	13.09	0.36	0.36	17.92	9.92	5.33	21.69	0.43	0.43	21.42	Full
C.10.8	Seminary St westside	Spread	NA	NA	1950	2	0	3	3%	6.02	0.50	15	3.04	4.30	0.20	0.20	10.13	7.13	4.18	7.30	0.25	0.25	12.38	9.38	5.84	11.95	0.30	0.30	14.88	Full
C.10.9	Seminary St eastside	Roadside ditch	40	40	1225	1	0.2	3	3%	2.02	0.50	10	3.72	1.77	0.15	0.00	0.00	0.00	5.07	2.97	0.19	0.00	0.00	0.00	7.03	4.83	0.23	0.03	1.50	0.00
C.10.10	Brooke St westside	Spread	NA	NA	775	0	0	8	3%	5.56	0.50	15	3.04	3.97	0.20	0.20	9.83	1.83	4.18	6.74	0.24	0.24	12.00	4.00	5.84	11.04	0.29	0.29	14.46	6.46
C.10.10	Morrison St eastside	Spread	NA	NA	625	0	0	6	3%	11.94	0.49	20	2.72	7.48	0.27	0.27	13.50	7.50	3.77	12.79	0.33	0.33	16.42	Full	5.33	21.20	0.37	0.37	18.46	Full
C.10.12	Morrison St westside	Spread	NA	NA	200		0	-6	1%	7.00	0.47	15	3.04	4.70	0.26	0.26	12.88	Full	4.18	7.98	0.31	0.31	15.71	Full	5.84	13.07	0.38	0.38	18.92	Full

NOTES

For roadside ditches available depth is the approximated depth of the ditch outside the roadway, 0.1' is indicative of no defined roadside ditch

For spread comps available depth of 0' is indicative of no gutter pan and 0.1' is indicative of a gutter pan

For spread comps a negative available spread is indicative of a local depression that results in an initial spread for all storm events

Upstream Intersections within 500ft of the highpoint are excluded from the upstream intersection counts

Available width is the approximated area available for spread outside an assumed 10ft travel lane

Roadway surcharge depth is the expected depth of water at the edge of pavement

Mannings n assumptions; ditch/channel = 0.025; road/gutter spread = .016

Road cross slopes assumed at 2%

Overland Relief Analysis (OLR)

Watershed 10

										10 Year								100 Year							
										10yr Karst Factor					0.58			100yr Karst Factor					0.68		
Identifier	Location	Description	Approximated Weir Elevation	Inlets Present	Throat Inlet or 2 Grates Present	Storm sewer capacity (cfs)	Drainage Area (Acre)	C Factor	Tc (Min)	Rainfall Intensity (in/hr)	OLR Flow (cfs)	Depth (ft)	Approximated WSE	Buildings Impacted	Local Roadway Inundation (ft)	Primary Route Inundation (ft)	Singular Access Point Impacts	Rainfall Intensity (in/hr)	OLR Flow (cfs)	Depth (ft)	Approximated WSE	Buildings Impacted	Local Roadway Inundation (ft)	Primary Route Inundation (ft)	Singular Access Point Impacts
O.10.1	Forrest Ave	Roadway	491.00	0	No	0.00	27.32	0.50	20	3.77	29.87	0.23	491.23	0	0	60	No	5.33	49.51	0.30	491.30	0	0	115	No
O.10.2	4th St	Curb	515.00	1	No	0.00	6.14	0.47	15	4.18	7.00	0.37	515.37	2	50	0	No	5.84	11.46	0.45	515.45	2	110	0	No
O.10.3	Hunter St	Houses/Yards	517.50	0	No	0.00	12.78	0.30	20	3.77	8.38	0.52	518.02	2	80	0	No	5.33	13.90	0.63	518.13	2	100	0	No
O.10.4	Brooke St	Houses/Yards/Roadway	493.00	1	No	0.00	20.22	0.49	20	3.77	21.66	0.29	493.29	1	10	0	No	5.33	35.91	0.38	493.38	1	20	0	No

NOTES

Weir coefficient assumed as 3.27

OLR flow accounts for storm sewer capacity where redundant inlets are present to ensure drainage

Storm sewer capacity is only accounted for were either throat inlets or redundant grate inlets are present within the 100 year ponding area

Storm Sewer Pipe Analysis

Watershed 10

																						2 Year					10 Year				
																						2yr Karst Factor				0.47	10yr Karst Factor				0.58
Inlet/Structure Name	Downstream Structure	Structure Type	Inlet Size (in)	Inlet Profile	Approximate Top Elevation/Invert	Approximate Invert Up	Approximate Invert Down	Pipe Length (ft)	Pipe Material	Pipe Size (in)	Approximate Pipe Slope (%)	Pipe Mannings 'n'	Flow Area (ft^2)	Hydraulic Radius	Full Flow Capacity (cfs)	Inlet C Factor	Inlet Drainage Area (Acres)	Time to Inlet (min)	System C Factor	System Drainage Area (Acre)	System Time (Min)	Inlet Rainfall Intensity (in/hr)	Flow To Inlet (cfs)	System Rainfall Intensity (in/hr)	System Flow (cfs)	System Flow/Pipe Full Flow (%)	Inlet Rainfall Intensity (in/hr)	Flow To Inlet (cfs)	System Rainfall Intensity (in/hr)	System Flow (cfs)	System Flow/Pipe Full Flow (%)
10.1.2	10.1.1	Grate	18 x 24	Sag	475.00	472.00	470.05	136	Concrete	12	1.4%	0.013	0.79	0.25	4.22	0.46	5.34	15	0.46	5.34	15	3.36	3.88	3.36	3.88	92%	4.59	6.54	4.59	6.54	155%
10.1.1	10.1.0	Grate	18 x 18	Sag	473.05	470.05	470	55	Concrete	24	0.1%	0.013	3.14	0.50	7.17	0.46	4.54	10	0.46	9.88	15	3.04	2.98	3.36	7.18	100%	4.18	5.06	4.59	12.10	169%
10.1.0		Outlet			470.00																										
10.2.1	10.2.0	Culvert Inv	15	Sag	466.00																										
10.2.0		Outlet	15		465.50																										
10.3.6	10.3.3	Curb Inlet	72	Grade	487.26																										
10.3.5	10.3.4	Curb Inlet	72	Grade	501.81																										
10.3.4	10.3.3	Curb Inlet	72	Grade	501.76																										
10.3.3	10.3.2	Curb Inlet	72	Grade	487.03																										
10.3.2	10.3.1	Curb Inlet	84	Grade	478.16																										
10.3.1	10.3.0	Curb Inlet	72	Grade	475.43																										
10.3.0		Outlet	15		470.71																										
10.4.1	10.4.0	Grate	24 x 24	Sag	490.54				PVC	12			0.79	0.25		0.3	0.25	5				3.72	0.13	Outlet Not Located			5.07	0.22	Outlet Not Located		
10.4.0		Outlet			Not Located																										
10.5.1	10.5.0	Curb Inlet	48	Sag	492.43				Concrete	15			1.23	0.31		0.49	20.80	20				3.36	16.10	Outlet Not Located			4.59	27.13	Outlet Not Located		
10.5.0		Outlet			Not Located																										
10.6.1	10.6.0	Grate	30 x 30	Sag	516.00											0.47	6.14	15				3.36	4.56	Outlet Not Located			4.59	7.68	Outlet Not Located		
10.6.0		Outlet			Not Located																										
10.7.0		Pass Through	36	Sag	527.70											0.5	0.21	5				3.72	0.18	NA			5.07	0.31	NA		

Engineered Design, Not Evaluated

NOTES

Structures assumed to be 3' deep unless direct field observations indicate significant difference

Negative pipe slopes are assumed to have the capacity equivalent to a slope of 0.1%

Infrastructure Committee
101 East Washington Street
Charles Town, WV 25414

Meeting: 10/01/26
Department: Infrastructure Committee
Category: Report
Initiator:

SCHEDULED

AGENDA ITEM (ID #)

2026-1964: Other Projects Updates from Staff

ATTACHMENTS: