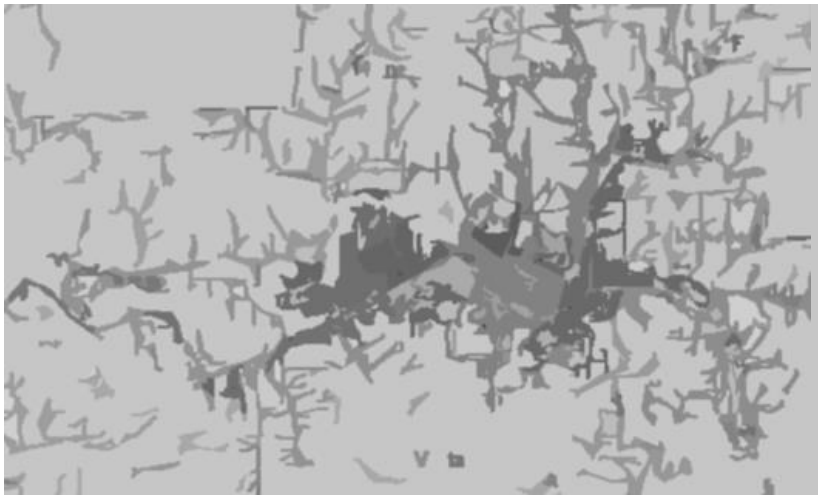
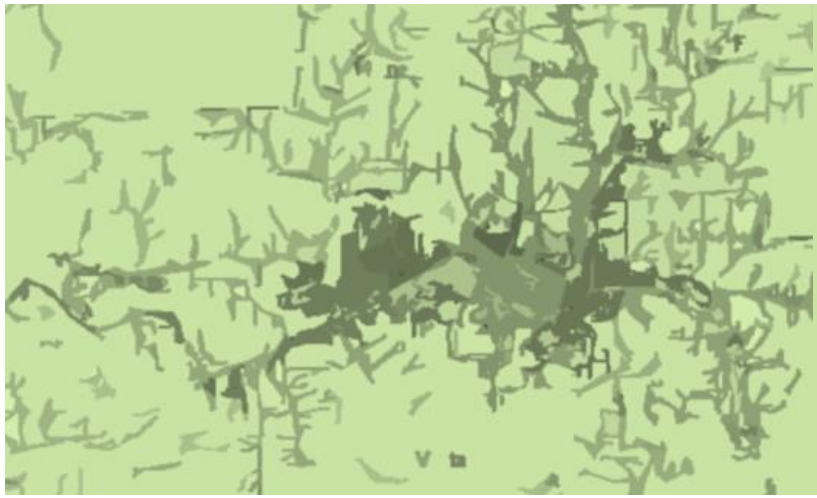


Where the Water Meets the Road: A BMTS Green Streets Guide



Prepared by:

BMTS

The preparation of this guide was funded through a grant from the Federal Highway Administration (FHWA). The views expressed herein do not represent an official position of FHWA.

About the cover: The cover art is an artistic rendering of the interplay of waterways and roadways within the BMTS planning area. ArcGIS and Adobe where used in its creation.

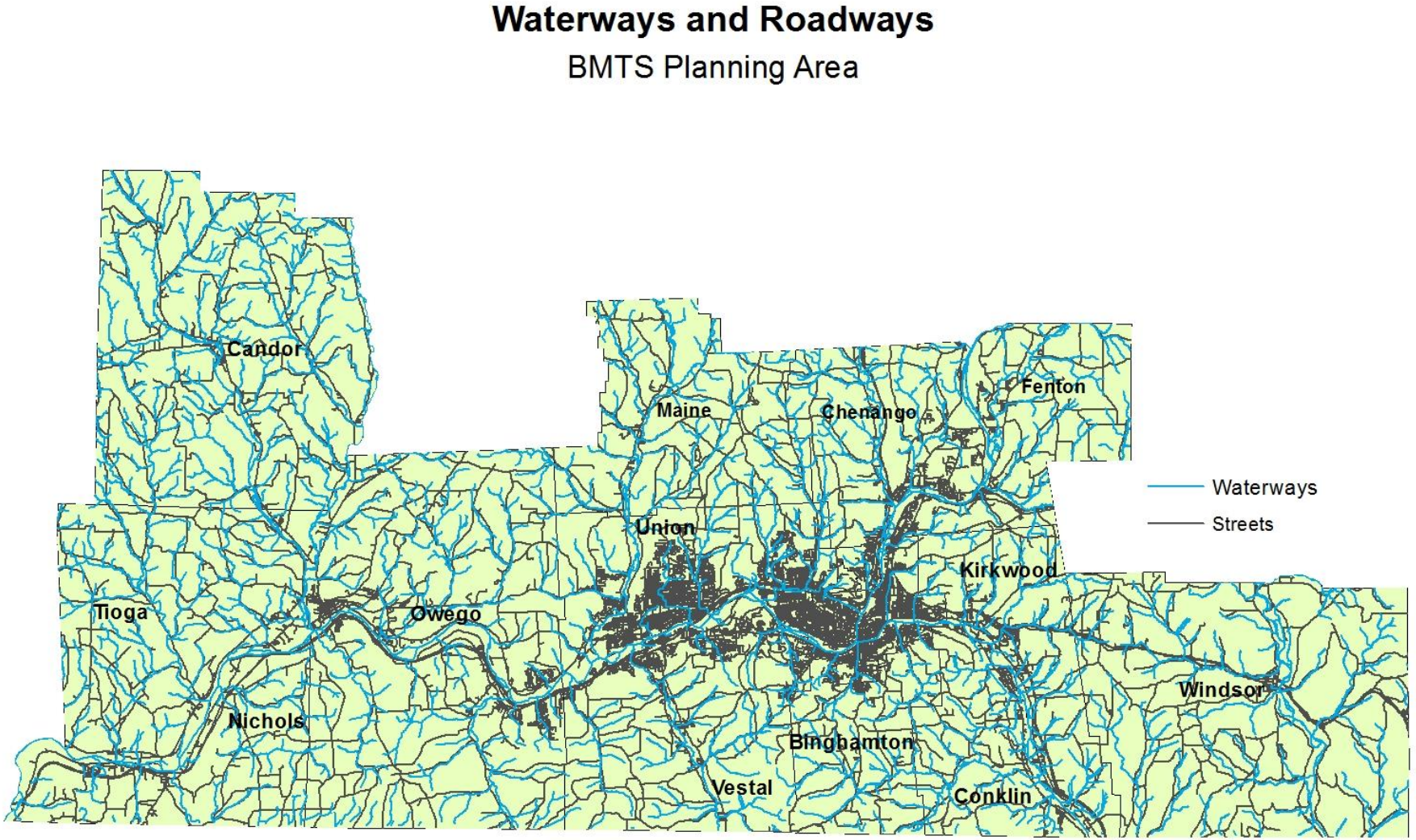


Figure 1: Waterways and Roadways in the BMTS Planning Area: Map prepared by BMTS, Data Source NYS Department of Conservation

Where the Water Meets the Road: A BMTS Green Streets Guide

With the confluence of the Chenango and Susquehanna Rivers at its core, the Binghamton Metropolitan Transportation Study planning area transportation system is profoundly influenced by water. Reciprocally, our waterways are affected by our transportation system. In fact, many of our roadways, rivers, tributaries and streams follow very similar paths through the topography of our municipalities (see Figure 1 above).

The relationship between our waterways, stormwater management systems and our transportation system became readily apparent during recent flood events, where many roadways were flooded, cutting off neighborhoods and causing significant damage to public and private infrastructure. Perhaps less apparent is the poor water quality of rivers and streams that are closely aligned with our transportation corridors.

Although streets comprise a significant amount of impervious area within the BMTS planning area and contribute significantly to runoff volumes and pollutants loads, stormwater management is often overlooked in street design. As municipalities are being challenged with developing more creative solutions to managing stormwater runoff, roadways offer opportunities to implement new green infrastructure stormwater practices. Greening our streets by incorporating green infrastructure into broader transportation investments will result in multiple environmental and community benefits within the BMTS planning area.

This guide is intended to serve as a tool to assist in the incorporation of green infrastructure into the early design phases of transportation projects, and to identify the region's highest priorities for green infrastructure. Through better planning and design, we can unlock new funding sources and achieve shared goals outlined in BMTS' long range transportation plan *Looking Forward, 2040*.

Figures 2-5: *Main St. Owego, 2011 (source: NY Community Rising Plan Tioga County); Infiltration Planter, 2 Court St. Binghamton (source: City of Binghamton Stormwater Planter Brochure); Permeable Pavement Southside Commons, Binghamton (source: City of Binghamton Pervious Pavement Brochure).*

Green Streets Overview

As stormwater flows across impervious streets and sidewalks it collects pollutants such as motor oil, chemicals, sediments, and trash. These pollutants are eventually discharged into local waterways, either directly or after passing through traditional grey infrastructure and into wastewater treatment plants. In many locations stormwater and sewer water are combined and conveyed to sewage treatment plants. During heaving rain events, the capacity of combined sewage systems can be exceeded causing untreated sewage to flow directly to waterways, onto nearby properties, to back up into basements, and to overflow manholes onto surface streets. Other areas lack stormwater infrastructure or have separate systems that allow stormwater to flow untreated into our streams and rivers. In addition to pollution, runoff flows can cause erosion and flooding resulting in property and infrastructure damage. Further, impervious surfaces and traditional 'gray' stormwater infrastructure prevent water from penetrating the soil and recharging groundwater supplies.

The United States Environmental Protection Agency (EPA) recommends that communities consider green infrastructure (GI) as an alternative to grey infrastructure. Instead of grey infrastructure systems that convey stormwater to a treatment plant, a green street utilizes GI to manage and treat stormwater at its source, where rain falls. GI practices specifically utilize plants and soils to direct, slow, filter, cleanse and absorb stormwater that flows from streets. GI may be combined with grey practices to reduce the burden upon traditional systems within existing developed areas and can also be used either singularly or in combination with grey practices to manage stormwater in areas that lack stormwater management. According to the EPA GI is often cheaper, less impactful to the environment, more aesthetically pleasing, and provides multiple community benefits as compared to grey infrastructure.

Benefits of a green street include:

- protects water quality in rivers and streams by removing up to 90% of pollutants
- replenishes groundwater supplies
- absorbs carbon emissions, improving air quality
- improves neighborhood aesthetics
- provides green connections between parks and open space
- improves pedestrian and bicycle safety, and calm traffic
- reduces localized flooding and peak stormwater flows
- frees capacity in the pipes to carry more wastewater to sewage treatment plants
- reduces or stops sewer backups in basements
- reduces the need to install or replace expensive underground collection, conveyance and treatment systems
- increased property values

Factors that warrant attention to stormwater management in the BMTS planning area are briefly discussed below:

- Much of BMTS' urban area falls within a **municipal small stormwater sewer system (MS4)** (see Figure 2). MS4s are required by the EPA to reduce the amount of pollutants carried by stormwater during storm events to waterbodies through preventative actions (e.g., protecting sensitive areas) and/or the use of structural controls (e.g., grassed swales or porous pavement). Other areas lack storm sewer infrastructure allowing water to directly flow untreated into waterways.
- **Extensive flooding** has historically impacted Broome and Tioga Counties, most recently 2006 and 2011. These flood events caused extensive, and in some cases irreparable, damage to public and private property. The NY Rising Community

Reconstruction Plans for Broome and Tioga County, both prepared in response to these flood events, recommend green infrastructure as strategies to reduce stormwater impacts. Tioga County's plan recommends cumulative improvements from both large-scale and small projects, such as permeable or semi-permeable pavement surfaces, rain barrels, vegetated swales and buffer strips, and rain gardens. Broome County's plan states green infrastructure, such as wetlands, rain gardens, bio-infiltration swales and porous pavements, should be used to enhance safety, preserve the natural environment and improve water quality.

- Separate wastewater and sewer studies for Broome and Tioga Counties identify **Infiltration and Inflow (I & I)** of stormwater into the sewer system as a "significant" problem and a "chronic deficiency", respectively, resulting in sanitary sewer overflows (SSO). Infiltration occurs when stormwater or groundwater seeps into the sewer system through cracks and other vulnerable locations in the pipes and joints. Inflow occurs when stormwater enters the sanitary sewer system via specific storm connections. When I & I is excessive sewer systems and treatment plants may exceed capacity causing untreated wasterwater to flow directly into waterways (SSO). The EPA has stated that green infrastructure may be used in conjunction with grey infrastructure to help eliminate SSOs.
- The Federal Clean Water Act requires states to periodically assess and report on the quality of waters in their state. States must identify ***impaired waters*** where designated uses, including water supply use, recreation activities and aquatic life are not fully supported due to pollution. States are required to develop strategies to reduce pollutant(s) restricting waterbody uses. Table 1 lists the river and streams segments within the BMTS planning area that have been identified by the DEC as being impaired or impacted.

Name	Description	River Basin	Water Quality
Apalachin Creek and tribs	entire stream and tribs (within NYS)	Susquehanna River	Minor Impacts
Castle Creek, Lower, and minor tribs	stream and tribs, from mouth to Castle Creek	Susquehanna River	Minor Impacts
Chenango River, Lower, Main Stem	from mouth to Chenango Forks	Susquehanna River	Impaired
Chenango River, Middle, Main Stem	from Chenango Forks to near Oxford	Susquehanna River	Impaired
Minor Tribs to Lower Susquehanna (north)	total length of select tribs fr Endicott to Johnson Cty	Susquehanna River	Impaired
Minor Tribs to Susquehanna River	total length of selected tribs fr Binghamton to Pa line	Susquehanna River	Minor Impacts
Owego Creek and minor tribs	stream and select tribs fr mouth to East/West Branch	Susquehanna River	Minor Impacts
Park Creek and tribs	entire stream and tribs	Susquehanna River	Impaired
Susquehanna River, Lower, Main Stem	from Ross Corners to Binghamton	Susquehanna River	Impaired
Susquehanna River, Lower, Main Stem	from Owego to Ross Corners (Class B)	Susquehanna River	Impaired
Susquehanna River, Lower, Main Stem	from NY-Pa line to near Lounsberry (Class B)	Susquehanna River	Impaired
Susquehanna River, Main Stem	from Binghamton to NY-Pa state line nr Riverside	Susquehanna River	Impaired
Susquehanna River, Main Stem	from NY-Pa state line to Sidney	Susquehanna River	Impaired

Figure 6: Impaired and Impacted Waters

Green Street Practices

Green streets incorporate a wide variety of stormwater management practices (SMPs) including street trees, permeable pavements, bioretention, and swales. Although the design and appearance of green streets will vary, the functional goals are the same:

- provide source control of stormwater to limit the transport of pollutants to stormwater conveyance and collection systems,
- restore predevelopment hydrology to the extent possible, and
- create roadways that help protect the environment and local water quality

The SMPs discussed in this guide are highly customizable and can be integrated into a variety of street types and on private property. When designing and engineering streetscape improvements SMPs should be considered within medians, corner and midblock curb extensions, chicanes, roadway and park edges, along building edges and sidewalks, and within roundabouts. Selecting the appropriate SMP will be dependent on street type and site conditions. Any SMP proposed in the right-of-way must consider possible effects on the existing street and its users, including motorists, bicyclists, and pedestrians. Well-designed SMPs can serve multiple functions, including traffic calming, streetscape beautification, and opportunities for green stormwater infrastructure-related educational and interpretive signage.

TYPICAL STREET

OPPORTUNITY

IMPLEMENTATION

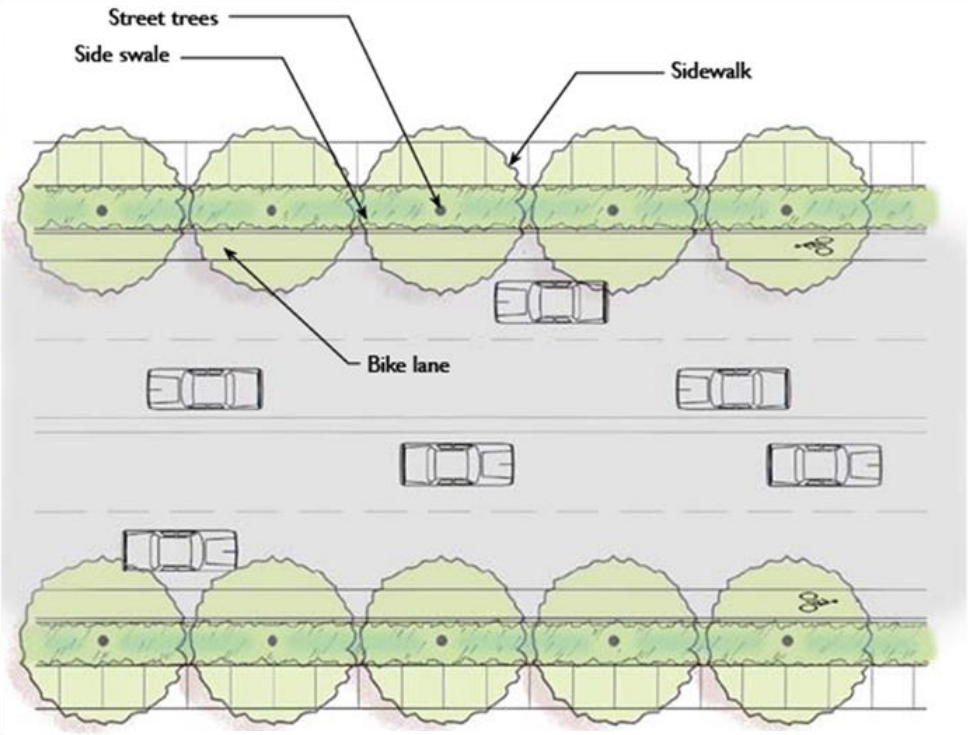


Figure 7: Green Infrastructure Design and Implementation (Source: US EPA)

A variety of SMPs are briefly discussed on the following pages. While not a comprehensive list of green infrastructure practices, these SMPs were chosen as best practices to help infiltrate and detain stormwater runoff within the right-of-way but would also be appropriate outside of the right-of-way on public or private developments.

Bioretention Areas

Figure 8: Bioretention Area, MacArthur School Parking Area, Binghamton

Overview

Bioretention areas are shallow vegetated depressions with a slight slope. Types of biorentention areas include bioswales, raingardens, tree boxes, and buffer strips. As water flows from roadways and into a bioretention areas it is slowed by plants and soil, allowing sediments and pollutants to settle out. Water soaks into the soil and is taken up by plants, and may infiltrate further into the ground if the soil is well-drained.

Benefits

- Reduces localized flooding through collection, storage and infiltration
- Improving water quality, by filter water through plants and soils
- Provides buffer between pedestrians and vehicles
- Easy to retrofit existing medians and utility strips into swales
- Can accommodate trees
- Adds aesthetic improvements to street
- Can serve as traffic calming element and improves pedestrian safety (curb extensions/bumps outs)
- Serves as an access management feature when used as median

Figure 9: Streetside Bioswale, Syracuse (Source: Milwaukee Stormwater Plan)

Placement Opportunities

- Utility strips
- Medians
- Traffic circles
- Curb extensions/bump outs
- Bicycle and pedestrian trails
- Parking lots

Figure 10: Bioretention, Route 343 Greenway

Considerations

- the top of the planting media must be lower than the street's gutter elevation
- must be connected to the street by inlets (types vary), allowing stormwater runoff from the street to flow into the swale
- choose salt and drought tolerant plant materials
- must consider sidewalk and street width, turning radii, on-street parking, bicycle access, sight distance

Stormwater Planters

Figure 11: Stornwater Planter and Street Tree, Syracuse (Source: Milwaukee Stormwater Plan)

Overview

A stormwater planter is a specialized, landscaped planter installed in the sidewalk area and designed to manage stormwater runoff. They are typically densely landscaped to uptake water and pollutants and for streetscape beautifcation. Planters are typically above-grade or at-grade with solid walls and a flow-through bottom. They include an impermeable liner and use an underdrain to direct treated runoff back to the collection system. At-grade street-adjacent planter boxes a take runoff from streets and sidewalks and may or may not include an underdrain depending on subsurface soil conditions.

Benefits

- Improving water quality by acting as a filter
- Provides a physical buffer between pedestrians and the street
- Adds aesthetic improvements to streetscape.
- Can be sized and placed to fit between existing surface features such as driveways, signs, street furnishings, and street trees.

Placement Opportunities

- Streets with adequate sidewalk widths, particularly in pedestrian shopping districts and downtowns
- Bicycle and pedestrian trails through urban areas (i.e. Two Rivers Greenway through downtown Binghamton)
- Public parks (i.e. Confluence Park)

Figure 12: Stormwater Planter, Court St, Binghamton

Figure 12: Stormwater Planter, Hawley Street, Binghamton (Source: Binghamton Stormwater Planter Brochure)

Considerations

- Placement should consider future sidewalk maintenance and snow removal
- Adequate sidewalk widths must be maintained
- Should be designed to pond water for less than 48 hours following a storm
- Inlets and curb depressions should be used for at-grade plants to direct water flow into planter

Trees

Overview

A stormwater tree is a street tree planted in a specialized tree pit installed in the sidewalk area or within a bioretention area. When placed in tree pits the pit is designed to so that the top of the planting media in the tree pit is lower than the street's gutter elevation and connected to the street by curb cut or inlet. Runoff from the adjacent sidewalk can flow directly into the tree pit from the sidewalk surf

Figure 14: City of Binghamton Street Tree Planting (Source: Fox 40)

Benefits

- Reduces stormwater runoff through transpiration through leaves and water uptake through roots
- Improves air quality by adsorbing air pollutants and intercepting particulates
- Reduces atmospheric carbon dioxide through direct sequestration and by reducing energy consumption of surrounding development
- Reduces urban heat island effect
- Adds beauty to streetscape and helps create a sense of place and well-being
- Increases property values and enhances economic activity

Placement Opportunities

- Any street with adequate right-of-way (installation options will vary depending on nature of streetscape)
- Coupled with other bioretention areas, such as bioswales
- Bicycle and pedestrian trails through urban areas (i.e. Two Rivers Greenway through downtown Binghamton)
- Public parks (i.e. Confluence Park)

Figure 15: Stormwater Planter and Street Trees, Binghamton (Source: Chuck Hauge)

Considerations

- Placement should consider future sidewalk maintenance
- Adequate sidewalk widths must be maintained
- Inlets and curb depressions should be used to direct water flow into tree planting area
- Multiple trees should be planted along a street to maximize benefits
- Plan for adequate root zones and inclusion of structural soils in more urbanized zones requiring tree pits

Pervious Pavement

Figure 16: Permeable concrete and permable pavers, McArthur School, Binghamton

Overview

Permeable pavement consisting of materials that allow water to pass freely through the surface, thereby eliminating or reducing runoff compared to impervious paving. Types of permeable pavements includes permeable asphalt, permeable concrete, and permeable pavers. Permeable pavement surfaces typically include a storage media such as stone beneath the permeable surface that provides the structural support of conventional pavement while serving as temporary storage of stormwater.

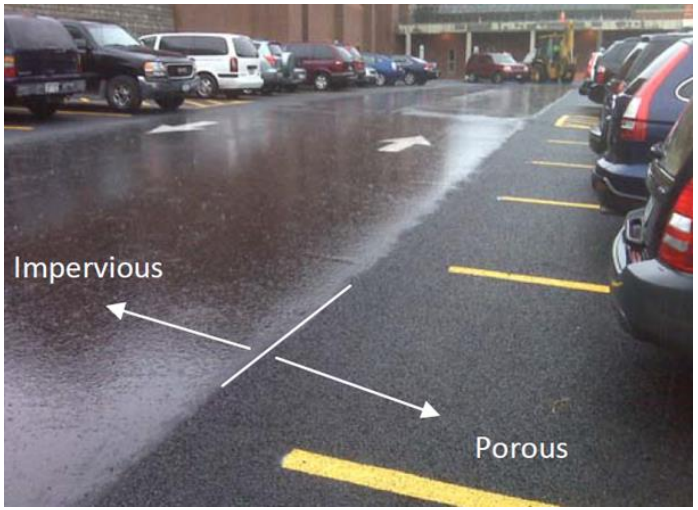


Figure 17: Permeable asphalt on-street parking during rain event, Syracuse (Source: Milwaukee Green Streets Stormwater Plan)

Benefits

- Provides stormwater management while maintaining paved and other hardscape surfaces
- Can be implemented in lieu of traditional pavement replacement projects

Placement Opportunities

- On- and off-street parking areas and loading zones
- Dedicated bike lanes or cycle tracks (except pavers)
- Bicycle and pedestrian trails
- Furniture zones of sidewalk areas
- Pedestrian plazas

Figure 18: Pervious On-street Parking, Syracuse (Source: Milwaukee Stormwater Plan)

Considerations

- Pervious materials used for pedestrian or bicycle access should be very smooth to protect against tripping and falling
- Periodic cleaning or vacuuming is required
- Design must consider traffic volume

GI Placement Opportunities

The follow table provides an outline of the best SMPs discussed above by street type.

Street Typology	Bioretention	Trees	Permeable Pavement	Stormwater Planter
Principle Arterial		**GI Practice Appropriateness***		
Expressway, controlled access	✓	✓		
Auto-oriented Commercial/Industrial	✓	✓		✓
Suburban/Rural	✓	✓		
Minor Arterial				
Mixed Use / Commercial	✓	✓	✓	✓
Downtown	✓	✓	✓	✓
Neighborhood Residential	✓	✓	✓	
Collector				
Residential	✓	✓	✓	✓
Mixed Use / Commercial	✓	✓	✓	✓
Suburban/Rural	✓	✓	✓	

✓ Practice appropriate for use within pedestrian and bicycle paths, parking and loaking areas, and shoulders

*Specifics of GI practice will vary based upon site specific conditions

Green Street Prioritization

In the BMTS planning area there are approximately 2,500 miles of roadway, which very conservatively represents at least 396,000,000 square feet of impervious area. Since streets are a significant percentage of publicly owned land they offer opportunities for communities to incorporate GI elements that will protect and improve public and private investments and property.

Roadway improvement projects are most often intended to address issues related to maintenance, system preservation and safety. Green infrastructure can be integrated in ways that help address these same issues. Implementation of green infrastructure can occur during small repair projects as well as during big capital improvement projects. Coordinating green infrastructure installation with broader transportation improvements can significantly reduce the overall cost of stormwater management. GI SMPs should be used in combination where possible to maximize benefits of green infrastructure.

Given the extent of the roadway network in the BMTS planning area, priority locations for green streets have been identified for planning purposes. However, GI should not necessary by limited to these priority areas or to public streets. Priority areas were chosen based on following factors (maps of these areas provided on the following pages):

Factor 1: *MS4 areas*
Factor 2: *Flood vulnerability*
Factor 3: *Water quality*
Factor 4: *Lack of stormwater infrastructure*

Increased priority for GI should be placed on areas that fall within more categories. Generally, highest priority should be given to those areas that fall within 3 of 4 Factors and lowest priority to those that fall within Only 1 Factor (see Figure 19). Higher priority areas should consider utilizing multiple GI SMPs to maximize benefits.

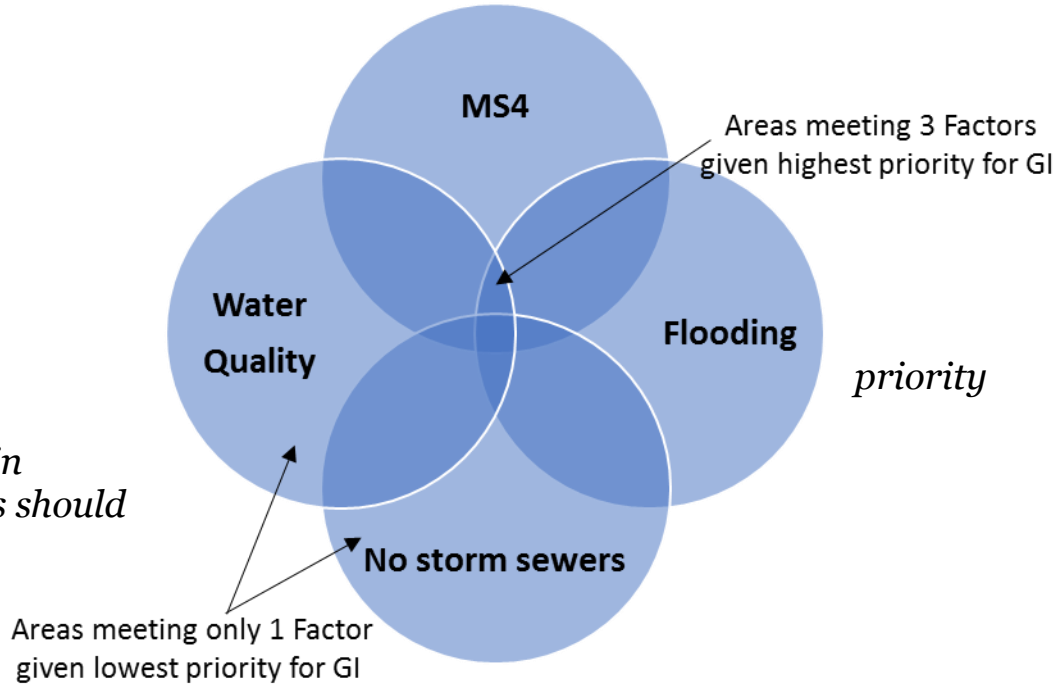


Figure 19: GI Prioritization

Factor 1: *Location is within a municipal separate storm sewer system regulated area (see Figure 20).*

MS4s are included as a priority because polluted stormwater runoff is transported through MS4s and then discharged, untreated, into local water bodies. Figure 2 illustrates the MS4 boundaries in Broome and Tioga Counties. These areas also suffer from I and I issues.

A municipal separate storm sewer system (MS4) is a conveyance or system of conveyances that is:

- owned by a state, city, town, village, or other public entity that discharges to waters of the U.S.,
- designed or used to collect or convey stormwater (e.g., storm drains, pipes, ditches),
- not combined with sanitary sewers, and
- not part of a sewage treatment plant, or publicly owned treatment works.

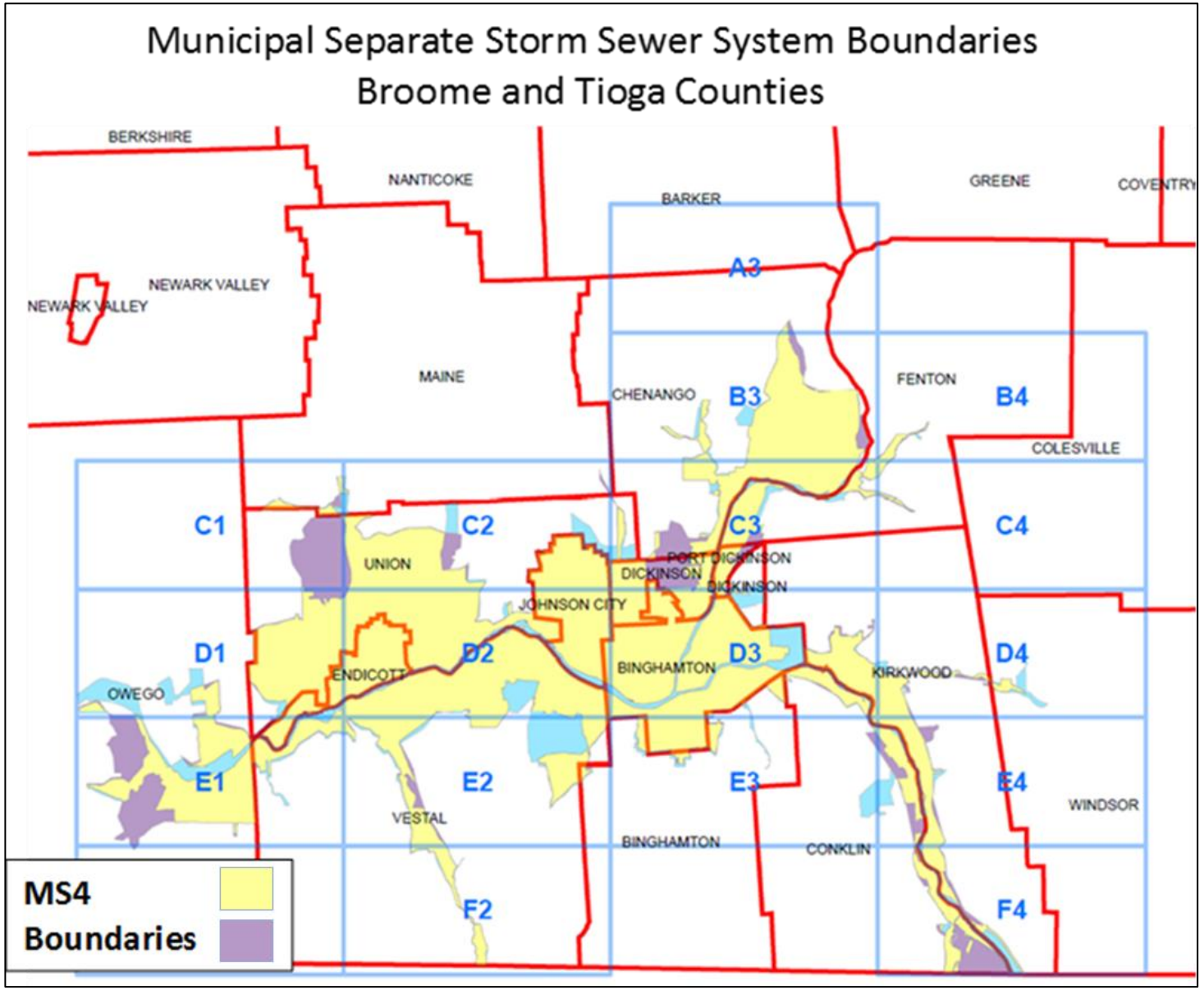


Figure 20: Broome Tioga MS4 areas. Map prepared by the NYS Department of Conservation

Factor 2: *Location is within an area identified in the New York Rising Community Reconstruction Plans for Broome and Tioga Counties as being at risk or high risk for flooding impacts (see Figures 21 and 22).*

The NY Rising Community Reconstruction Plans for Broome and Tioga County recommend green infrastructure as strategies to reduce stormwater impacts.

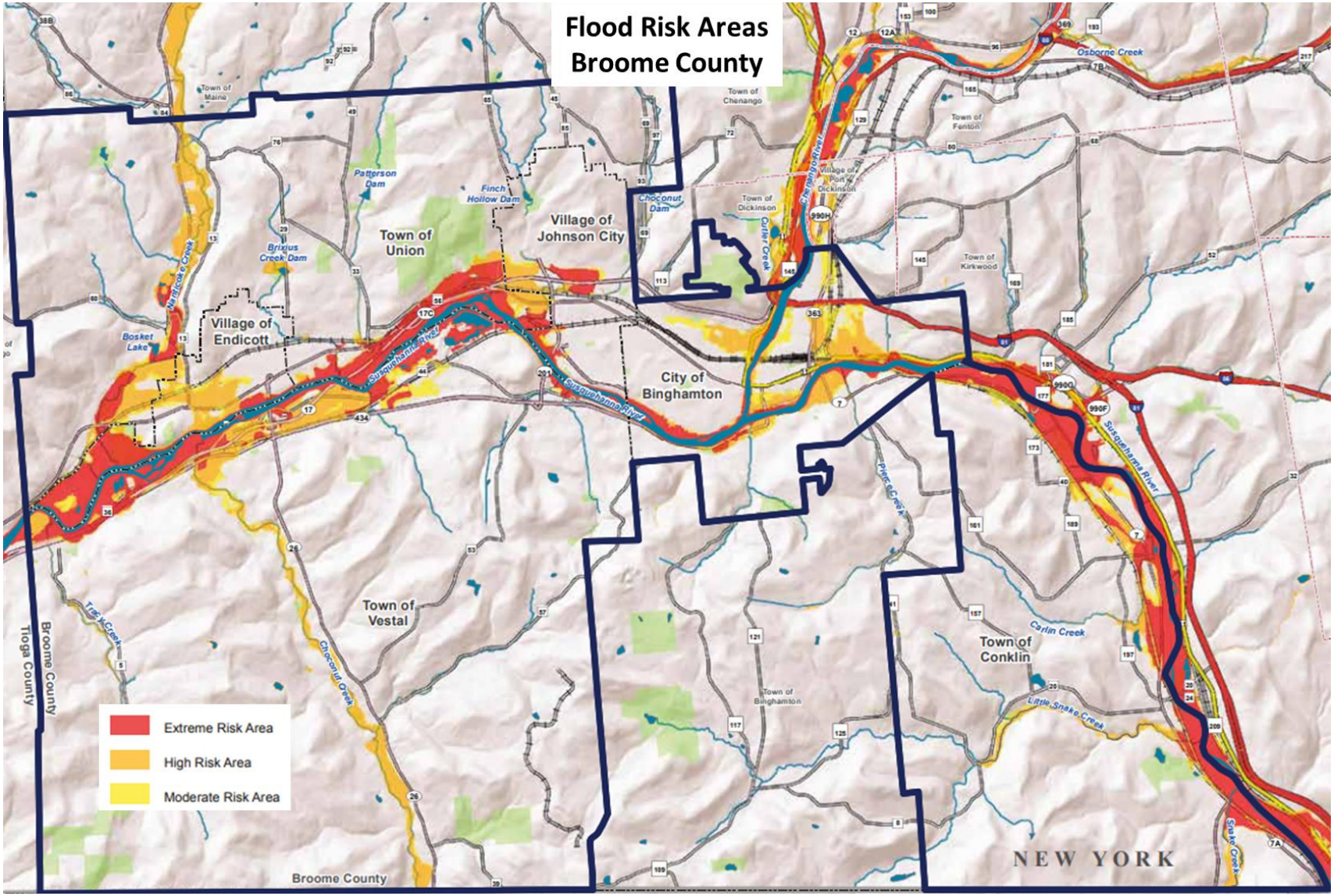


Figure 21: Flood Risks Areas, Broome County; Map Source: Broome NY Community Reconstruction Plan, 2014)

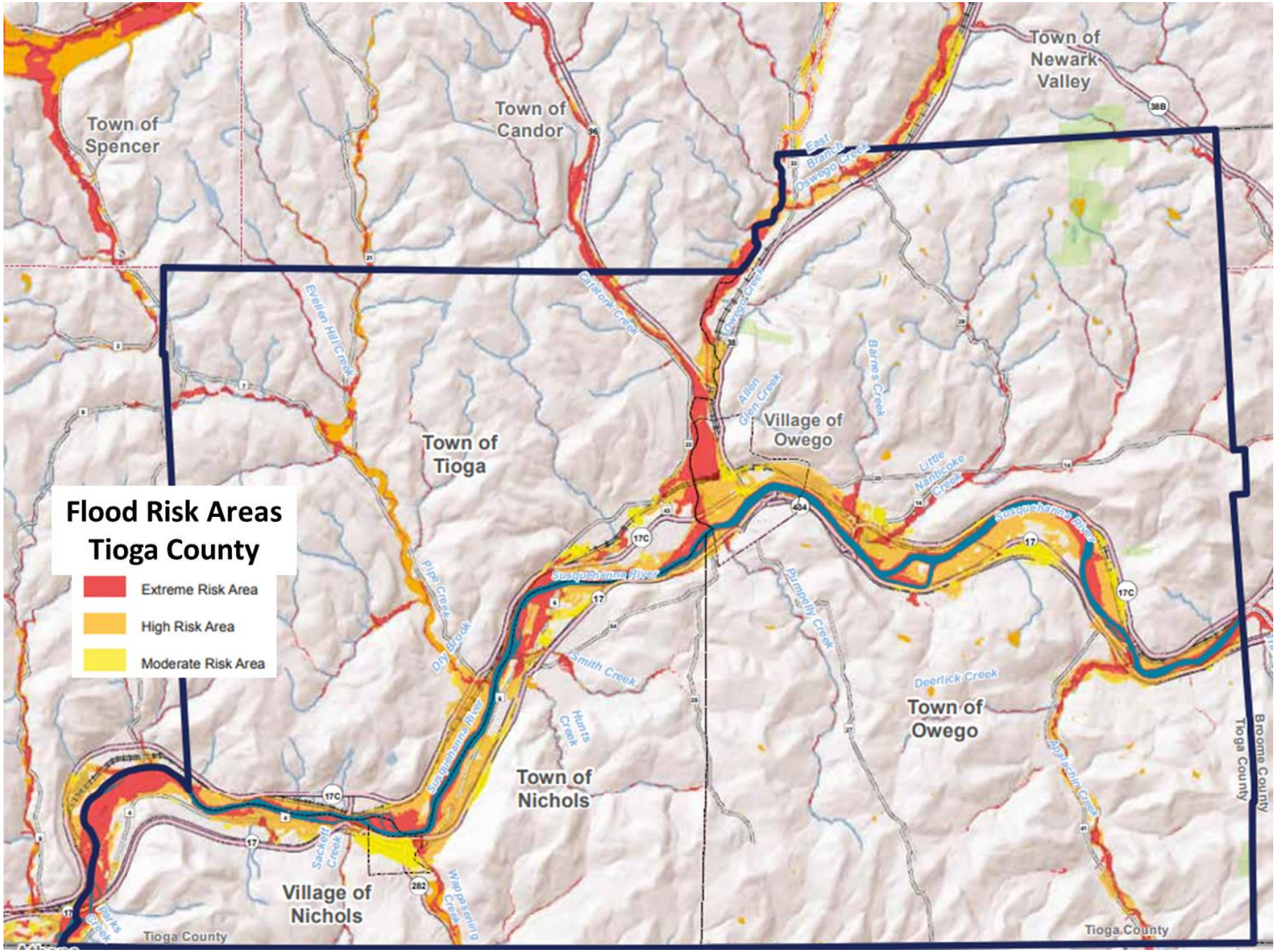
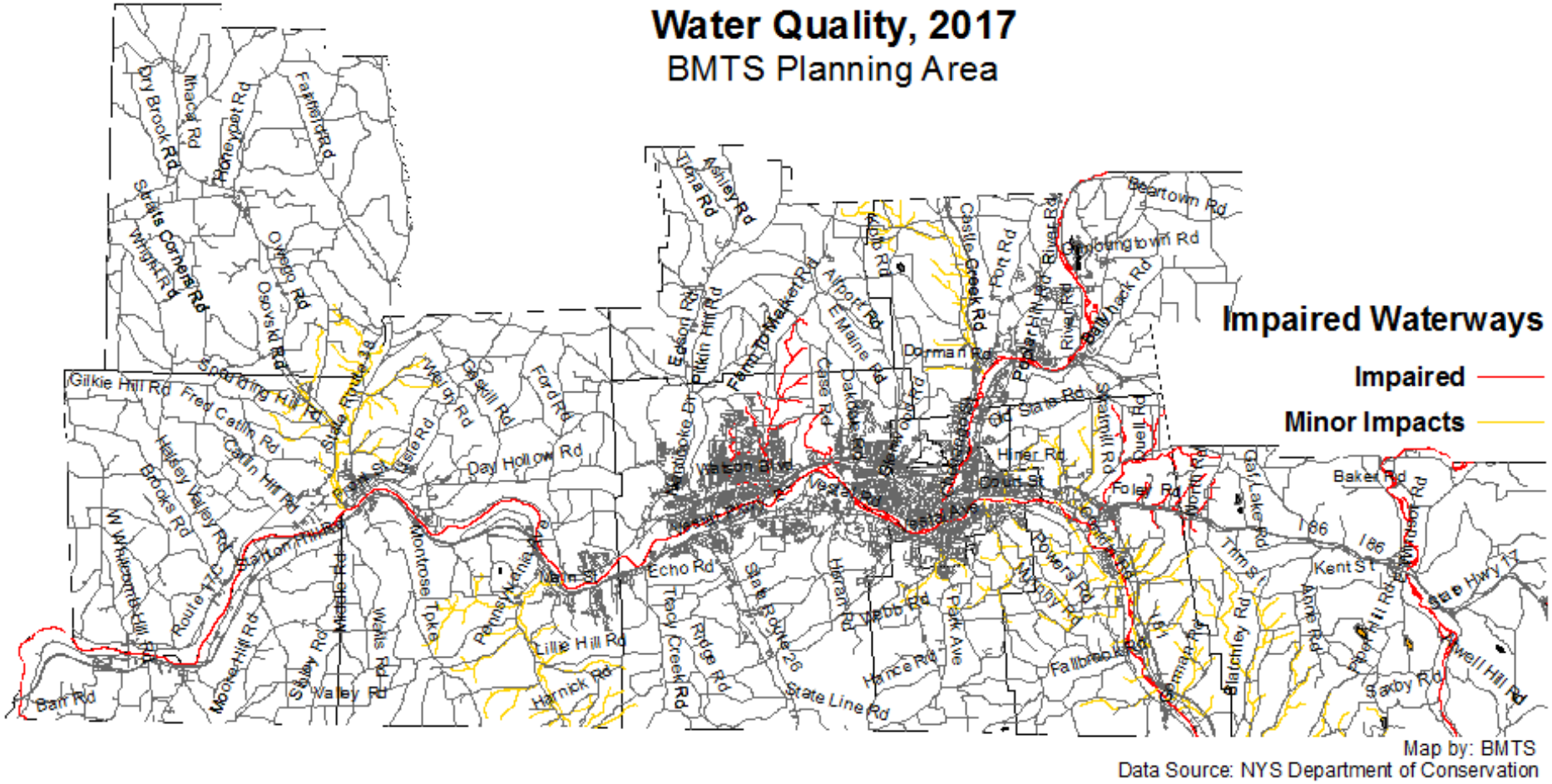


Figure 22: Flood Risk Areas, Tioga County; Map Source: Tioga NY Rising Community Reconstruction Plan, 2014

Factor 3: *Location is within proximity of a waterway deemed impaired or with minor quality impacts by the New York State Department of Environmental Conservation.*

GI practices should be considered along roadways within proximity to impaired waterways to reduce the input of pollutant(s) restricting waterbody uses. Roads collect a wide variety of pollutants and deliver them into the conveyance system and ultimately receiving waterways. Metals, combustion byproducts, and automotive fluids from vehicles combines with the nutrients, trash, and suspended solids resulting in a toxic mix that impairs our waterways.



Factor 4: *Location is within an area that lacks a storm sewer system.*

Most areas that lie outside of the MS4 boundaries illustrated in Figure 2 lack any type of stormwater infrastructure. Green infrastructure can be used to eliminate or reduce the need to expand sewer systems in these areas and can reduce localized flooding (EPA, 2014).

Example Project: *Route 201 and Route 17 Cloverleaf Interchange, Johnson City*

The Route 201/Route 17 interchange area in Johnson meets three of the four Factors and should be consider as a high priority area for GI. Broome County's Community Rising plan recommends the addition of bio-retention measures within undeveloped and underutilized land area around the interchange. The project would provide a series of inter-connected bio-retention areas to expand the Little Choconut Creek's floodplain and provide additional flood storage.

Benefits of the project include:

- reduced flood risk to surrounding properties
- reduced erosion of commercial properties near the interchange
- reduced stormwater runoff into the Susquehanna River watershed
- reduced pollution of the watershed
- aesthetic improvements

Figure23: Existing Conditions, Route 201/Route 17

Figure 24: Bio-retention Conceptual Design, Route 201/Route 17 (Source: Broome NY Community Reconstruction Plan, 2014)

Example Project: *Main Street at Murray, City of Binghamton*

Main Street near Murray falls within one of the four Factors for GI consideration (MS4 and would be considered lower in priority for GI. Given its lower priority and urban setting smaller treatments would be appropriate. Images below for the Main/Court Street Corridor Charrette Report from Blueprint Binghamton, the city's comprehensive plan, illustrates how Main Street could be transformed overtime starting with streetscape improvements including pervious on-street parking, tree wells and vegetated bioswales.

Figures 25-27: Counter clockwise from top left, Main at Murray existing conditions; application of pervious parking, tree wells and bioswales; photo simulation of long-term streetscape transformation (Source: Main/Court Street Corridor Charrette Report, City of Binghamton).

Funding

Transportation Alternatives Set-Aside – Federal funding (FHWA) for programs and projects defined as **transportation alternatives,** including on- and off-road pedestrian and bicycle facilities, infrastructure projects for improving non-driver access to public transportation and enhanced mobility, community improvement activities such as historic preservation and vegetation management, *environmental mitigation related to stormwater* and habitat connectivity; recreational trail projects; safe routes to school projects; and projects for planning, designing, or constructing boulevards and other roadways largely in the right-of-way of former divided highways.

Federal Emergency Management Agency (FEMA) Hazard Mitigation Grant Program – Helps communities implement hazard mitigation measures following a Presidential major disaster declaration. This is a federal grant that is administered by the state. May fund green infrastructure if a benefit-cost analysis shows that the damages saved from the project exceed the cost of the project.

Water Quality Improvement Project (WQIP) Program – NYDEC Division of Water competitive, reimbursement grant program for projects that reduce polluted runoff, improve water quality and restore habitat. Requests for Proposals (RFP) for previous rounds have included funding for green infrastructure projects.

Urban and Community Forestry Program Cost Share Grants – NYDEC Division of Lands and Forests program providing assistance to communities in comprehensive planning, management, and education to create healthy urban and community forests. Street tree plantings is an eligible project type.

Green Innovation Grant Program – NYS Environmental Facilities Corporation program supporting projects that utilize unique stormwater infrastructure design and create cutting-edge green technologies. Funding for eight specific green infrastructure practices.

EPA Urban Waters Small Grants – U.S. Environmental Protection Agency (EPA) funding to improve urban water quality through activities that also support community revitalization and other local priorities. RFPs may include green infrastructure.

U.S. Forest Service Urban and Community Forestry Challenge Cost Share Grant Program – Funding for program development, study, and collaboration that will launch some of the strategies in the (2016-2026) Ten Year Urban Forestry Action Plan. Green infrastructure projects have been eligible for funding in previous RFPs.

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