KINNICKINNIC RIVER WATERSHED: GREEN INFRASTRUCTURE PLAN

GRAEF

STORMWATER SOLUTIONS ENGINEERING

Sixteenth Street COMMUNITY HEALTH CENTERS

Prepared for

MILWAUKEE METROPOLITAN SEWERAGE DISTRICT

2018

MMSD

PARTNERS FOR A CLEANER ENVIRONMENT

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Green alley installation near Pulaski Park in 2015 by City of Milwaukee

TABLE OF CONTENTS

Youth testing a finished green alley near Pulaski Park in 2015 by City of Milwaukee

EXECUTIVE SUMMARY

As the smallest, most urbanized watershed in the Milwaukee Metropolitan Sewerage District's 411-square-mile planning area, the Kinnickinnic River Watershed has unique challenges and opportunities related to flooding, water quality, and restoration. Decades of urbanization and development have negatively affected the water quality, in-stream habitat, and river corridor aesthetics and habitat. With the build-out of impervious surfaces, the watershed continues to struggle with stormwater absorption. In the 1960s, the river was channelized with concrete in an attempt to quickly move flood waters out of neighborhoods and into Lake Michigan. With failing channels and ever changing urban conditions, the river is now being re-naturalized to achieve the very same goal of flood risk reduction. The Kinnickinnic River's return to a more natural state has the added benefits of increased public safety and asset creation. A re-naturalized river can also generate social, economic, and environmental benefits for nearby residents and the community at large.

The Milwaukee Metropolitan Sewerage District (MMSD) led a collaborative effort to review planned investments in the watershed to ensure that they will work to both reduce flood risk to the community and improve the riparian corridors and surrounding green space. The result was the Kinnickinnic River Watershed Flood Management Plan, which outlines stormwater management and comprehensive flood risk reduction recommendations. The output of this process identified that although green infrastructure as a standalone strategy would be infeasible given the land conditions and constraints, green infrastructure is a critical component that would provide additional social, environmental and economic benefits. Acting as resilient sponges throughout the watershed, green infrastructure can absorb the shock from storms and smaller-scale flood events by slowing and filtering stormwater. Green infrastructure also can generate higher property values for nearby residents, enhance natural aesthetics, improve water quality, and positively impact community health. The Kinnickinnic River Watershed Green Infrastructure Plan (KKGIP) is a response to the need and opportunity to identify the roles, benefits, and effectiveness of green infrastructure strategies across the watershed.

OBJECTIVES OF THE PLAN

- Building on the MMSD Regional Green Infrastructure Plan, create detailed and strategic recommendations for types and locations of green infrastructure
- Integrate stakeholder feedback related to priorities, barriers, and opportunities
- Create an implementable plan that supports larger flood management objectives

GOALS OF THE PLAN

- Stakeholder coordination of green infrastructure investments to realize collective impact goals
- As a companion to the Kinnickinnic River Watershed Flood Management Plan, help inform locations and types of green infrastructure projects to provide 1% probability flood risk support and other co-benefits
- Guide MMSD, municipalities, Milwaukee County, and other public and private stakeholders in meeting various environmental, social, and economic goals, including Total Maximum Daily Load (TMDL) attainment

MEETING MMSD'S 2035 VISION

The Milwaukee region has transformed its approach to water in order to clean up the area's rivers and preserve Lake Michigan. MMSD envisions a healthier Milwaukee region and cleaner Lake Michigan through integrated watershed management, water quality leadership and collaboration, and climate change mitigation, in part, through the development of a Resilience Plan. Integrated watershed management goals, such as zero homes in the 1% probability floodplain and capturing the equivalent of 0.5 inch of rainfall through green infrastructure, are critical to achieving this vision.

RECOMMENDATIONS

The KKGIP provides a number of tools to guide the strategic implementation of green infrastructure in the Kinnickinnic River Watershed. Green infrastructure is a constructed feature that mimics nature to capture, retain, treat, and infiltrate stormwater. Full implementation will help meet MMSD's 2035 Vision as well as support additional stakeholder objectives. The recommendations have been compiled into four tools.

1 PRIORITY SUBBASINS MAP

This compiled data shows that there is high potential for the implementation of green infrastructure throughout the watershed. The rankings for all 66 subbasins range from 'Medium-Low Area of Impact' to 'Highest Area of Impact'. This analysis includes all facets of the watershed as it relates to green infrastructure considerations.

2 REDUCE IMPACTS TO STRUCTURES MAP

As flows move through the watershed, they have the potential to impact properties in different ways, largely based on land characteristics, a structure's location within the subbasin and the proximity to waterways. This map focuses on how the strategic location of green infrastructure can benefit structures in the subbasins and watershed. Infiltration-based green infrastructure strategies are recommended, with the focus on infiltrating more water upstream or away from impacted structures. This helps to reduce surface flows, especially where groundwater levels are already high. Recommended green infrastructure implementation specifically avoids areas with high ground water levels.

3 WATER QUALITY MAP

Approximately 83% of the watershed drains directly into a river or tributary stream (the other 17% drains to the combined sewer). With dense development, commercial land use, and transportation corridors, managing pollution, phosphorus, and runoff is critical. This map identifies locations with the highest levels of nonpoint source pollution.

4 POTENTIAL FOR IMPLEMENTATION MAP

Considerations for this map include current and planned projects or investments, capital improvements, organizations working in the area, and large impervious areas. Integration of green infrastructure into planned investments can be supported with this map.

SCALING UP TO MEET REGIONAL GREEN INFRASTRUCTURE GOALS

The MMSD Regional Green Infrastructure Plan (RGIP, 2013) provided recommendations related to specific green infrastructure strategies and quantities for watersheds to capture the equivalent of 0.5 inch of rainfall. Further, the RGIP recommends that additional comprehensive green infrastructure plans for watersheds, subbasins, and municipalities be created to analyze opportunities on a more detailed scale so that the impact of implementation can be assessed based on customized data and goals.

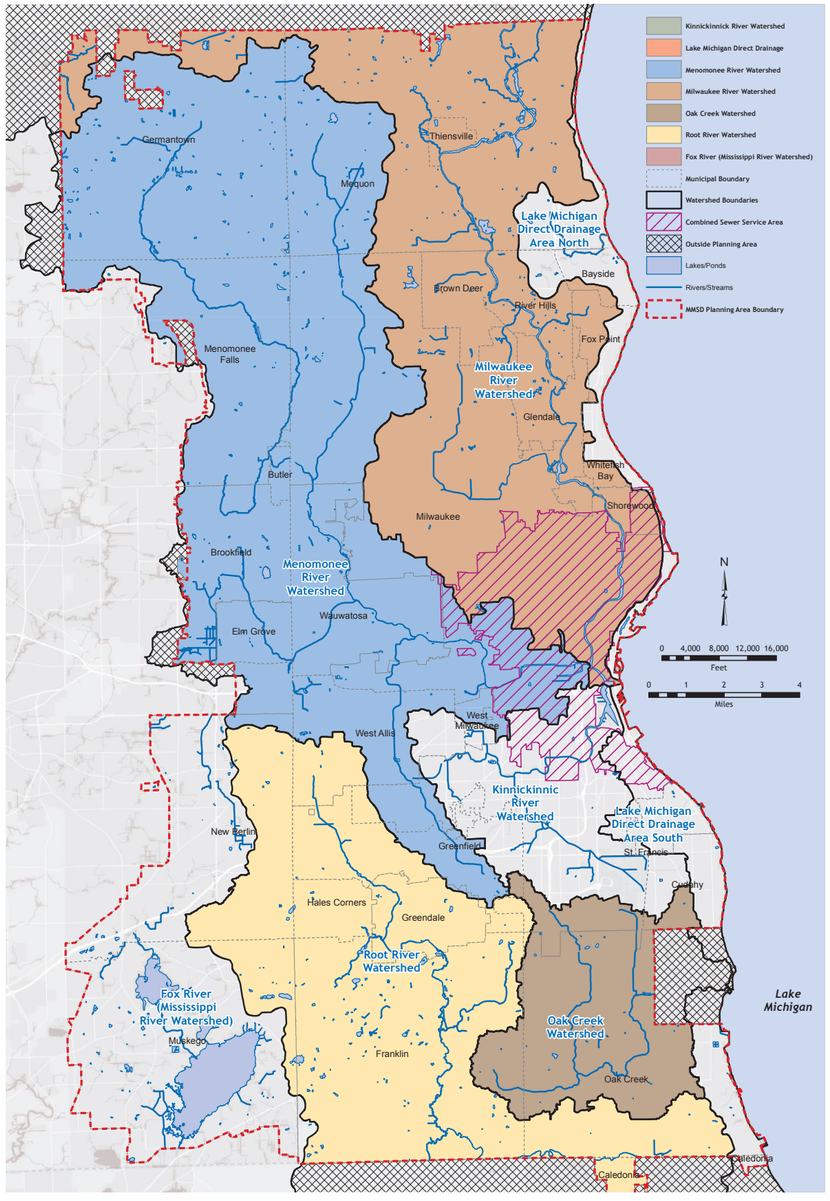
The KKGIP is the first of these plans to be created as part of the larger watershed planning effort. This plan builds on the RGIP recommendations to allow multiple stakeholders to strategically implement green infrastructure in a way that meets their objectives.

Figure 1 details both the originally recommended types and quantities of green infrastructure, as well as updated recommendations as a result of this planning effort. For instance, the original recommendation of 22,000 rain gardens may seem unattainable considering there are over 40,000 parcels in the watershed, all of varying sizes and conditions. This plan provides more specificity to increase the benefits of strategies based on land use conditions and project objectives.

FIGURE 1. KK RIVER WATERSHED GREEN INFRASTRUCTURE GOALS

GREEN INFRASTRUCTURE FEATURE	ORIGINAL RGIP QUANTITY	RECOMMENDED CHANGES	UPDATED QUANTITY	REFERENCE MAPS	TYPICAL AREAS OF IMPLEMENTATION
Bioswales	RGIP combined bioswales with rain gardens	In public rights of way or on Commercial Developments. Design subgrade with 3′ stone storage for 10 gallons/ square feet capacity.	1,200,000 Square Feet (2,400 10′ x 50′ Bioswales)	1 Reduce Impacts to Structures 2 Prioritized Subbasins 3 Water Quality 4 Ease Of Implementation	Street Rights Of Way, Parking Lots, Improvement Districts, Residential Lots & Commercial Developments
Cisterns	200 Cisterns	Promote where urban agriculture or other outdoor uses need water.	200 Cisterns	All Areas	Publicly-Owned Lands / Buildings, Schools
Green Roofs / Blue Roofs	1,000 Buildings	Monolithic / contiguous / built-in-place green roof systems hold 1.5″ depth & are more durable.	333 Buildings	All areas where appropriate roofs exist or are planned.	Public Buildings, Schools, Commercial Developments, Improvement Districts
Native Landscaping	200 City Blocks	Use native turf grasses (i.e. buffalo grass or low-mow deep rooting fescue) in publicly-owned lands.	200 City Blocks	All Areas 4 Ease Of Implementation	Publicly-Owned Lands, Schools, Commercial Developments, Improvement Districts, Residential Lots
Porous Pavement	1,210 City Blocks	Incorporate additional storage (3′ storage depth suggested). Promote green alleys & use in parking lots where deicing salt usage is less.	403 City Block-Equivalent In Alleys & Parking Lots	1 Reduce Impacts to Structures 2 Prioritized Subbasins 3 Water Quality 4 Ease Of Implementation	Alley Rights Of Way, Parking Lots, Schools, Commercial Developments, Improvement Districts
Rain Barrels	17,100 Homes	Consider using StormGUARDen (eg. to 6.5 rain barrels) or other similar alternatives.	2,635 Homes	All Areas	Residential Lots, Publicly-Owned Buildings, Commercial Developments, Improvement Districts
Rain Gardens	3.3 Million Square Feet (22,000 10′ x 15′ Gardens)	Incorporate additional storage (gravel layer), amend soil beneath rain garden (up to 5 gallons/square foot).	60,000 Square Feet (10,000 10′ x 6′ Gardens)	1 Reduce Impacts to Structures 2 Prioritized Subbasins	Street Rights Of Way, Parking Lots, Improvement Districts, Residential Lots & Commercial Developments
Soil Amendments	200 City Blocks			All Areas	Publicly-Owned Lands, Schools, Improvement Districts, Commercial Developments, Residential Lots
Stormwater Trees	10 Trees / Block		20 New Trees / Block	All Areas	Publicly-Owned Lands, Schools, Street Rights Of Way, Commercial Developments

FIGURE 2. MMSD'S PLANNING AREA



Source: MMSD Regional Green Infrastructure Plan, 2013

1 KINNICKINNIC RIVER WATERSHED OVERVIEW

THE REGIONAL NEED

Over the past several decades, as a result of land use and population changes, the Milwaukee metropolitan region has transformed its approach to managing stormwater. Looking to the future, green infrastructure is one piece of the multi-tiered approach to meeting MMSD's 2035 Vision for zero basement backups, zero overflows, and improved water quality. Widespread green infrastructure implementation plays an important role in achieving this vision by capturing stormwater and allowing it to be held on-site, infiltrate into the ground, or evaporate to reduce stress on grey infrastructure systems.

Green infrastructure complements MMSD's flood management projects, municipal investments (i.e. system maintenance), and private property efforts to reduce inflow and increase groundwater infiltration. These strategies also support grey infrastructure, such as sewer pipes, storage tunnels, and reclamation facilities – grey infrastructure has been and will continue to be the backbone for wastewater management.

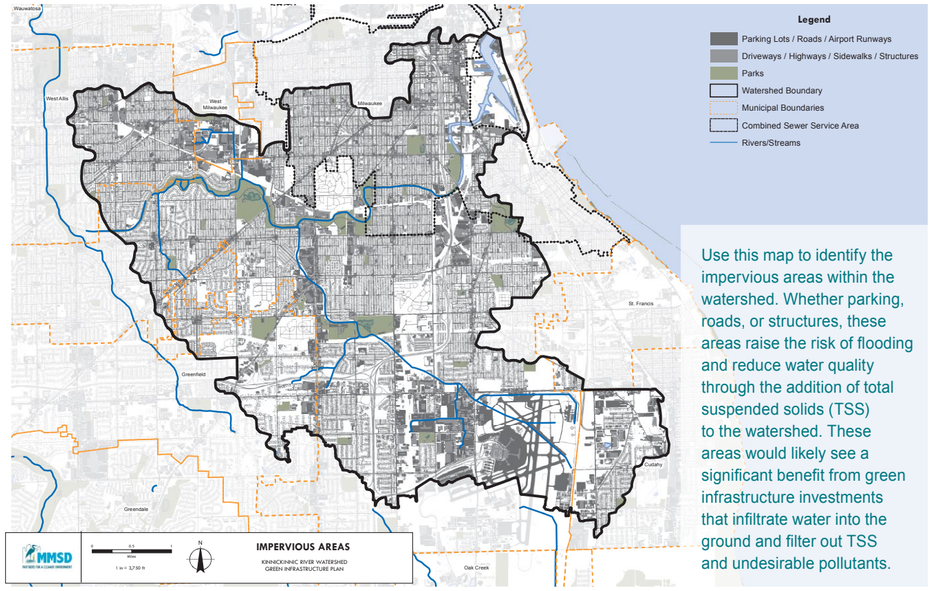
Infrastructure is expensive, but comparative analysis in the Kinnickinnic River Watershed has shown that over the course of 10 years, implementation of a mix of grey and green infrastructure is cost effective (including operations and maintenance) and results in additional quality of life benefits (see Maps & Additional Resources, "Green Infrastructure Scenario Tool," for more information). MMSD's goal of capturing the equivalent of 0.5 inch of rain that falls on impervious surfaces, or 740 million gallons of stormwater over the planning area, will help reduce inflow into the sewers and rivers, and can provide additional community benefits. Together, MMSD and partners can achieve a cleaner environment and healthier communities.

THE KINNICKINNIC RIVER WATERSHED

The Kinnickinnic River (KK River) Watershed is part of the Milwaukee River Basin, a 900-square mile drainage area comprised of six watersheds that drain directly to Lake Michigan (Figure 2). Of these, the KK River Watershed is the most densely developed and urbanized in the region. This watershed is 24.7 square miles with 44% of the land impervious. The watershed drains parts of the City of Milwaukee, City of Greenfield, City of West Allis, Village of West Milwaukee, City of Cudahy, and City of St. Francis. The watershed is comprised of six subwatersheds and 66 subbasins that ultimately drain to the KK River, the Inner Harbor, and Lake Michigan. The 25 miles of streams within the watershed are comprised of the KK River and its major tributaries: Wilson Park Creek, Villa Mann Creek, 43rd Street Ditch, Lyons Park Creek, Cherokee Creek, and Holmes Avenue Creek – all of which contribute flow to the KK River.

The watershed is heavily urbanized — 90% of its land mass has been fully developed for nearly 40 years: 46% for transportation and utilities, 34% for residential use, 10% for commercial and other uses, and only 10% left undeveloped as parks or open space. General Mitchell International Airport, the largest airport in Wisconsin, covers most of the southeastern portion of the watershed. The majority of the watershed lies within the boundaries of the City of Milwaukee, and approximately 17% falls within the combined sewer system area (where stormwater and wastewater run through the same sewer lines to be treated by MMSD). The remaining 83% of the watershed sends stormwater directly into the KK River and its tributaries, untreated and unfiltered.

FIGURE 3. IMPERVIOUS AREAS



Use this map to identify the impervious areas within the watershed. Whether parking, roads, or structures, these areas raise the risk of flooding and reduce water quality through the addition of total suspended solids (TSS) to the watershed. These areas would likely see a significant benefit from green infrastructure investments that infiltrate water into the ground and filter out TSS and undesirable pollutants.

Approximately 30% of the streams within the KK River system are lined with concrete, 30% are enclosed channels (in culverts), and most of the remaining streams are exhibiting significant levels of erosion. Some portions of open stream channels have experienced up to five feet of downcutting (loss of streambank) within the last 40 years, impeding access to the stream and sending polluted sediment into the waterway.

MMSD is developing the 2050 Facilities Plan using the principles of asset management to translate the organization's asset needs and long-term goals and objectives (environmental, social, and economic) into prioritized projects and initiatives. When complete, the 2050 Facilities Plan will identify, analyze, and rank MMSD's risks to prioritize the facilities, programs, operational improvements, and policies recommended to mitigate the risks in part related to green infrastructure and achieving the 2035 Vision. Plan components that should be considered in the context of the KKGIP include:

- Modeling the use of green infrastructure in the combined and separated storm sewer areas to reduce sewer overflows
- Comparing the effectiveness of various green infrastructure strategies on hydrology, infiltration and inflow, and pollutant loading
- Analyzing potential pollutant load reductions through green infrastructure at the watershed scale, including the KK River Watershed
- Organizing existing and proposed activities to mitigate risks associated with effectiveness, financial constraints, regulations, tracking, and maintenance

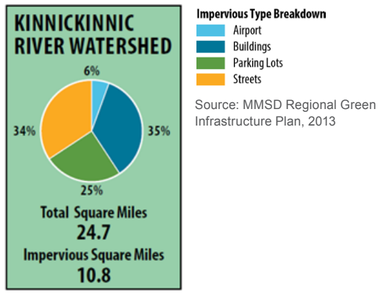
ISSUES & OPPORTUNITIES IN THE WATERSHED

Although this watershed has various challenges (largely due to a fully built-out landscape), there are substantial investments in its river and streams, pollutant reduction, and the community itself that can serve as opportunities to improve this urban space and make it a functioning community asset. This Plan will help identify beneficial projects that can meet multiple social, economic, and environmental objectives when implemented.

ISSUE: Poor Water Quality

Stormwater runoff from urban areas contains pollutants (pathogens, sediment, and heavy metals) that enter streams, rivers, Lake Michigan, and the beaches. Other plans outline the following water quality concerns in the KK River Watershed:

- Lack of riparian habitat
- Increasing frequency of flood events
- Lack of widespread policy supporting water quality improvement efforts
- Growing disconnect between community members and water resources
- Substantial polluted runoff that results in increased loadings of total suspended solids (TSS) and total phosphorus (TP)
- According to Technical Planning Report-39 (TR-39) and the Milwaukee River Basin draft total maximum daily load (TMDL), the annual average load of TP to streams of the KK River Watershed is estimated to be about 12,750 pounds per year, and approximately 77.9% of the TP loadings to streams are contributed by urban runoff sources



Source: MMSD Regional Green Infrastructure Plan, 2013

ISSUE: Large Impervious Cover

Impervious surfaces are hard surfaces that do not allow rainwater to filter into the ground. During heavy rains that produce large volumes of stormwater, combined and sanitary sewers fill up potentially causing sewer overflows and basement backups. Impervious surfaces include streets, buildings, driveways, airport runways, parking lots, sidewalks, schoolyards, and the channelized sections of the river and its streams. Watershed characteristics include:

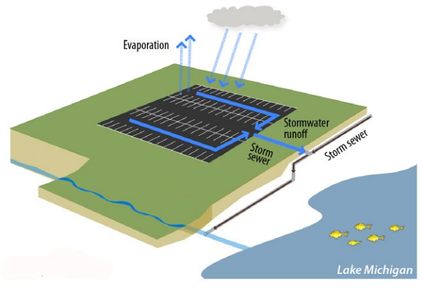
- Minimal available land for infiltration
- 10.8 square miles of impervious surface, such as roofs and pavement, or approximately 44% of the 24.7 square mile watershed
- Highly urban area with large impervious surfaces force high volumes of untreated and polluted stormwater runoff into the waterways and create flash flooding conditions

OPPORTUNITY: Planned Investments

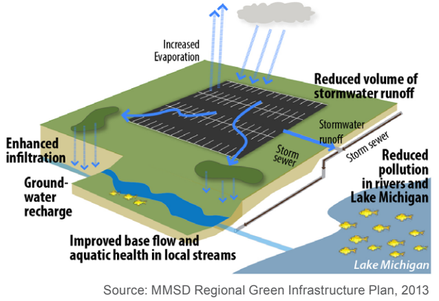
Large investments in watercourse improvements, community revitalization and municipal public works projects will continue to be made in the watershed and are anticipated to increase. Though government budgets are stressed, stakeholders can work together to leverage planned investments to identify the best project location based on the desired outcome (e.g. water quality improvements, reduced impact to structures, potential for implementation), as well as incorporate secondary and tertiary project objectives (e.g. reduction of urban heat island effect).

The KK River is lined and crisscrossed with unique networks of infrastructure — roads, alleyways, driveways, sidewalks, structures, bridges, sewers, and storm-drain pipes — all of which can present challenges and opportunities when considering water quality and quantity concerns.

Before Green Infrastructure



After Green Infrastructure



Source: MMSD Regional Green Infrastructure Plan, 2013

TYPES OF GREEN INFRASTRUCTURE

There are many different types of green infrastructure and strategies for implementation. These strategies vary in terms of cost, target locations, effectiveness, as well as maintenance considerations. It is critical to implement strategies based on the ability to maintain and monitor the feature. Some types of green infrastructure can be implemented and maintained fairly easily, while some require professional assistance. Due diligence is needed to ensure that the particular type of green infrastructure will achieve the desired goal of stormwater management.

BIOSWALES

Landscape features that capture and infiltrate runoff and can remove pollutants.

BLUE ROOFS

Roofs that are designed for temporary water storage with either passive or active control devices.

GREEN ROOFS

Partially or completely planted roofs with vegetation growing in soil or other growing media to hold rainwater.

GREENWAYS

Riparian and non-riparian buffer zones and strips that store and drain stormwater runoff into the ground naturally.

NATIVE LANDSCAPING

Native plants that can tolerate drought and flooding cycles because of deep roots and climate-specific adaptations.

POROUS PAVEMENT

Pavement that can reduce and infiltrate surface runoff through its permeable surface into a stone or filter media below.

RAIN GARDENS

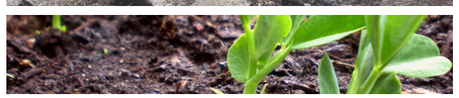
Gardens that are watered by pooled stormwater runoff, slowly infiltrating it into the ground along root pathways.

RAINWATER CATCHMENT

The capture and storage of water, potentially for reuse later.

REMOVAL OF PAVEMENT & STRUCTURES

Removal of structures or paving in order to allow infiltration.



SOIL AMENDMENTS

Organic materials spread on existing lawn to enhance its ability to infiltrate or absorb water.

STORMWATER TREES

Trees that hold rainwater on their leaves/branches, infiltrate it into the ground, absorb it through root systems and release it into the atmosphere (also known as evapotranspiration).

WETLANDS

Areas that have soils that are inundated or saturated for part of the year or the entire year.

FIGURE 4. LAND USE MATRIX FOR POTENTIAL IMPLEMENTATION

LAND USE	LOCATION	BIOSWALES	GREEN ROOFS / BLUE ROOFS	GREENWAYS	NATIVE LANDSCAPING	POROUS PAVEMENT	RAIN GARDENS	RAINWATER CATCHMENT	REMOVAL OF PAVEMENT & STRUCTURES	SOIL AMENDMENTS	STORMWATER TREES	WETLANDS (CONSTRUCTION OR RESTORATION)
Commercial	Parking / Driveway	●				●			●			
	Buildings		●					●				
	Walkways				●				●	●	●	
	Green Space				●					●	●	
Industrial	Parking / Driveway	●				●			●			
	Buildings		●					●				
	Green Space				●					●	●	
Residential	Roof (capture runoff)						●	●				
	Yard				●		●			●	●	
	Driveway					●						
	Alley					●						
Transportation & Utilities	Streets / Alley					●						
	Parking / Driveway					●			●			
	Medians	●			●	●			●	●	●	
	Buildings		●			●		●				
	Green Space				●		●			●	●	●
Government & Institutional	Parking / Driveway	●				●			●	●		
	Buildings		●					●				
	Green Space	●			●			●		●	●	●
Parks & Recreational Space	Parking / Driveway	●		●		●			●			
	Buildings		●					●				
	Green Space	●		●	●		●			●	●	●

As this infrastructure is maintained, improved, and replaced, it is critical that opportunities to integrate green infrastructure and other measures of resilience be considered. The future health and vitality of the KK River Watershed hinges on holistic and comprehensive planning, as well as collaboration across jurisdictional boundaries. Identifying and leveraging public and private partnerships should continue to be explored and implemented as cost effective strategies. This may include moving stormwater from a public right of way to a private site with a willing partner.

OPPORTUNITY: Land Use & Low Impact Redevelopment

Given the large amount of impervious surface in the watershed, any future planning for development and redevelopment must include an understanding of the types of green infrastructure that are appropriate for certain areas. The Land Use Matrix (Figure 4) is intended to provide an overview of the types of green infrastructure strategies that are appropriate for various land uses. For instance, if a commercial property owner is interested in green infrastructure for a parking lot, the choices are (1) removal of unused or underused pavement, (2) installation of a bioswale to collect runoff from the lot, (3) installation of porous pavement to replace traditional pavements, or (4) a combination of these, in addition to street trees.

OPPORTUNITY: Triple Bottom Line Of Sustainability

Traditional (grey) infrastructure is designed to move urban stormwater away from the built environment. Green infrastructure not only achieves the stormwater management objectives of grey infrastructure, but it can also help communities protect the environment, improve resident health, and provide additional social and economic benefits. Following a comprehensive approach to stormwater management enables multiple partners to play a role, empowers neighborhoods to get more out of capital investments, and grants municipalities the opportunity to leverage multiple goals with a single investment (Figure 5).

Green infrastructure provides opportunities for multiple economic, social, and environmental benefits, often referred to as the triple bottom line (TBL), for residential, commercial, and municipal partners within the watershed. MMSD's Regional Green Infrastructure Plan estimates more than $700 million of economic benefits in the planning area related to a reduced burden on existing sewer infrastructure, increases in property values, and additional construction and maintenance jobs related to green infrastructure implementation across the MMSD planning area. Social benefits related to green infrastructure include improved quality of life, increased property values, energy savings, and job growth. Environmental benefits include groundwater recharge, carbon sequestration, reduced carbon emissions, energy conservation, and improved air and water quality. Figure 6 evaluates how each green infrastructure strategy relates to the TBL.

The presence of vegetation is associated with many of the above mentioned benefits. The Green Infrastructure Scenario Tool (GIST), created by Climate Interactive for the KK River Watershed, generated various models to compare the impact of investments with respect to all grey infrastructure, some grey and some green, and all green infrastructure investments. The results indicated that an equal investment in green infrastructure not only achieved the desired grey infrastructure results (e.g. reduced combined sewer overflows and basement backups), but also led to increased property values, job creation, decreased air pollution, reduced operation and maintenance costs, and, for vegetated alternatives, a lessened urban heat island effect. The variety of configuration and location opportunities for green infrastructure allows for improvements to water quality and contributes to a reduction in peak flows related to urban flooding. (See pages 39-41 for more information about the GIST.)

Investments in green infrastructure also can improve existing public green space, create new public green space, and serve as opportunities for environmental education. It is important for the breadth of TBL benefits to be a part of the discussion with decision makers, design professionals, and residents. Incorporating local feedback on projects can help create stewardship for these spaces and reduce the long-term operations and maintenance costs.

FIGURE 5. TRIPLE BOTTOM LINE OF SUSTAINABILITY

FIGURE 6. TRIPLE BOTTOM LINE CO-BENEFITS FOR GREEN INFRASTRUCTURE STRATEGIES

High	
Medium	
Low	
None	

TRIPLE BOTTOM LINE OF SUSTAINABILITY	CO-BENEFITS	BIOSWALES	GREEN ROOFS / BLUE ROOFS	GREENWAYS	NATIVE LANDSCAPING	POROUS PAVEMENT	RAIN GARDENS	RAINWATER CATCHMENT	REMOVAL OF PAVEMENT & STRUCTURES	SOIL AMENDMENTS	STORMWATER TREES	WETLAND CONSTRUCTION OR RESTORATION
Economic	Initial Cost Of Investment	M	H	M	L	M	L	M	M	M	L	H
	Cost Of Operations & Maintenance	M	M	L	L	M	L	L	None	L	L	M
	Job Growth	H	H	L	L	M	L	L	L	L	L	M
	Property Value Increase	H	L	H	H	L	H	L	L	L	H	M
	Existing Grey Infrastructure Relief	M	L	L	L	L	L	L	L	L	L	H
Social	Potential To Reduce Crime Through Design	H	M	H	M	L	H	L	L	None	H	M
	Recreation / Education Opportunities	H	L	H	M	M	H	M	L	L	M	H
	Community Connectedness	M	L	H	L	L	L	L	L	L	M	H
Environmental	Water Quality Improvement	H	None	L	None	M	M	None	L	None	None	H
	Energy Savings	M	H	None	L	None	L	None	None	None	M	None
	Urban Heat Island Reduction	M	M	M	L	None	L	None	M	None	H	L
	Habitat Improvement	H	H	H	H	L	H	L	H	H	H	H
	Air Quality Improvement	H	L	L	M	None	M	None	L	None	H	M

KINNICKINNIC RIVER WATERSHED FLOOD MANAGEMENT PLAN

The KK River Watershed Flood Management Plan (KKRWFMP), completed in May 2017, identifies a series of interrelated strategies and projects that reduce the risk of flooding and respond to an increased floodplain. In some areas, the flood flow has increased by 20%-50% (based on flood flow calculations approved in 2014) for the 1% annual probability flood event (a 100-year flood). The increase in floodplain is attributed to an increase in frequency of rainfall events, intensity of those events, and continued land use changes in the watershed. This increase in flow puts a total of 688 properties within the updated floodplain at risk.

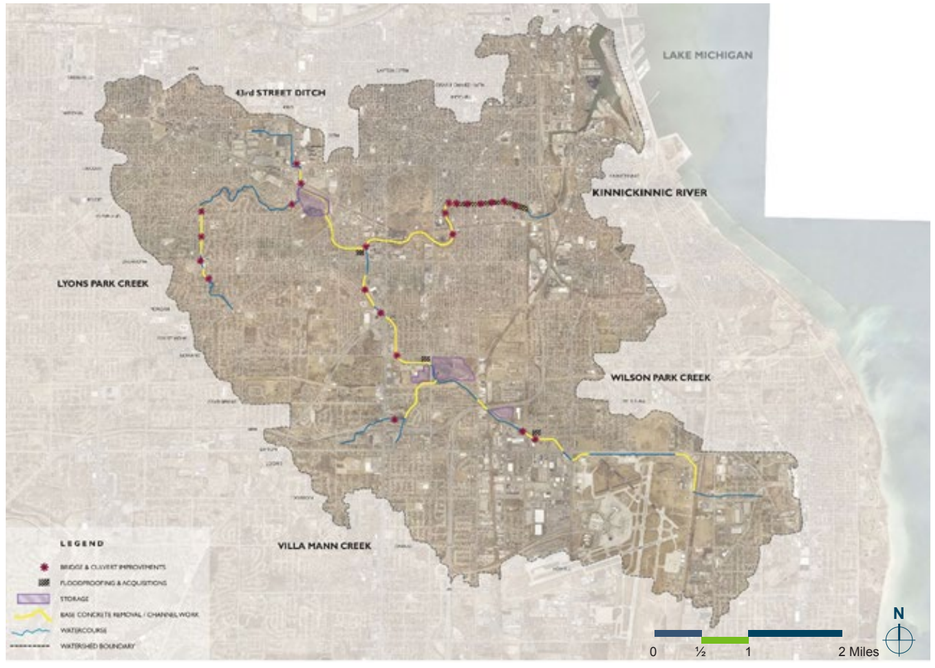
Through the phased implementation of recommended flood risk reduction projects, these properties will no longer remain in the floodplain. Projects must be phased strategically to avoid putting additional properties at risk for flooding. The recommendations include the removal of concrete channel lining, temporary storage for flood water, bridge and culvert improvements, channel improvements, floodproofing, property acquisitions, and green infrastructure. Figure 7 outlines the proposed locations of the following strategies:

- Remove 6.3 miles of concrete-lined river channel
- Replace or improve 20 bridges
- Purchase at least 83 properties
- Store ~560 acre-feet of flood water at locations including Central Steel & Wire, Jackson Park & Wilson Park

The improvements are anticipated to be implemented in a phased approach by the MMSD over the next 20 years at a cost of up to $250 million.

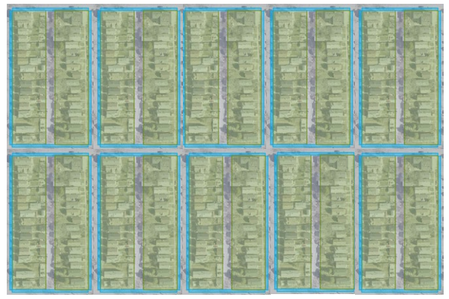
The KKRWFMP effort included a group of over 70 stakeholders that provided input into interrelated flood risk reduction strategies. The KKGIP is a result of a subcommittee from that larger effort formed to develop companion green infrastructure recommendations.

FIGURE 7. KINNICKINNIC RIVER WATERSHED WATERCOURSE RECOMMENDATIONS



Green Infrastructure As A Strategy

As part of early identification of flood risk strategies, a green infrastructure alternative was evaluated to assess the role and potential impact of green infrastructure as a standalone strategy to reduce flood risk for the 1% probability flood event. The alternative was structured on a model assuming 4' wide porous pavement parking lanes, with a stone storage layer 4.5' below, or two 600' long x 2' deep x 6' wide bioswales on both sides of each city block in the watershed. The modeled result, when fully implemented, was an 18% decrease in peak flows as a standalone alternative.



The above picture is a representation of the model applied to a ten-block area (though the model covered the entire watershed). The blue outlines around each block represent porous pavement or bioswales.

This amount of flow reduction does not provide a significant decrease in reducing flood risk. Green infrastructure at this scale is not economically feasible or recognized by the Federal Emergency Management Agency (FEMA) as a viable tool to reduce flood risk. However, green infrastructure has demonstrated it can play an integral role in added resiliency, localized stormwater management, and flood risk reduction support.

EFFORTS TO-DATE

Regional Green Infrastructure Plan

In 2013, MMSD developed the Regional Green Infrastructure Plan (RGIP) that established a regional vision for scaling up the implementation of green infrastructure to capture the equivalent of 0.5 inch of rain falling on impervious areas in MMSD's planning area, which covers six unique watersheds. The RGIP established goals for each watershed and a framework that was used to prioritize subbasins in each watershed. Eleven land use, water quality, and water quantity strategies were identified as significant factors to be taken into account when considering implementation of green infrastructure (Figure 10).

These factors were identified and prioritized by a steering committee. Prioritization options were 0.5 (low significance) and 1 (high significance), with the majority of factors resulting in a high significance rating. The RGIP made specific recommendations for green infrastructure strategies in each watershed with a suggested investment of $142 million in the KK River Watershed. Although the entire watershed is in substantial need of investment, the RGIP identified eight critical subbasins for investment based on the steering committee and data prioritization (Figure 11-green).

The KKGIP updates the priority subbasins for project implementation based on additional stakeholder input, revised and more specified weight factors, and a reprioritization of the weighted factors (Figure 11-purple).

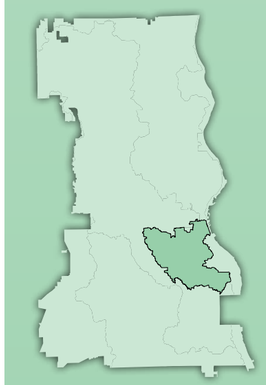
ADDITIONAL EFFORTS

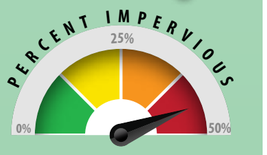
As the watershed and investments in it continue to evolve, its plans, processes, and data are updated. Other plans that were evaluated and, to the extent possible, incorporated into this effort include:

- Kinnickinnic River Corridor Neighborhood Plan (2009)
- Kinnickinnic River Watershed Restoration Plan (2010)
- S. 6th Street as the Green Corridor: Designation Plan (2011)
- MMSD's Regional Green Infrastructure Plan (2013)
- Catalyzing Healthy Neighborhoods with Green Streets: Pulaski Park Neighborhood (2013)
- Pulaski Park Neighborhood Stormwater Plan: A Unique Approach to Stormwater Planning, Implementation and Community Revitalization (2015)
- The Kinnickinnic River Watershed Updated Implementation Plan (2016)
- MMSD Kinnickinnic River Watershed Flood Management Plan (2017)

FIGURE 8. KINNICKINNIC RIVER WATERSHED OVERVIEW

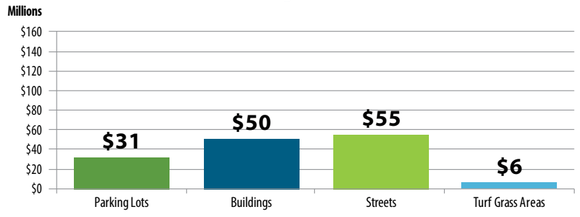
Kinnickinnic River Watershed



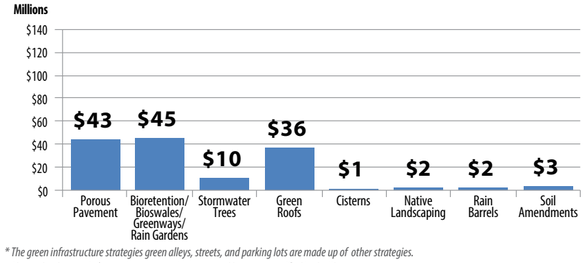


The Kinnickinnic River Watershed has the highest percent impervious area in the MMSD planning area and has high concentrations of total suspended solids and phosphorus. In areas of West Allis, the City of Milwaukee, and portions of Greenfield, there are high levels of inflow and infiltration. Coordination among private property inflow and infiltration reduction practices, sump pump installation, and building rain gardens could significantly reduce inflow and infiltration into sanitary sewers. Green infrastructure is consistent with recommendations of the Kinnickinnic River Watershed Restoration Plan. There are areas with limited installation potential due to high-density developments. Buildings in these areas may still be treated with green roofs, cisterns, and rain barrels. Implementation on streets and parking lots will be important where the dense development occurs due to the limited potential for implementation on some private properties.

Green Infrastructure Investment Target Area: $142 million



Capital Cost by Green Infrastructure Strategy*



** The green infrastructure strategies green alleys, streets, and parking lots are made up of other strategies. The wetlands green infrastructure strategy is encouraged but not quantified in the Plan.*

*** 5,000 SF average green roof*

**** Large Buildings >6,500 SF roof*

Quantities of Green Infrastructure Planned to meet 2035 Vision in the Kinnickinnic River Watershed

Porous Pavement: 1,210 average city blocks with porous pavement

Bioretention / Rain Gardens: 22,000, 10-foot by 15-foot gardens

Stormwater Trees: 10 new trees per average city block

Green Roofs: 1,000 buildings with green roofs**

Cisterns: 200 large buildings*** with cisterns

Native Landscaping: 200 average city blocks converted to native landscaping

Rain Barrels: 17,100 homes with one rain barrel

Soil Amendments: 200 average city blocks with soil amendments

Watershed Green Infrastructure Investment: $142 million

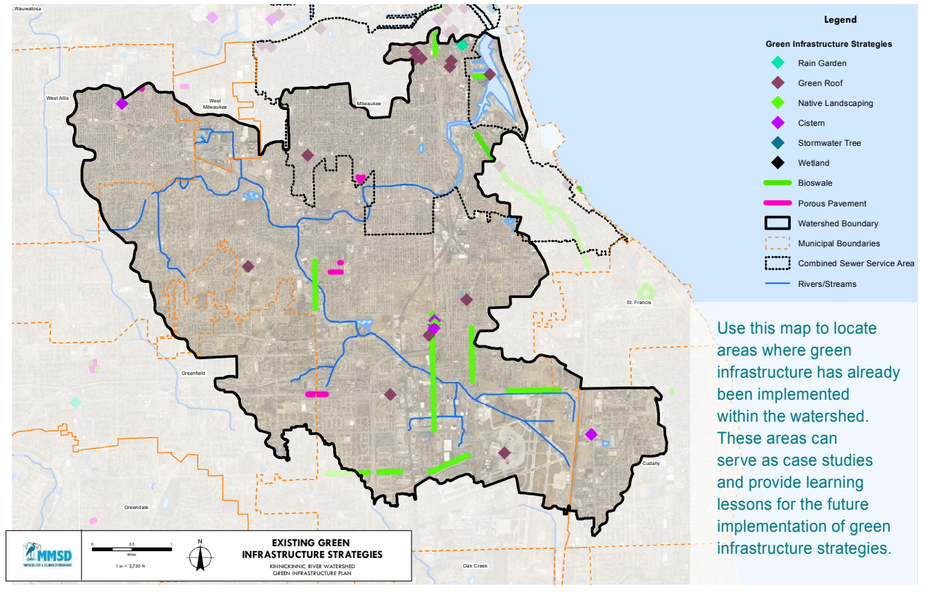
Source: MMSD Regional Green Infrastructure Plan, 2013

WATERSHED PROJECTS TO-DATE

Many thoughtful and comprehensive projects have been completed in the watershed on both public and private properties. These projects have addressed stormwater needs on parcel and neighborhood scales, and have demonstrated the need and opportunity for green infrastructure in the watershed. These green infrastructure investments have also delineated best practices when it comes to maintenance, opportunities for scaling up, environmental education, and stakeholder engagement. Figure 9 highlights green infrastructure strategies that have been installed in the watershed to-date.

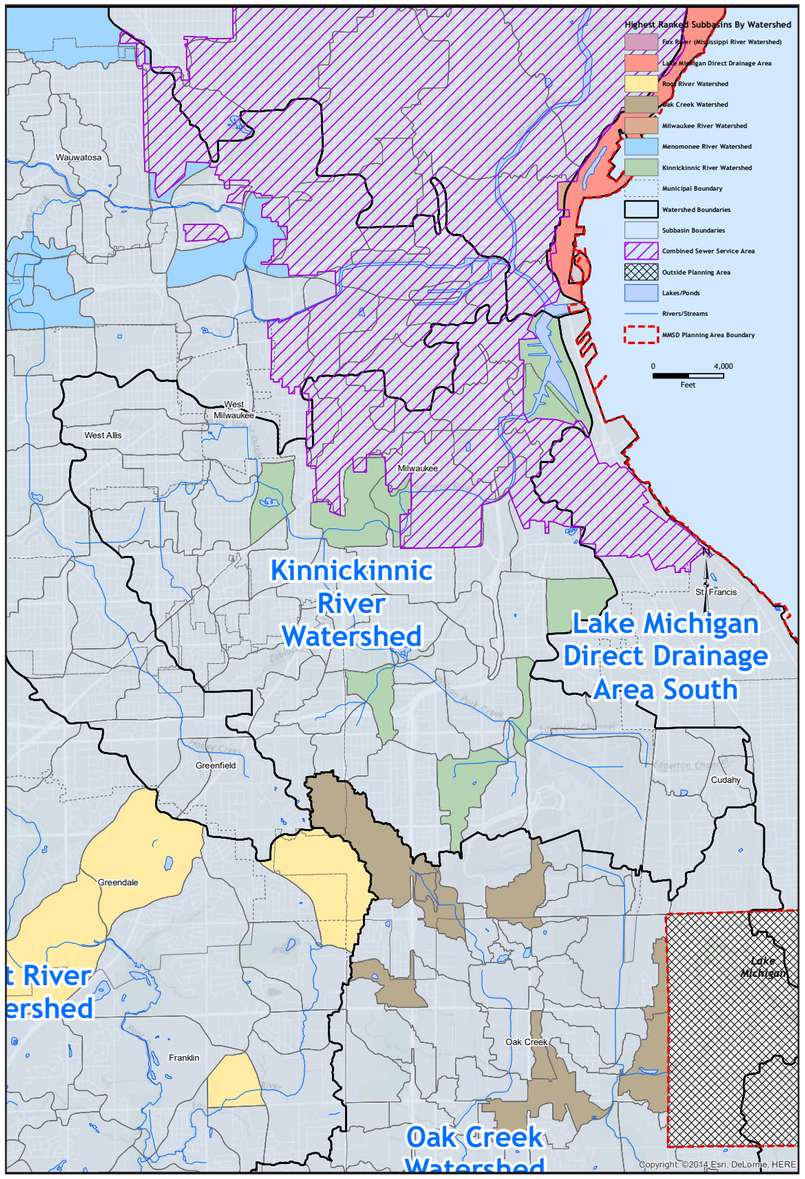
A resident in the S. 6th-16th Streets area around the KK River with his rain barrel from a neighborhood rain barrel program organized by the Sixteenth Street Community Health Centers, Kinnickinnic River Neighbors in Action, and MMSD

FIGURE 9. GREEN INFRASTRUCTURE PROJECTS IN THE WATERSHED TO-DATE



Use this map to locate areas where green infrastructure has already been implemented within the watershed. These areas can serve as case studies and provide learning lessons for the future implementation of green infrastructure strategies.

FIGURE 10. KINNICKINNIC RIVER WATERSHED PRIORITIZED SUBBASINS FROM RGIP (2013)



Source: MMSD Regional Green Infrastructure Plan, 2013

2 METHODOLOGY

The Kinnickinnic River Watershed Green Infrastructure Plan (KKGIP) is based on the foundation of the RGIP analysis framework and was customized specifically to address the integrated goals, opportunities, and needs of the KK River Watershed. These opportunities were driven by stakeholder feedback conducted as a parallel process during the development of the Kinnickinnic River Watershed Flood Management Plan. For the purposes of this Plan, the scale of analysis was performed at the subbasin level. Initially, analyses were performed at the parcel level to determine the priority subbasins; however, subbasins were then determined to be the appropriate level of analysis, as specific parcels can be identified within each (which was not the intent of the Plan).

The RGIP focused on 11 factors as part of its analysis. Additional factors (and associated data resources) were identified that are most critical to the KK River Watershed. This process of customization helped develop more specific recommendations for green infrastructure implementation in a way that supports other plan and project efforts in the watershed.

The KKGIP is the result of a larger process for comprehensive flood management planning for the watershed. A green infrastructure subcommittee was formed from the initial group of stakeholders and was regularly updated on the process and provided input on opportunities for how green infrastructure can be integrated into public and private projects throughout the watershed. The public and private stakeholders who were involved provided input during the methodology and analysis and have helped inform the basis of this Plan.

Stakeholders evaluated previous factors and came to consensus on additional factors (Figure 11) that should be considered in the spatial analysis for the KK River Watershed. As part of the evaluation process, participants were asked to rank the factors, creating customized weights that were then averaged. While all factors were determined to be important by the stakeholders, weighing the factors was a way to identify which factors should receive the highest priority. The feedback, including the averaged weights, were integrated into a geographic information system (GIS) model.

The factors and weights for the KK River Watershed, and the ranking of the 66 subbasins generated by the model, are detailed on the following pages. Among the 66 subbasins, the total combined weights (ranging from 1-5 for each) ranged from a total of 10.4 to 26.9. Larger numbers indicate there is more opportunity for project implementation. The rankings are critical for stakeholders to consider when making green infrastructure investments in the watershed as they can identify the most beneficial locations, opportunities for partnership, and potential for cost sharing.

FIGURE 11. SUBBASIN PRIORITIZATION ANALYSIS FACTORS & WEIGHTS

FACTORS	REASON FOR CONSIDERATION	ORIGINAL RGIP WEIGHTS	REVISED KKGIP WEIGHTS
Vacant Land	Opportunities for easy implementation, focusing on vacant land solely dedicated to green infrastructure implementation	1	4.50
Opportunities Areas	Opportunities for easy implementation within redevelopment areas	1	4.54
Areas With Existing Green Infrastructure Strategies	Builds on momentum and success of other green infrastructure projects	1	2.67
Parks	Creates new park amenities where there are large open spaces - includes 500' buffer	1	3.29
Selective Sewer Separation Opportunities	Removing stormwater from the combined sewer to storm sewers provides opportunities to route stormwater through green infrastructure	0.5	1.79
Potential Stream Corridor Rehabilitation Locations	Opportunities for planned implementation and complements projects by reducing pollutants - includes 500' buffer	1	4.33
High Inflow Areas To The Deep Tunnel	Green infrastructure could reduce inflow to the Deep Tunnel by managing a portion of wet-weather flow	1	2.75
Report Wet Basement Areas	Green infrastructure could reduce basement backup risk by managing a portion of wet-weather flow	1	3.42
Potential Drainage Problem Areas	Historical stream locations can be correlated with increased surface flooding potential — green infrastructure could help by managing a portion of wet-weather flow	0.5	3.04
Potential High Sewer Inflow & Infiltration Areas	High levels of stormwater in sanitary sewer pipes indicate higher sewer inflow and infiltration rates — green infrastructure could help these areas by disconnecting downspouts and directing to green infrastructure	1	1.75
High Pollutant Loading Areas	Improves poor water quality by reducing pollutant concentrations (pathogens, nutrients, heavy metals), erosion, sedimentation, pollution, etc.	1	4.75
1% Flood Risk Support	Strategic placement of green infrastructure to assist with flood risk reduction by adding resiliency	Factors not evaluated &/or weighted in RGIP analyses	4.00
Environmentally Impaired	Improves habitat and air quality needs for groundwater recharge, road salt reduction, noise pollution reduction, atmospheric CO2, energy use, urban heat island effect, and health concerns (asthmas)		3.86
Capital Improvements	Opportunities to incorporate green infrastructure into future capital improvement projects and plans		4.00
Strong Established Partnerships	Builds on the momentum of neighborhood leadership, partnerships and organizations (non-profits, neighborhood associations, block clubs, etc.) to concentrate green infrastructure investment and co-benefits; leveraging volunteers		3.36
Improvement Districts (BIDs, NIDs, & TINs)	Business Improvement Districts (BIDs), Neighborhood Improvement Districts (NIDs), & Targeted Investment Neighborhoods (TINs): Builds on momentum of organized property owners, grows understanding and demand for green infrastructure, leverages opportunities for coordinated maintenance		3.22
Schools	Cultivates public education opportunities (about the environment and understanding/acceptance/demand/ support for green infrastructure) - with 500' buffer		4.25
Physical Site Constraints	High water table, high slopes, site geology, topography, brownfields		4.00

MAP_ID	TAXKEY	PARCEL_TYP	PARCEL_DES	RECORD_DAT	OVERLAP	MCD	SOURCE	COMMENT	SHAPE_Leng	SHAPE_Area	Acres	SlopeUndr5	D2GWOver6	BDRKOve
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1163401	5540170000	0		<Null>	0	53000			794.650432	30398.477619	0.697856	0	0.9	
1163397	5540166000	0		<Null>	0	53000			397.744456	8026.415195	0.184262	0	0.9	
1163398	5540167000	0		<Null>	0	53000			393.77705	8017.063299	0.184047	0	0.9	
1163402	5540171000	0		<Null>	0	53000			340.145915	7180.279536	0.164837	0	0.9	
1163403	5540172000	0		<Null>	0	53000			305.536141	5568.661078	0.127839	0	0.9	
1163404	5540173000	0		<Null>	0	53000			312.281463	5664.611091	0.130042	0	0.9	
1163405	5540174000	0		<Null>	0	53000			360.839903	7334.536321	0.168378	0	0.9	
1047889	4611341000	0		<Null>	0	53000			339.619662	4191.919854	0.096234	0	0.9	
1163408	5540177000	0		<Null>	0	53000			517.174046	11940.399737	0.274115	0	0.9	
1050430	<Null>	1		<Null>	0	53000			1238.316835	49949.862878	1.146696	0	0	
1047890	4611357000	0		<Null>	0	53000			340.154944	4199.814519	0.096415	0	0.9	
1068326	5730865000	0		<Null>	0	53000			344.575797	6261.773895	0.143751	0.9	0.9	
1047893	4611338000	0		<Null>	0	53000			368.939752	6250.786918	0.143499	0	0.9	
1046673	4611430000	0		<Null>	0	53000			341.216011	6070.806704	0.139367	0.9	0.9	
1066343	5730364000	0		<Null>	0	53000			371.487889	6763.640251	0.155272	0	0.9	

A table of attribute data incorporating all of the factors and the revised weights for each factor, recalculated on the subbasin level from the parcel level

STEPS OF ANALYSIS

1. Gather original data sources
2. Update data
3. Identify additional factors that are most critical to the KK River Watershed stakeholders
4. Review factors and gather feedback from stakeholders
5. Perform supplementary analyses to be incorporated into GIS model for prioritization
6. Create in-depth scale and weights customized for the watershed ranging from 1-5, in place of the RGIP scale of 0.5 or 1
7. Gather feedback from stakeholders on appropriate weights for each identified factor
8. Compile data layers into new layers after additional analyses are performed
9. Stakeholders review and determine the most important uses for data
10. Compile data spatially for use by stakeholders to strategically implement green infrastructure in the watershed

The different factors can be used for green infrastructure evaluation independently, depending on the user, or as an aggregate map. Stakeholders identified four key uses for data and maps as a result of this effort:

1. Priority Subbasins For Strategic Implementation
2. Reduce Impacts To Structures
3. Water Quality
4. Potential For Implementation

The prioritized subbasins are not meant to discourage green infrastructure in areas that are not ranked as “high priority” in the watershed; however, they are meant to be a tool to evaluate projects based on the goals of the stakeholders and identify locations that are most beneficial.

A new community bioswale in wet and dry conditions near Pulaski Park

A resident living between S. 6th-16th Street near the KK River with her new rain barrel as part of a program organized by the Sixteenth Street Community Health Centers, the KK River Neighbors in Action, and MMSD

Youth learn about and experiment with a new green alley near Pulaski Park

Permeable pavers installed on Greenfield Avenue near the School of Freshwater Sciences (City of Milwaukee)

Examples of new bioswales installed by the City of Milwaukee in the median of S. 27th Street and other major divided thoroughfares throughout the city (City of Milwaukee)

3 PRIORITIZATION ANALYSIS RESULTS

The analysis resulted in multiple types of data and map outputs. Through discussions with stakeholders, the project team was able to delineate how various maps could be combined in a 'snapshot' approach that would be most useful for stakeholders in their work. Maps were clustered into the following groups:

- Priority Subbasins For Strategic Implementation
- Reduce Impacts To Structures
- Water Quality
- Potential For Implementation

1 PRIORITY SUBBASINS FOR STRATEGIC IMPLEMENTATION

Watersheds have natural geologic delineations of smaller drainage areas referred to as subbasins. Although all of the subbasins drain to the larger watershed, they vary in terms of pollutants carried into the larger waterway, how fast or slow water enters into the waterway, and how they impact the overall flows in the watershed. Priority subbasins, or subbasins that provide the greatest benefit, determine where installing green infrastructure will have the most impact.

The subbasins in the watershed were evaluated for level of impact, based on the 18 factors and weights identified and refined during the planning process. While only eight subbasins were identified as highest priority (indicated with a ✿ in Figure 12) in the RGIP, all 66 subbasins were ranked by level of impact as part of the analyses for this effort. As an additional point of differentiation, this Plan places the 66 subbasins into five categories of prioritization.

Spatial data is information that identifies the geographic location of features and boundaries, typically stored as coordinates that can be mapped. Spatial data for all 18 factors were mapped and calculated with the associated weights for each subbasin to identify those with the most opportunities and benefits. Maps showing all of the factors that were considered are included in the appendix. The final 'Priority Subbasins For Strategic Implementation' map shows that there is high potential for the implementation of green infrastructure throughout the watershed. The rankings for all 66 subbasins range from 'Medium-Low Area of Impact' to 'Highest Area of Impact,' indicating the impact of opportunity and effectiveness of green infrastructure implementation.

A new bioswale installed in 2017 near Pulaski Park

While some subbasins rank as lower priority, this does not indicate that integration of green infrastructure is not worthwhile. Furthermore, there are many critical co-benefits (Figure 6) of green infrastructure that are not factored into these analyses and that should be considered for all green infrastructure projects. High-impact subbasins identified in this analysis highlight areas of commercial and transportation uses, or major public infrastructure projects. The timing of storms and flows in the watershed is also a critical factor, revealing strategic opportunities for stormwater storage to reduce impacts to areas with greater stormwater issues.

This map can be used to identify priority subbasins for strategic green infrastructure investment – for private and public infrastructure as well as development projects. The analysis points towards investment opportunities in areas of the watershed that should be prioritized based on level of impact, when possible.

FIGURE 12. PRIORITY SUBBASINS FOR STRATEGIC IMPLEMENTATION

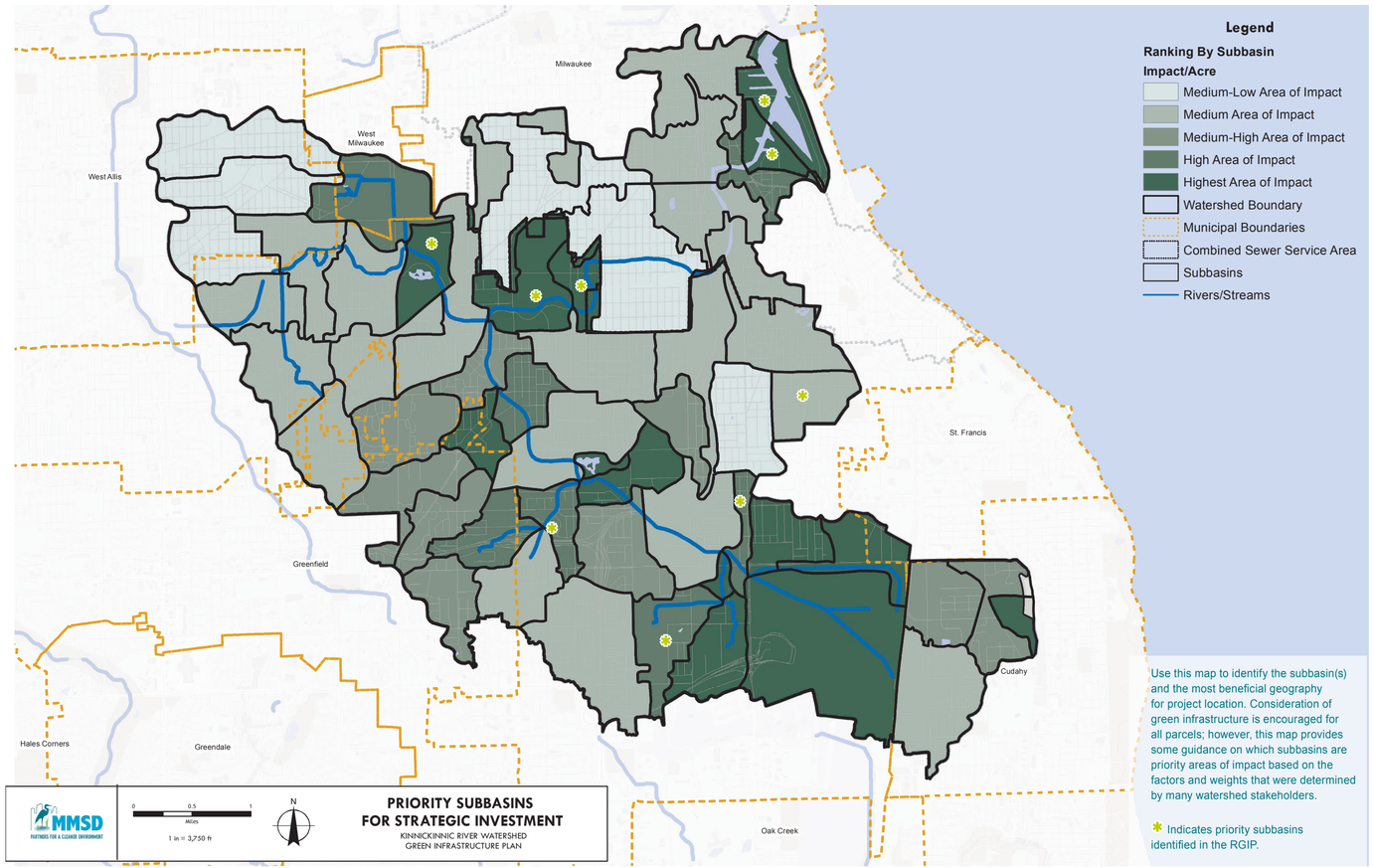
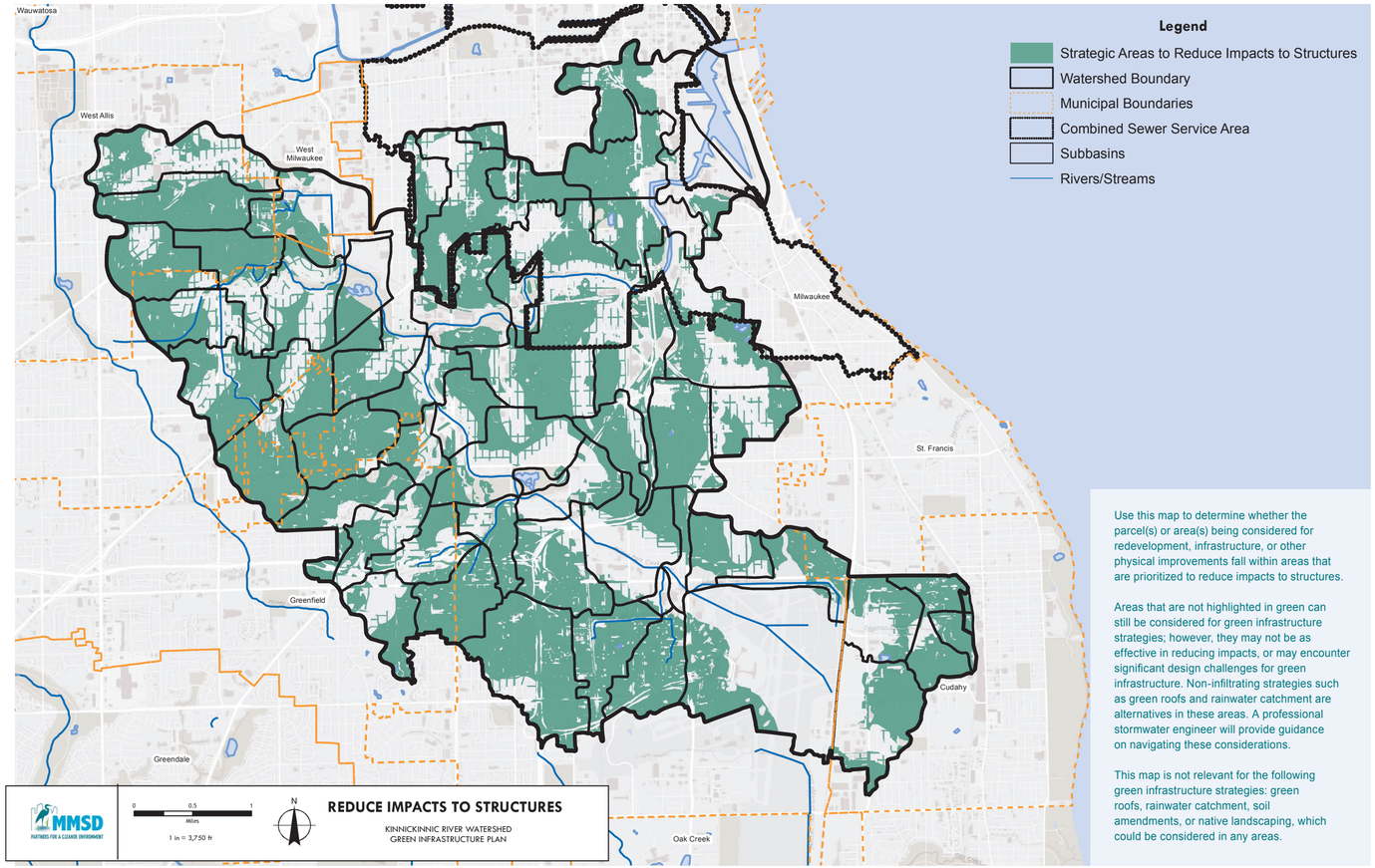


FIGURE 13. REDUCE IMPACTS TO STRUCTURES



Use this map to determine whether the parcel(s) or area(s) being considered for redevelopment, infrastructure, or other physical improvements fall within areas that are prioritized to reduce impacts to structures.

Areas that are not highlighted in green can still be considered for green infrastructure strategies; however, they may not be as effective in reducing impacts, or may encounter significant design challenges for green infrastructure. Non-infiltrating strategies such as green roofs and rainwater catchment are alternatives in these areas. A professional stormwater engineer will provide guidance on navigating these considerations.

This map is not relevant for the following green infrastructure strategies: green roofs, rainwater catchment, soil amendments, or native landscaping, which could be considered in any areas.

2 REDUCE IMPACTS TO STRUCTURES

While green infrastructure can be beneficial throughout the watershed, there are specific areas within each subbasin that are more beneficial than others when it comes to reducing flood risk to structures, largely based on physical characteristics and location within the subbasins. The updated draft floodplain of the watershed indicates 688 structures within the floodplain. Green infrastructure can help shave of peak flows and provide added resilience to the larger watershed flood management. This map focuses on priority areas for implementation of most infiltration-based green infrastructure strategies with the philosophy that infiltrating more water upstream or away from structures helps to reduce surface flows, especially where groundwater levels are already high. These areas are highlighted in green.

Infiltration-based green infrastructure includes porous pavements, biofiltration, soil amendments, bioswales, and rain gardens. Private developers and property owners should use this map when redeveloping or making property improvements to consider installing additional green infrastructure beyond what is required by ordinance or stormwater rules for their specific parcels. Areas not highlighted are considered impractical for infiltration-based green infrastructure due to existing conditions such as high groundwater, clay soils that allow for less infiltration, locations where streams existed prior to development, areas with steep slopes, and areas with shallow bedrock.

Areas not highlighted in green can still be considered for green infrastructure, though they may not have the same level of impact in reducing stormwater effects on structures, and may also have additional design constraints (i.e. steep slopes, soils not conducive for infiltration, etc). Smaller scale green infrastructure strategies (such as stormwater trees, native landscaping, cisterns, rain barrels and soil amendments) may be better options in the non-highlighted areas.

A rain garden on a residential property near Pulaski Park helps protect surrounding structures from basement backups and other flood risks

A typical basement backup that could be reduced if green infrastructure strategies are installed in strategic areas within subbasins

Basement conditions after a severe flood causing significant damage – although green infrastructure cannot prevent this type of damage on its own, paired with other strategies, it can help shave off peak flows and reduce the impact of smaller rain events

3 WATER QUALITY

Water quality is a significant factor to be considered in the watershed, given the high level of imperviousness. This map was created to identify the areas with higher levels of total suspended solids (TSS), contaminants, and pollutants, which all reduce water quality. Subbasins were assessed for levels of TSS with controls (e.g., street sweeping and cleaning of catch basins) as performed by the municipalities within the watershed. Areas highlighted in brown are considered environmentally impaired parcels (i.e., parcels without trees) that pose unique constraints that require additional considerations when implementing green infrastructure.

USING GREEN INFRASTRUCTURE TO MEET TMDLS FOR STORMWATER DISCHARGE PERMITS

Municipalities in southeastern Wisconsin have permitted stormwater discharges through Wisconsin Pollutant Discharge Elimination System (WPDES) stormwater permits. Each community has permit requirements as set by Wisconsin Department of Natural Resources (DNR). New Total Maximum Daily Load (TMDL) requirements are underway that may require each community to reduce phosphorus and bacteria from their stormwater discharges, in addition to managing the total suspended solids (TSS). Green infrastructure may be able to better combat phosphorus and bacteria than traditional stormwater strategies that were focused only on TSS. This is especially relevant in this watershed because of the built-out land use conditions.

Water quality improvements can be estimated using software such as WinSLAMM (Source Loading and Management Model). For this Plan, a simplified WinSLAMM analysis was performed for each KK River Watershed municipality given the proposed green infrastructure practices (bioswales, porous pavement and rain gardens) presented in Figure 14. According to the total acreage and amount of impervious surface in each municipality, a 15%-20% estimated reduction in all TMDL constituents of concern can be expected from the full implementation of the green infrastructure practices recommended in Figure 14.

WATER QUALITY

TOTAL PHOSPHORUS (TP)

A source of phosphorus comes from “nonpoint” or “runoff” pollution. Such pollution occurs when heavy rains and melting snow wash over farm fields and feedlots and carry fertilizer, manure and soil into lakes and streams, or carry phosphorus-containing contaminants from urban streets and parking lots. Phosphorus is a nutrient and acts like a fertilizer. Its presence or absence controls the extent of plant and algae growth in the water. If too much phosphorus is present, it causes excess growth of nuisance plants and algae.

TOTAL SUSPENDED SOLIDS (TSS)

A water quality measurement that includes all particles suspended in water. Sources include autumn leaf fall litter, pet waste, road salt, industrial discharges, fertilizers, road runoff, construction runoff, and soil erosion.

TOTAL MAXIMUM DAILY LOADS (TMDLs)

A water quality limit that sets goals or targets for watershed restoration plans. Basically it is a pollution “budget” for a water body or water segment that establishes the pollutant reduction needed from each pollutant source to meet water quality standards.

Source: http://water.epa.gov and http://dnr.wi.gov

An example of a 10-year rain event from fall of 2016, revealing the significance of turbidity in the watershed

FIGURE 14. WATER QUALITY

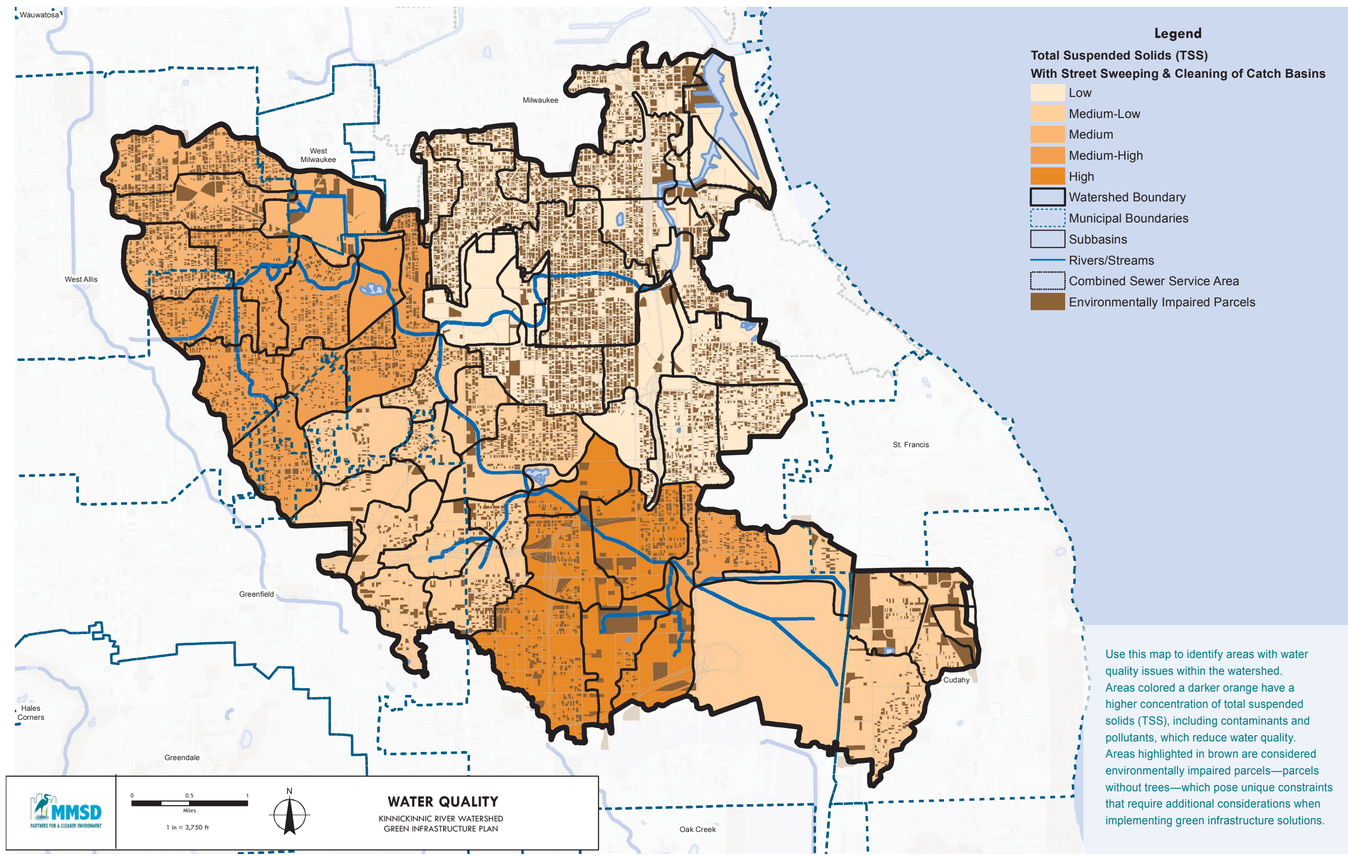
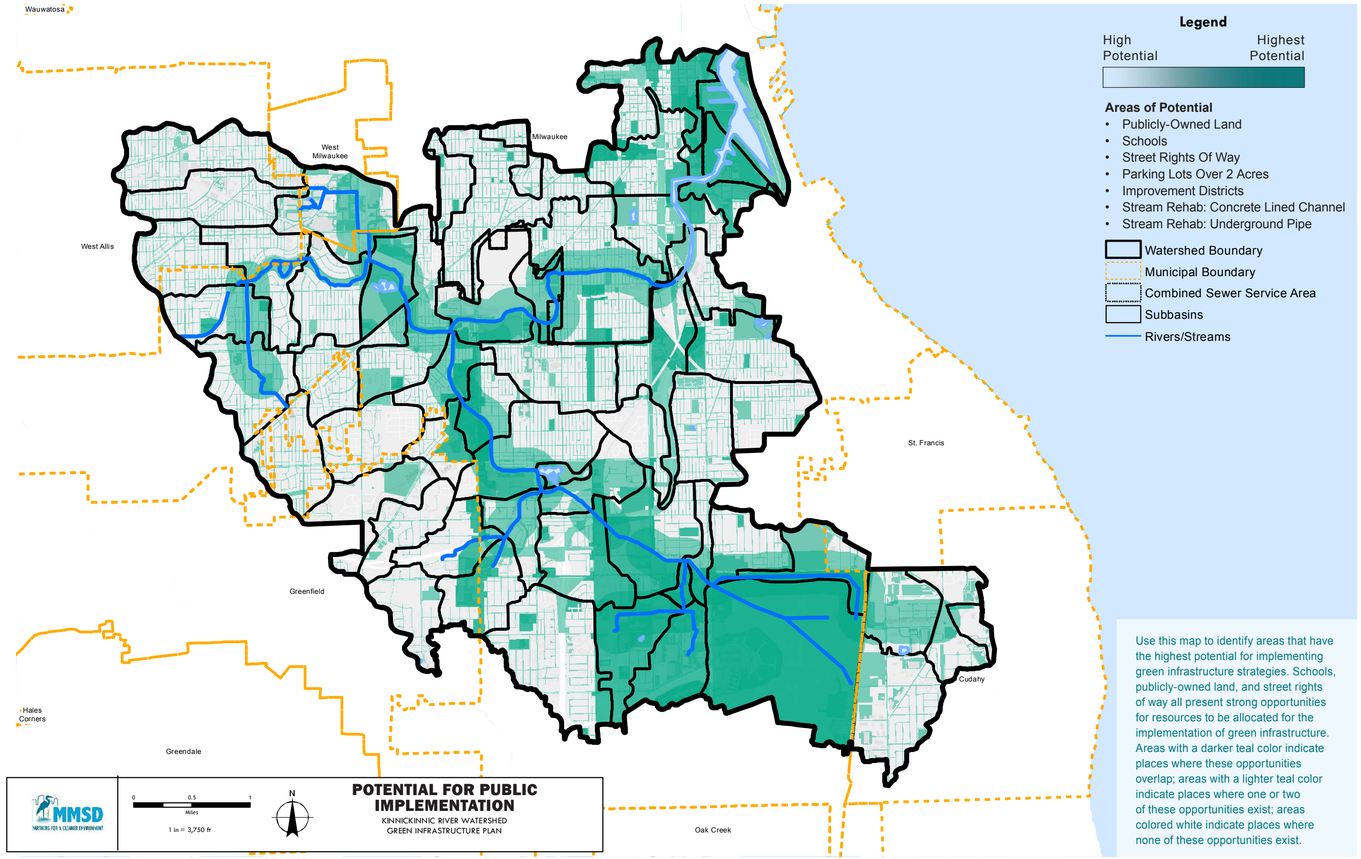


FIGURE 15. POTENTIAL FOR IMPLEMENTATION



4 POTENTIAL FOR IMPLEMENTATION

There are various opportunities to collaboratively implement green infrastructure in the watershed that support the TBL of sustainability and leverage planned investments. Positive steps are already being taken by municipalities and private property owners, and investments continue to be made with respect to these goals. Considerations made while creating this map include project types with increased opportunity for implementation, public capital improvements, large impervious areas, and highly organized areas with increased interest and capacity for planned implementation. The following sections describe these factors in greater detail:

Publicly-Owned Land

Lands that are publicly-owned are significant opportunity areas given municipal, county, and state investments. Many local, publicly-led improvement projects incorporate green infrastructure whenever feasible, tapping into MMSD's Green Solutions funding that is made available to municipalities in addition to other funding resources. Examples of public land include local parks, libraries, and the General Mitchell International Airport. There are 674 publicly-owned parcels in the watershed.

Schools

Public and private schools are key areas for implementation because of the growing focus on redesigning schoolyards to better meet school objectives, including the integration of health and the environment into education and reduction of the maintenance costs of spaces. Many local efforts are underway to increase sustainability while improving schoolyards and buildings through efforts to reduce pavement, create healthier outdoor environments, increase opportunities for exploratory environmental education, create shade, infiltrate stormwater, and reduce the urban heat island effect. These efforts are significant, as many schoolyards are expansive impervious surfaces. There are 48 schools in the watershed, varying in size from 0.2 – 46 acres in size, with significant amounts of unnecessary impervious surface.

MMSD's Green Infrastructure Guidebook for Schools (www.freshcoastguardians.com/resources/our-plans) and Reflo's Green Schools Consortium of Milwaukee (www.gscm.refloh2o.com) are examples of resources that can guide schools as they strive to increase sustainability and resilience while making schoolyard and building improvements. Furthermore, the implementation of green infrastructure at schools has the added benefit of expanding knowledge and accessibility to green infrastructure for a large audience—students, parents, educators, and local community members.

Parking Lots Over Two Acres

There are currently 157 parking lots that are over two acres in the watershed. These are highlighted as significant areas of opportunity for porous pavements, bioswales, and other green infrastructure strategies as these parking lots are reconfigured or repaved. Furthermore, strong consideration should be given for incorporating green infrastructure into new parking lot areas, regardless of size. A decrease in additional parking areas in the watershed should be strongly considered by reducing parking requirements when appropriate, encouraging shared parking arrangements between neighboring uses, and converting excess parking areas to other uses. Municipal codes and ordinances may need to be adjusted to better identify the necessary available space for parking in relation to the building's square footage, use characteristics, and adjacent parking opportunities.

Youth reading signage about the terraced bioswale and its significance in Pulaski Park on the west side of the pavilion

Flood management project at S. 6th Street during construction (now complete)

Flood management project at S. 6th Street in fall 2017

Public Rights Of Way & Public Buildings

There are approximately 2,820 acres of public roads and alleys in the watershed. Many municipalities consider opportunities to integrate green infrastructure into street improvements where feasible, though winter roadway salt, underground utilities, and mature tree roots sometimes limit opportunities for implementing green infrastructure. Parking lanes, street medians and street terraces present opportunities for the integration of bioswales, soil amendments and stormwater trees. Alleys, typically treated with smaller amounts of de-icing chemicals than streets, are great opportunities for porous pavement. In addition to public rights of way, public buildings (such as libraries, administration, or maintenance buildings) provide opportunities for installing porous pavement in the remote sections of parking lots that are used less frequently in the winter (thus, with less tendency to be salted). Public buildings also have large roof areas for downspout disconnection and capture or addition of green roofs.

Flood Management Projects

The removal of concrete channel lining (and re-naturalization) of over six miles of the KK River and its tributaries is currently being implemented in phases by MMSD to manage flooding. As these watershed-wide infrastructure improvements take place, they will also improve in-stream habitat and stream bank stabilization, reduce erosion and increase fish passage—green infrastructure is complementary to these efforts. Although green infrastructure implementation is not recommended within the floodplain, strategic implementation has the potential to shave off some peak flows, reduce pollution entering the waterway in critical areas, and connect the surrounding communities to the project in a more localized and place-based way.

Business Improvement Districts & Neighborhood Improvement Districts

Business Improvement Districts (BIDs) and Neighborhood Improvement Districts (NIDs) are commercial, industrial, or residential districts that are funded and operated by businesses, property owners, and other community members. The districts are viable as long as the BID board and property owners continue to fund the organizations through additional taxation. These districts focus on building organizational capacity and implementation of physical improvements throughout the district to strengthen the economic vitality and quality of life. BIDs can also sponsor work such as urban design features using green infrastructure like public plazas, markets and improvements to the streetscapes.

These districts offer opportunities for leveraging investments that provide benefits by unlocking resources for implementing green infrastructure. One example of these benefits is the installation of traffic-calming curb bump-outs intended to reduce the speed of traffic and create designated areas for pedestrians to cross the street. Rather than build a traditional bump-out, green infrastructure could be added to filter street runoff, add aesthetic value, and increase educational opportunities and public awareness, while satisfying the primary goals of traffic calming and pedestrian accessibility. As BIDs and NIDs are collaborative bodies with boards that represent property owners and work closely with governmental bodies at varying scales, they are in an advantageous position to advocate for the integration of green infrastructure during the planning of infrastructure projects.

Listed below are the existing BIDs and NIDs within the watershed:

- Harbor District (BID)
- Historic Mitchell Street (BID)
- Gateway to Milwaukee (BID)
- South 27th Street (BID)
- Kinnickinnic Avenue (BID)
- Walker's Point (NID)

Tax Incremental Financing Districts

Tax Incremental Financing (TIF) is a tool used by municipalities to leverage private investment by providing incentives for developers to create projects that would not otherwise occur in the area. There are presently seven Tax Incremental Districts (TIDs) that use TIF in the KK River Watershed. Redevelopment projects in these TIDs should be carefully considered for their potential to integrate green infrastructure during the planning phase between the municipalities and private developers. Listed below are the existing TIDs within the watershed:

- Florida Yards (1993)
- Solar Paints – Raios (2002)
- Chase Commerce Center (2005)
- Mitchell Street (2008)
- S. 27th Street and W. Howard Avenue (2010)
- S. 6th Street and W. National Avenue (2015)
- S. 1st Street and W. Greenfield Avenue (2015)

Non-Profits & Community Organizations

There are numerous non-profits and community organizations that actively work on physical improvements, green infrastructure, environmental education, habitat restoration, community engagement, and trail development throughout the watershed. These groups should continue to be viewed as critical partners in implementing green infrastructure and connecting larger investments to the community. There is substantial potential for leveraging future projects on a variety of scales, from the installation of rain barrels to larger-scale green infrastructure support (through grant funding, community engagement, or project support).

This list is not exhaustive, but is a sampling of groups that are active in the watershed. Many of these groups do not have defined geographies, and therefore were not mapped and included in the weights of the analysis. Collaboration between groups is critical, however, and partnerships with non-profits and neighborhood organizations, including block clubs, should be considered to increase the impact of and communication about projects in the watershed.

Residents of the watershed participating in a Milwaukee Riverkeeper river clean-up, organized around Pulaski Park by the Sixteenth Street Community Health Centers and the KK River Neighbors in Action

6th Street Green Corridor & The Garden District

The 6th Street Green Corridor includes a BID, and the initiative has attracted the active support of the Garden District Neighborhood Association, the Gateway to Milwaukee, Energy Exchange, and the City of Milwaukee's Environmental Collaboration Office. The Corridor serves as a living laboratory for the demonstration of green technology and innovation that improves water quality, reduces stormwater runoff, saves energy, cleans the air and stimulates business and job growth.

Harbor District, Inc.

This organization is working to achieve a world-class revitalization of Milwaukee's harbor that sets the standard for how waterfronts work – environmentally, economically, and socially. The organization brings together local, state, federal, and private sector efforts and interests, combined with community engagement, to strengthen existing businesses and neighborhoods. Harbor District, Inc. completed a water and land use plan that identifies specific stormwater solutions that can be integrated into planned investments or built as stand alone strategies.

Sixteenth Street Community Health Centers

The Environmental Health Department at the Sixteenth Street Community Health Centers focuses on initiatives designed to improve the south side community's environmental, physical, social, and economic well-being, with the goal of improved health outcomes. These efforts include revitalizing the KK River corridor and surrounding neighborhoods, restoring the KK River Watershed, preventing childhood lead poisoning, and sustainably revitalizing Milwaukee's Harbor District.

Layton Boulevard West Neighbors

Layton Boulevard West Neighbors (LBWN) builds strong and healthy neighborhoods in the City of Milwaukee by stabilizing and revitalizing the Silver City, Burnham Park and Layton Park communities. These south side neighborhoods are some of Milwaukee's most diverse and economically vibrant. LBWN staff work side-by-side with residents and stakeholders to leverage neighborhood investment resulting in renovated homes, new businesses, public space improvements, new and existing business investments, workforce development, and community projects and events.

Community organizations assist homeowners in the watershed with home improvements, including native landscaping and rain gardens for their front yards to increase curb appeal, reduce use of fertilizer, and reduce property impacts from rain events

KK River Neighbors In Action

The KK River Neighbors in Action (KK NIA) works in conjunction with the Sixteenth Street Community Health Center's Environmental Health Department's efforts to build a healthier and more sustainable community by helping people get to know one another, feel safe, and invest in their community. These projects include improving streetscapes, designing and installing public art within Pulaski Park, coordinating neighborhood and river clean-ups, hosting annual picnics and other special events, and advocating for safer streets and expanded recreational, economic, and housing opportunities.

Walker Square Neighborhood Association

The Walker Square Neighborhood Association supports residents, businesses, and other community members in the Walker Square neighborhood.

Walker's Point Association

The Walker's Point Association serves as a voice for all stakeholders and influences development to honor community history and to align with the envisioned spirit of Walker's Point. The priorities for green and sustainable development include craft industries, fresh water industry, mixed housing, and safety initiatives that support the economic and social diversity of the neighborhood.

4 NEXT STEPS

HOW TO USE THIS PLAN

WHO: As a whole, this Plan will be useful to any entity seeking to improve water quality or reduce water quantity in the drainage system within the KK River Watershed: water resource managers, county conservationists, municipalities, non-profit organizations, environmental consultants, and other public and private sector actors.

HOW: The priorities and practices presented structure a comprehensive implementation framework that addresses numerous opportunities to realize a healthier watershed through coordinated and strategic green infrastructure implementation. This Plan should be used as a guide for project implementers in the KK River Watershed to help support the decision-making process. In addition, this Plan should serve as a starting point to identify opportunities for overlapping watershed goals.

SCALING UP TO MEET THE RGIP GOALS

The RGIP made recommendations for the types and numbers of green infrastructure strategies to be placed in each watershed to meet the 2035 Vision of capturing the first 0.5 inch of runoff from all hard surfaces. As a result of the analysis performed as part of this plan, the focus has shifted from capturing the first 0.5 inch from all hard surfaces to capturing larger volumes of runoff within strategically placed green infrastructure, creating an equal or greater amount of storage where it can be most effective.

Figure 16 details both the originally recommended types and quantities of green infrastructure, those recommended in this plan, and the reference maps to be used in siting the green infrastructure. Maximizing the stormwater capture potential per green infrastructure location provides for a more attainable plan in terms of available space, number of projects, affordability and effectiveness.

Reducing the footprint of green infrastructure strategies, while providing equal or more capacity to the original RGIP recommendation, sometimes lowers implementation and maintenance costs and reduces the disturbances of and coordination necessary for installation. For example, monolithic, contiguous, and built-in-place green roofs can handle up to 1.5 inches of rainfall depth and allow for deeper rootzones, enabling systems that need less long-term maintenance. The RGIP called for 1,000 green roofs to be placed in the KK River Watershed, yet it may be a challenge to find 1,000 buildings with appropriate roofs. This Plan recommends 333 green roofs that are designed to manage 1.5 inches of rainfall.

FIGURE 16. KK RIVER WATERSHED GREEN INFRASTRUCTURE GOALS
(FIGURE 1. IN EXECUTIVE SUMMARY)

GREEN INFRASTRUCTURE FEATURE	ORIGINAL RGIP QUANTITY	RECOMMENDED CHANGES	UPDATED QUANTITY	REFERENCE MAPS	TYPICAL AREAS OF IMPLEMENTATION
Bioswales	RGIP combined bioswales with rain gardens	In public rights of way or on Commercial Developments. Design subgrade with 3′ stone storage for 10 gallons/ square feet capacity.	1,200,000 Square Feet (2,400 10′ x 50′ Bioswales)	1 Reduce Impacts to Structures 2 Prioritized Subbasins 3 Water Quality 4 Ease Of Implementation	Street Rights Of Way, Parking Lots, Improvement Districts, Residential Lots & Commercial Developments
Cisterns	200 Cisterns	Promote where urban agriculture or other outdoor uses need water.	200 Cisterns	All Areas	Publicly-Owned Lands / Buildings, Schools
Green Roofs / Blue Roofs	1,000 Buildings	Monolithic / contiguous / built-in-place green roof systems hold 1.5″ depth & are more durable.	333 Buildings	All areas where appropriate roofs exist or are planned.	Public Buildings, Schools, Commercial Developments, Improvement Districts
Native Landscaping	200 City Blocks	Use native turf grasses (i.e. buffalo grass or low-mow deep rooting fescue) in publicly-owned lands.	200 City Blocks	All Areas 4 Ease Of Implementation	Publicly-Owned Lands, Schools, Commercial Developments, Improvement Districts, Residential Lots
Porous Pavement	1,210 City Blocks	Incorporate additional storage (3′ storage depth suggested). Promote green alleys & use in parking lots where deicing salt usage is less.	403 City Block-Equivalent In Alleys & Parking Lots	1 Reduce Impacts to Structures 2 Prioritized Subbasins 3 Water Quality 4 Ease Of Implementation	Alley Rights Of Way, Parking Lots, Schools, Commercial Developments, Improvement Districts
Rain Barrels	17,100 Homes	Consider using StormGUARDen (eq. to 6.5 rain barrels) or other similar alternatives.	2,635 Homes	All Areas	Residential Lots, Publicly-Owned Buildings, Commercial Developments, Improvement Districts
Rain Gardens	3.3 Million Square Feet (22,000 10′ x 15′ Gardens)	Incorporate additional storage (gravel layer), amend soil beneath rain garden (up to 5 gallons/square foot).	60,000 Square Feet (10,000 10′ x 6′ Gardens)	1 Reduce Impacts to Structures 2 Prioritized Subbasins	Street Rights Of Way, Parking Lots, Improvement Districts, Residential Lots & Commercial Developments
Soil Amendments	200 City Blocks			All Areas	Publicly-Owned Lands, Schools, Improvement Districts, Commercial Developments, Residential Lots
Stormwater Trees	10 Trees / Block		20 New Trees / Block	All Areas	Publicly-Owned Lands, Schools, Street Rights Of Way, Commercial Developments

GENERAL MITCHELL INTERNATIONAL AIRPORT & AEROTROPOLIS MILWAUKEE

Aerotropolis Milwaukee completed a plan in 2017 that should be considered when implementing green infrastructure in the identified plan geography (http://city.milwaukee.gov/AreaPlans/Southeast/aerotropolis#.WqGk6-jwbRY). While it is challenging to integrate green infrastructure in many spaces around the airport due to Federal Aviation Administration regulations, there are other significant opportunities that could be explored. These opportunities include many of the impervious surfaces at the airport – especially on the western end, in the departures and arrivals circulation areas, in the numerous large parking lots, and in surrounding areas. Permeable and porous materials could be strategically integrated into these areas. Soil amendments can also be used throughout the pervious areas to increase infiltration. Additional strategies should be considered with respect to the unique context of the airport (e.g., vegetation should be chosen that would not attract waterfowl).

The Aerotropolis area is a concentration of industrial lands. As these areas continue to attract development and redevelopment, opportunities to integrate green infrastructure into the parcel development plans should be considered.

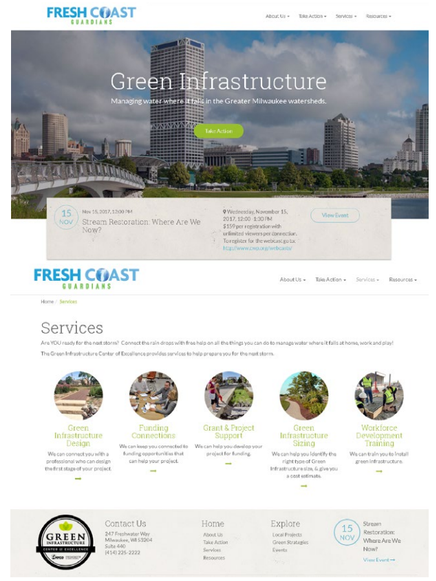
Additional sustainability objectives can be found in the County's Sustainability Management Plan for the General Mitchell International Airport.

MMSD'S GREEN INFRASTRUCTURE CENTER OF EXCELLENCE

MMSD opened a walk-in service center to provide free services, support, and resources to public and private partners. The goal is to scale up green infrastructure in the region to capture up to 740 million gallons of water every time it rains. The center is located in the Global Water Center (247 Freshwater Way, Suite 440, Milwaukee, WI)—Contact: (414) 225-2222 or www.freshcoastguardians.com.

Services include:

- **Funding Connections:** Find financial support to help make the project a reality
- **Grant & Project Support:** Help formulate a project idea and find grants to fund it
- **Green Infrastructure Sizing**: Identify the right green infrastructure solution(s) for a target space
- **Workforce Development Training:** Explore training opportunities for green infrastructure installation, maintenance, and inspection
- **Other services** and advice, as needed



MMSD's www.freshcoastguardians.com website showcasing the Green Infrastructure Center of Excellence and its services

Bioswale installed in the neighborhood surrounding Pulaski Park

KINNICKINNIC RIVER WATERSHED: GREEN INFRASTRUCTURE PLAN

5 MAPS & ADDITIONAL RESOURCES

Water, People and Prosperity In the Kinnickinnic River Watershed: Results of a watershed-wide conversation using the Green Infrastructure Scenarios Tool • August, 2015

Background

In July 2013 Climate Interactive began working with the Milwaukee Metropolitan Sewerage District (MMSD) to create a computer simulation tool for testing potential investment scenarios in green infrastructure in the Kinnickinnic River Watershed. The tool, the Green Infrastructure Scenarios Tool (GIST), was designed to help community leaders in Milwaukee explore three questions:

(1) What are the benefits that might arise from a scale up of green infrastructure in the watershed?
(2) Which infrastructure choices produce the benefits that residents of the watershed would most like to see?
(3) What will it take to scale up green infrastructure in a way that would capture those benefits?

Climate Interactive formed a partnership with two organizations well known in the watershed for their work on health, environment and equity, The Sixteenth Street Community Health Centers and 1000 Friends of Wisconsin. Together we invited dozens of citizens and leaders from across the watershed to join in a series of workshops focused on the above questions.

Building a Broader, Stronger Voice for Green Infrastructure

Conversations with key stakeholders indicated that, despite many good efforts, green infrastructure didn't appear to be on the verge of "growing to scale" in the watershed.

The output of GIST suggested a reason: no subset of groups in the watershed could take green infrastructure to scale on their own. The MMSD could offer a vision and financing and environmental groups could provide education and support, but residents, business owners, municipalities, and the County would need to be open to the idea of constructing green infrastructure on their properties in order for green infrastructure to reach significant scale. While many ongoing projects could provide opportunities for the installation of green infrastructure, we learned that the goal of scaling up investment in green infrastructure wasn't widely shared.

These observations led us to focus the workshops on the objective of **building a broader, stronger, better-informed voice to help bring green infrastructure in the watershed to its full potential**.

Key Workshop Elements

Four elements were key to the overall success of the workshops:

Element One: Diversity of participants

The participants were from the three largest municipalities in the watershed. Amongst the approximately 60 people who attended the workshops were:

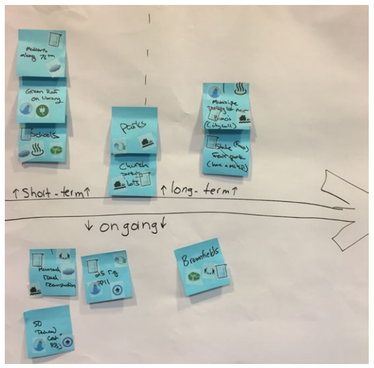
- Health professionals
- Advocates for water quality, jobs, social justice, urban resilience and sustainability
- Planners, storm water engineers, public works staff and redevelopment experts
- Landscape architects and consultants
- Educators from the Milwaukee Public Schools and local universities
- Local business owners

Feedback from participants frequently cited this diverse mix of participants as one of the strengths of

the process, which built new relationships and made the common ground between issues more visible.

Element Two: Scenario Testing
The workshops were designed around groups of participants testing different scenarios to answer the questions: Where should available dollars be invested? What mix of green infrastructure is most desirable? Who needs to be involved? These exercises encouraged people to learn from each other, question assumptions, and discuss their desired future for the watershed.

Element Three: Looking For Opportunity
Groups of participants also worked to identify opportunities for green infrastructure in each community. Participants pooled their knowledge and created opportunity maps for everything from private development projects to county parks planning to road construction projects. Consistent feedback from participants was that their understanding of potential opportunities increased as a result.



Element Four: Local Expertise
Each workshop included speakers with practical knowledge of green infrastructure. From a business owner who had installed a green roof to a college about to embark on a major storm water management project, these green infrastructure 'veterans' were honest in their assessment of what was working well, and what they would do differently the next time. Participants were hungry for their information.

Insights From the Workshops

Doing nothing is not an attractive option
Maintaining current infrastructure would set the people of the watershed up for more flooding, basement backups and combined sewer overflows. In addition, water quality requirements are soon to come into force, so investments to improve water quality will be required across the watershed.

Most people favored the benefits of investing in green infrastructure
While investment in grey infrastructure might produce slightly more reduction in combined sewer overflows compared to green infrastructure, grey infrastructure investments didn't deliver as many of the other co-benefits participants cared about, including improved air quality, energy savings, additional green space and urban heat island reduction.

Most people didn't think that these benefits would be the outcome of 'business as usual'
Most people felt that without increasing advocacy on behalf of green infrastructure, it was unlikely that its benefits would be realized. Participants recognized that creating their desired future for the watershed would require more collaboration, organization, and a sense of shared purpose.

No one group can do it alone
Scenario testing with GIST showed participants that the scale up of green infrastructure requires contributions from all sectors: local businesses, residents, government, and non-profits. Participants agreed that continued education and outreach would be required to ensure the active participation of each slice of the community.

Not all green infrastructure is created equal when it comes to benefits
Vegetation-rich types of green infrastructure, such as rain gardens, biorentention and green roofs produced more helpful benefits than scenarios dominated by permeable pavement. Participants came to understand that it is the living, transpiring surface of plants that reduces the urban heat island effect and improves air quality. The ongoing advocacy of those who champion green infrastructure will be needed to make sure that green infrastructure isn't viewed as 'one size fits all'.

There is a need for ways to connect efforts and share learning
The appetite for stories 'from the field' seemed to indicate that there is a need for more learning about green infrastructure and for forums where people can ask for and offer support and resources, and where leaders in fields as diverse as health, jobs, and environment can support and learn from one another.

The idea of "co-benefits" provides a powerful framing for decision making
Interviews with participants after the workshops demonstrated that many people have adopted the framing of co-benefits in thinking about the question of "green vs. grey" and many were even applying that framing to other issues in the community. In this way, the idea of co-benefits has provided a common language and reference point for thinking about investments, policy and priorities.

Forward Momentum

In the final workshop participants strategized about how the insights from the workshops could influence planning and decision making about green infrastructure in the watershed. The strategy elements that were identified included:

Participants are carrying the multiple benefits of green infrastructure forward in their roles

- Several participants are members of the Green Infrastructure subcommittee of the Watershed Advisory Committee (WAC), a group that advises the MMSD on projects aimed at flood mitigation. The WAC's organizers invited any interested GIST alumni to join the committee, further increasing the voices in support of green infrastructure in that influential body.
- As municipalities prepare for the new TMDL requirements, there is interest in using GIST a planning tool for strategies to improve water quality.
- The MMSD is initiating a community advisory board, which workshops participants can join, to provide further guidance on its Kinnickinnic River Watershed Green Infrastructure Plan.
- Several members of the City of Milwaukee Office of Sustainability participated in the GIST workshops and are now working on a green infrastructure plan which will be informed by the experiences with GIST.

Via this cross-fertilization of on-going efforts, the whole system perspective inspired by GIST will inform ongoing decision-making.

Leaders in Green Infrastructure education and outreach are now equipped to use GIST
As a result of these workshops, Sixteenth Street Community Health Centers and 1000 Friends of Wisconsin staff are now experts in using GIST and can offer the same experience to other groups of stakeholders. Possibilities include 1000 Friends expanding their work on green infrastructure codes and ordinances, and Sixteenth Street increasing green infrastructure education and outreach efforts, perhaps related to the Pulaski Park green infrastructure effort.

Workshop participants hope to come together in high leverage collaborative projects.
The workshops led us to realize (1) the value of sharing lessons and best practices across communities and sectors and (2) the potential for successful projects to bring support to green infrastructure. Some of the potential sites for green infrastructure projects identified in the workshops rose to the top for their potential to share lessons learned and serve as successful examples. One of these projects is the work that is already underway in the Pulaski Park neighborhood, which could be shared with workshop participants and their colleagues as it progresses. Even participants that are not directly involved could help give the project support and visibility, and draw upon its impacts to build support for additional work. Another opportunity is the possibility of leveraging the work planned at Alverno College, to complement it with projects in the surrounding neighborhoods. This idea is especially promising because Greenfield abuts Alverno's location in Milwaukee. Projects there present opportunities for learning between cities. Finally some workshop participants have begun to discuss the potential for periodic meeting of a "Co-Benefits Network" that could continue to develop the co-benefits framework in the watershed and provide opportunities for collaboration and mutual support.

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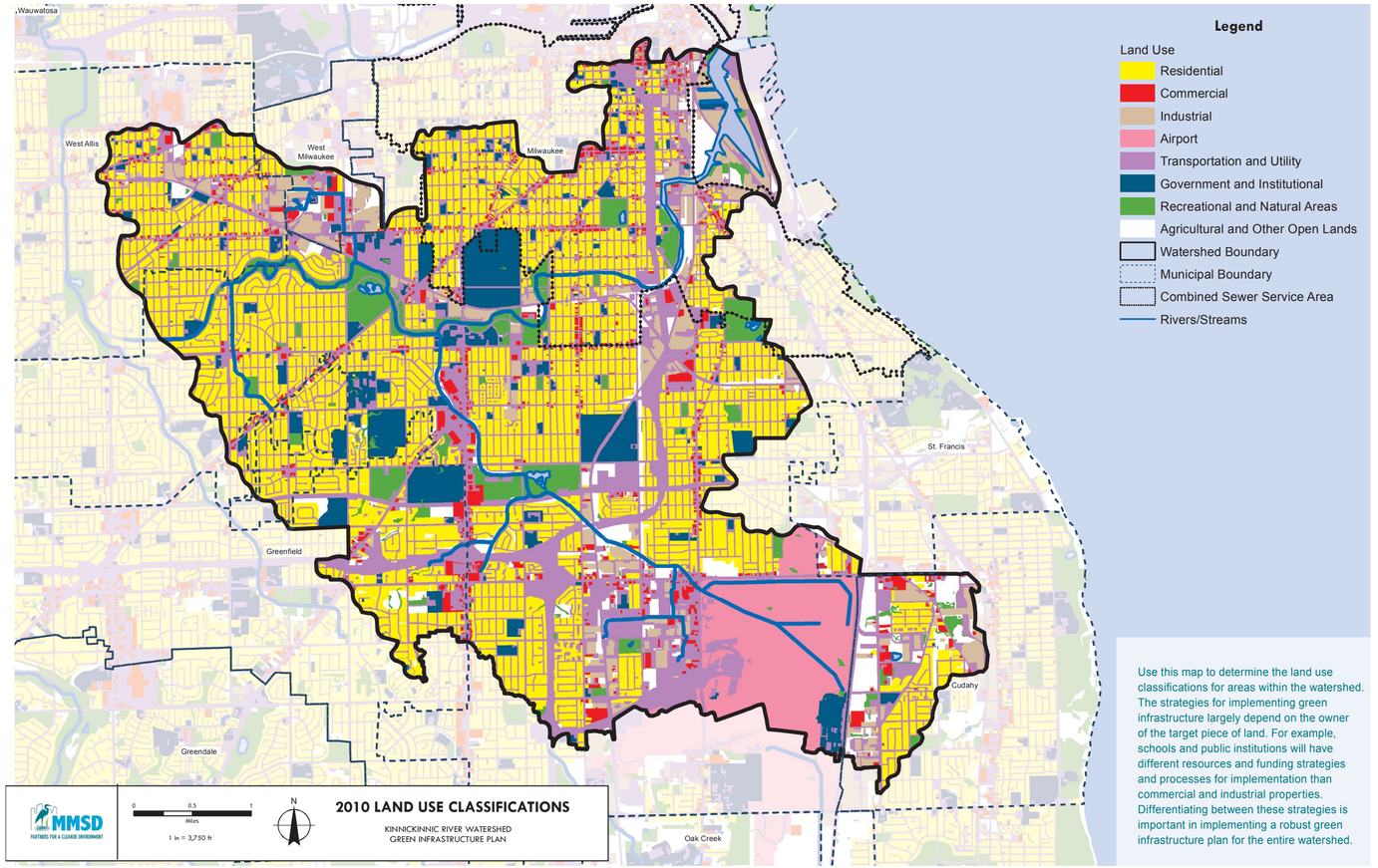
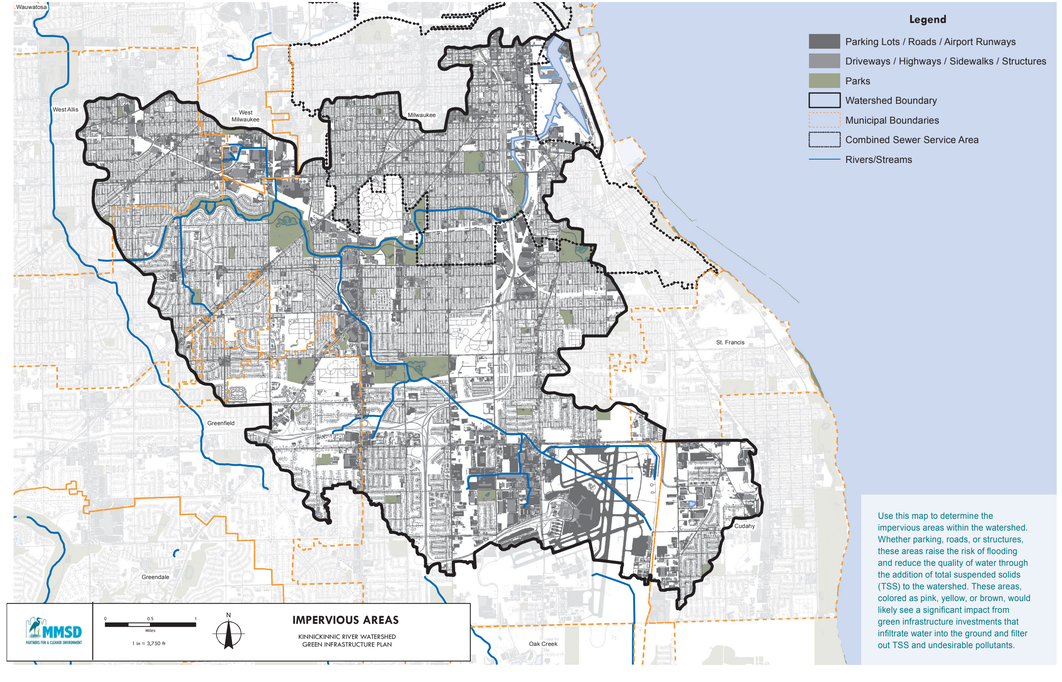
FIGURE A-1. 2010 LAND USE CLASSIFICATIONS



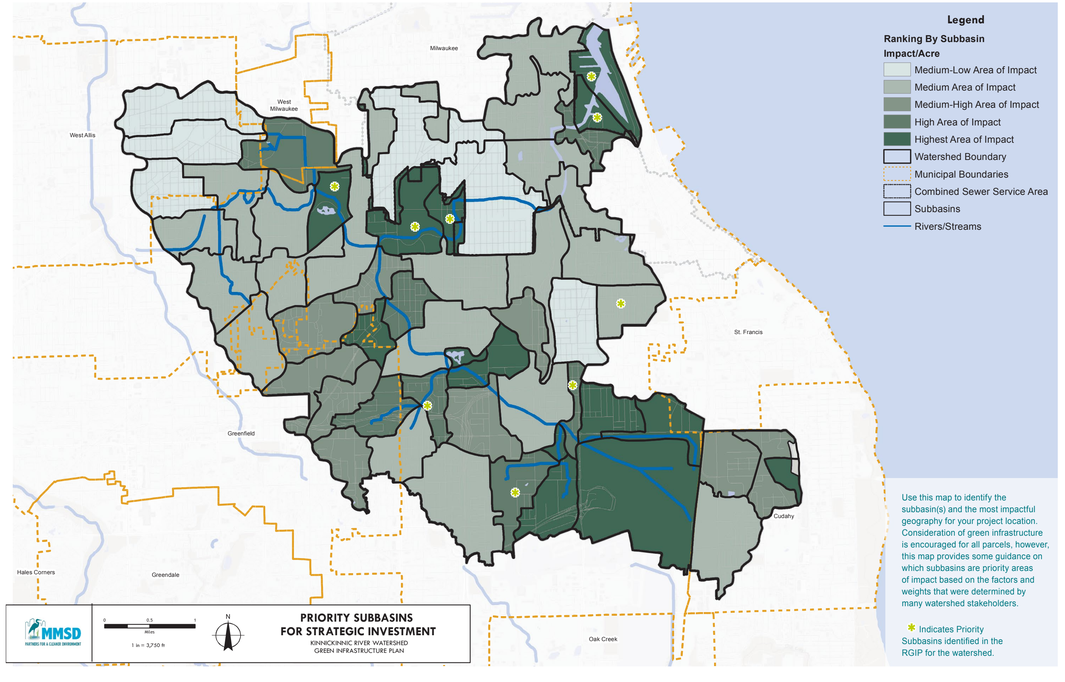
Use this map to determine the land use classifications for areas within the watershed. The strategies for implementing green infrastructure largely depend on the owner of the target piece of land. For example, schools and public institutions will have different resources and funding strategies and processes for implementation than commercial and industrial properties. Differentiating between these strategies is important in implementing a robust green infrastructure plan for the entire watershed.

FIGURE A-2. IMPERVIOUS AREAS



Use this map to determine the impervious areas within the watershed. Whether parking, roads, or structures, these areas raise the risk of flooding and reduce the quality of water through the addition of total suspended solids (TSS) to the watershed. These areas, colored as pink, yellow, or brown, would likely see a significant impact from green infrastructure investments that infiltrate water into the ground and filter out TSS and undesirable pollutants.

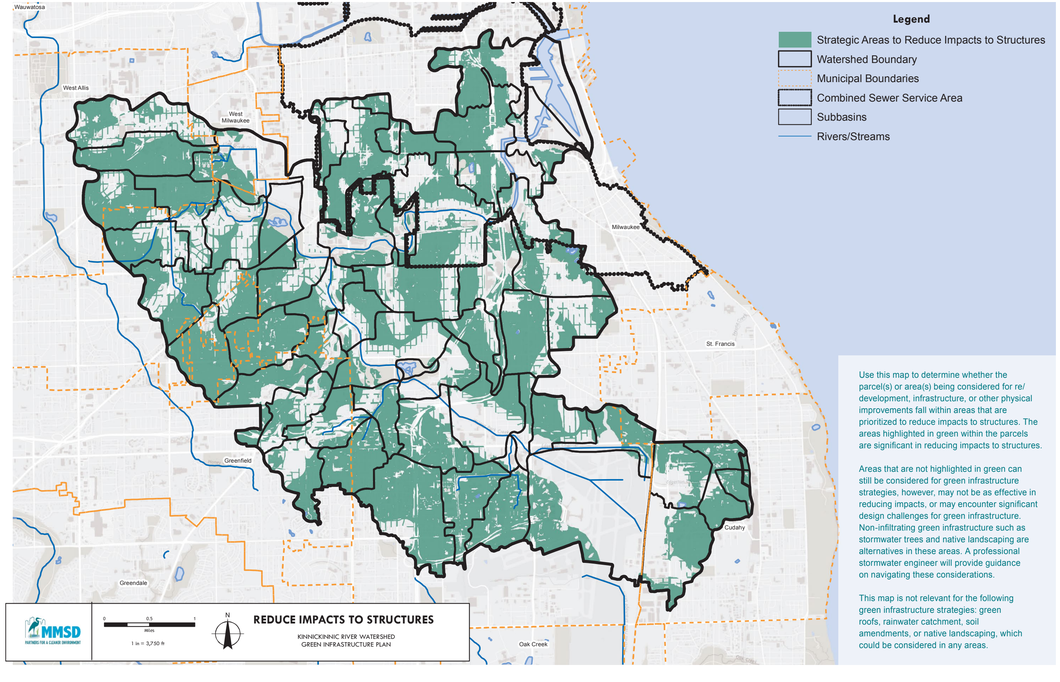
FIGURE A-3. PRIORITY SUBBASINS FOR STRATEGIC IMPLEMENTATION



Use this map to identify the subbasin(s) and the most impactful geography for your project location. Consideration of green infrastructure is encouraged for all parcels, however, this map provides some guidance on which subbasins are priority areas of impact based on the factors and weights that were determined by many watershed stakeholders.

* Indicates Priority Subbasins identified in the RGIP for the watershed.

FIGURE A-4. REDUCE IMPACTS TO STRUCTURES

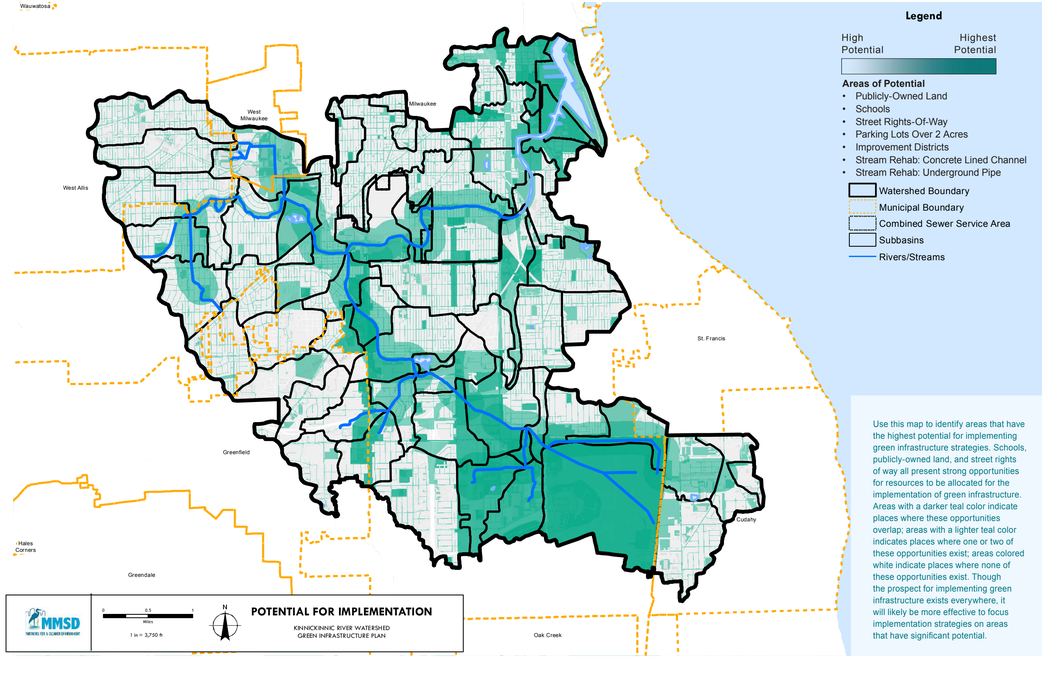


Use this map to determine whether the parcel(s) or area(s) being considered for re/development, infrastructure, or other physical improvements fall within areas that are prioritized to reduce impacts to structures. The areas highlighted in green within the parcels are significant in reducing impacts to structures.

Areas that are not highlighted in green can still be considered for green infrastructure strategies, however, may not be as effective in reducing impacts, or may encounter significant design challenges for green infrastructure. Non-infiltrating green infrastructure such as stormwater trees and native landscaping are alternatives in these areas. A professional stormwater engineer will provide guidance on navigating these considerations.

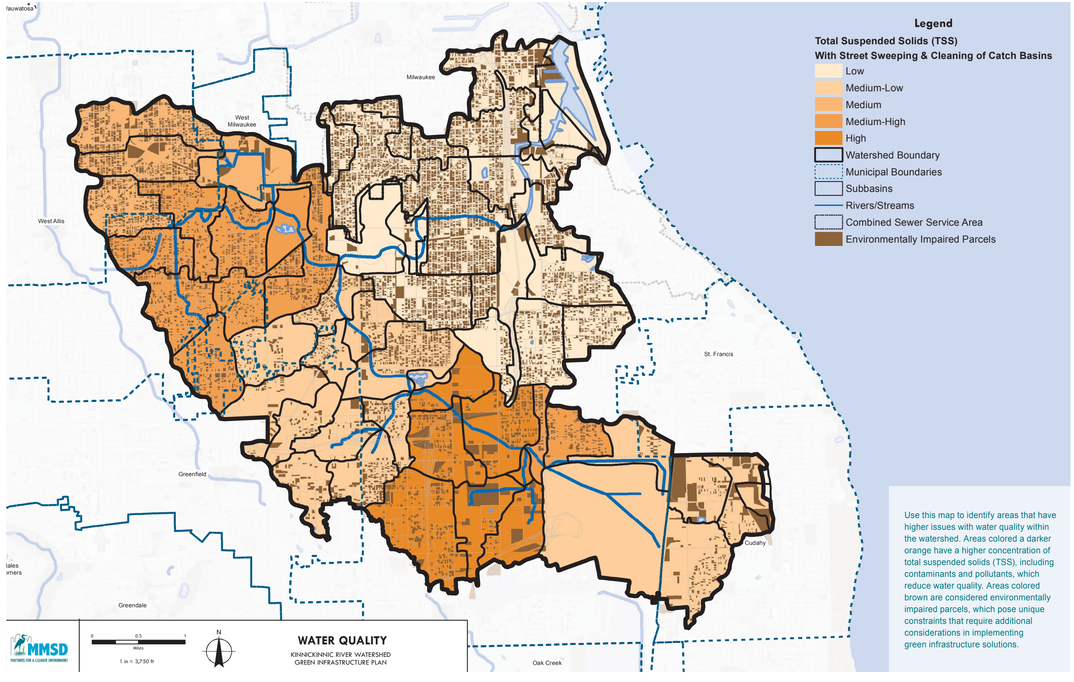
This map is not relevant for the following green infrastructure strategies: green roofs, rainwater catchment, soil amendments, or native landscaping, which could be considered in any areas.

FIGURE A-5. POTENTIAL FOR IMPLEMENTATION



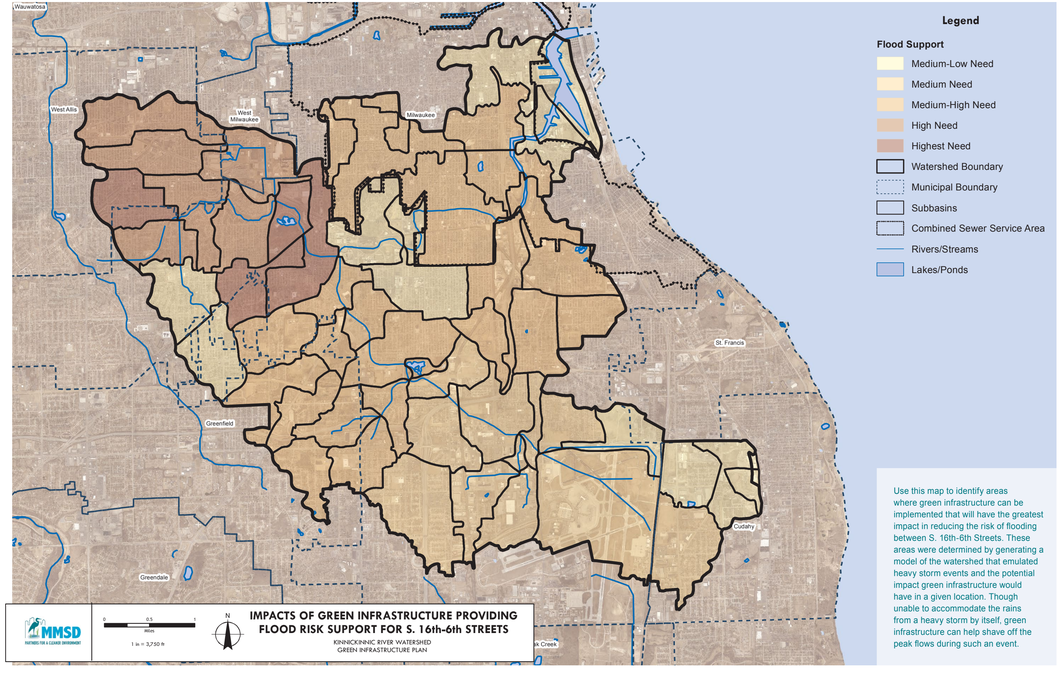
Use this map to identify areas that have the highest potential for implementing green infrastructure strategies. Schools, publicly-owned land, and street rights of way all present strong opportunities for resources to be allocated for the implementation of green infrastructure. Areas with a darker teal color indicate places where these opportunities overlap; areas with a lighter teal color indicates places where one or two of these opportunities exist; areas colored white indicate places where none of these opportunities exist. Though the prospect for implementing green infrastructure exists everywhere, it will likely be more effective to focus implementation strategies on areas that have significant potential.

FIGURE A-6. WATER QUALITY



Use this map to identify areas that have higher issues with water quality within the watershed. Areas colored a darker orange have a higher concentration of total suspended solids (TSS), including contaminants and pollutants, which reduce water quality. Areas colored brown are considered environmentally impaired parcels, which pose unique constraints that require additional considerations in implementing green infrastructure solutions.

FIGURE A-7. IMPACTS OF GREEN INFRASTRUCTURE PROVIDING FLOOD RISK SUPPORT FOR S. 16TH-6TH STREETS



Use this map to identify areas where green infrastructure can be implemented that will have the greatest impact in reducing the risk of flooding between S. 16th-6th Streets. These areas were determined by generating a model of the watershed that emulated heavy storm events and the potential impact green infrastructure would have in a given location. Though unable to accommodate the rains from a heavy storm by itself, green infrastructure can help shave off the peak flows during such an event.

FIGURE A-8. EXISTING GREEN INFRASTRUCTURE STRATEGIES

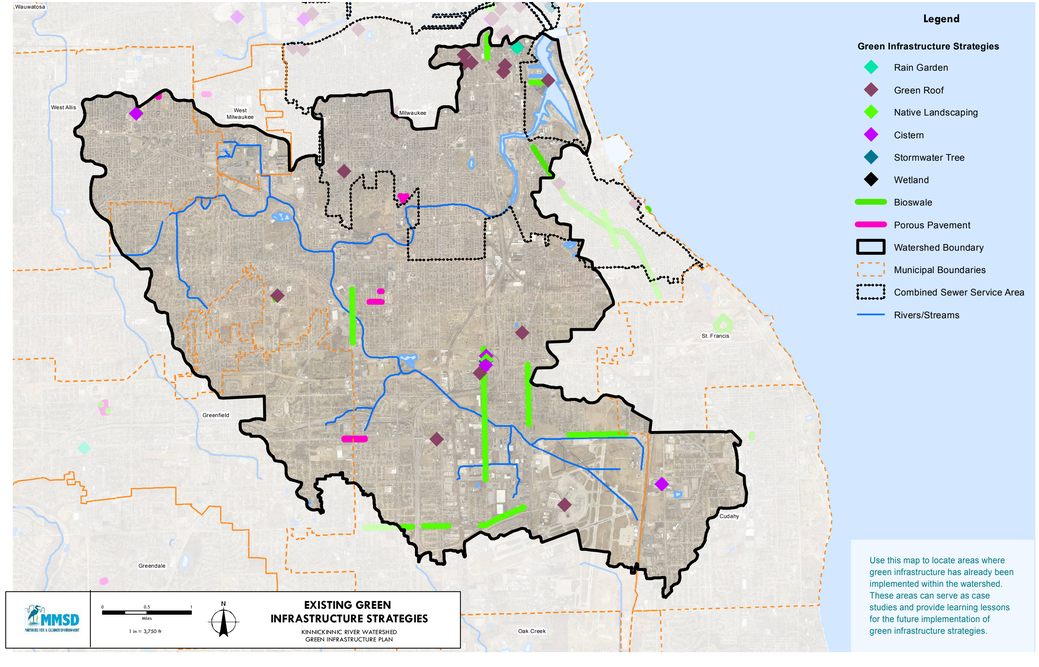


FIGURE A-9. TOTAL SUSPENDED SOLIDS WITH CONTROLS

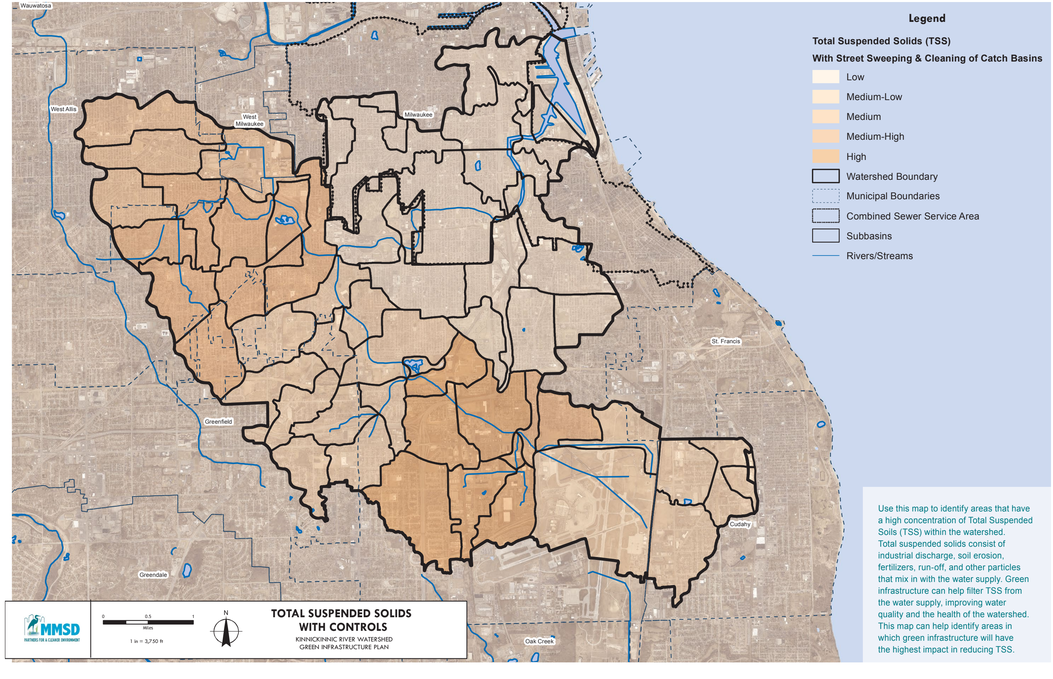
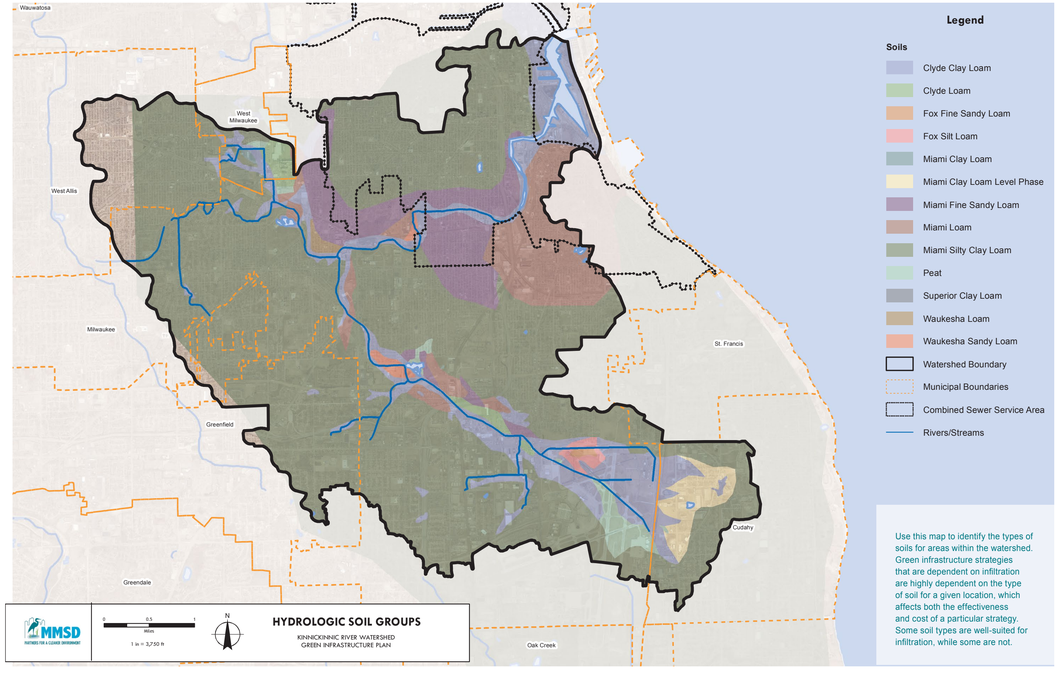
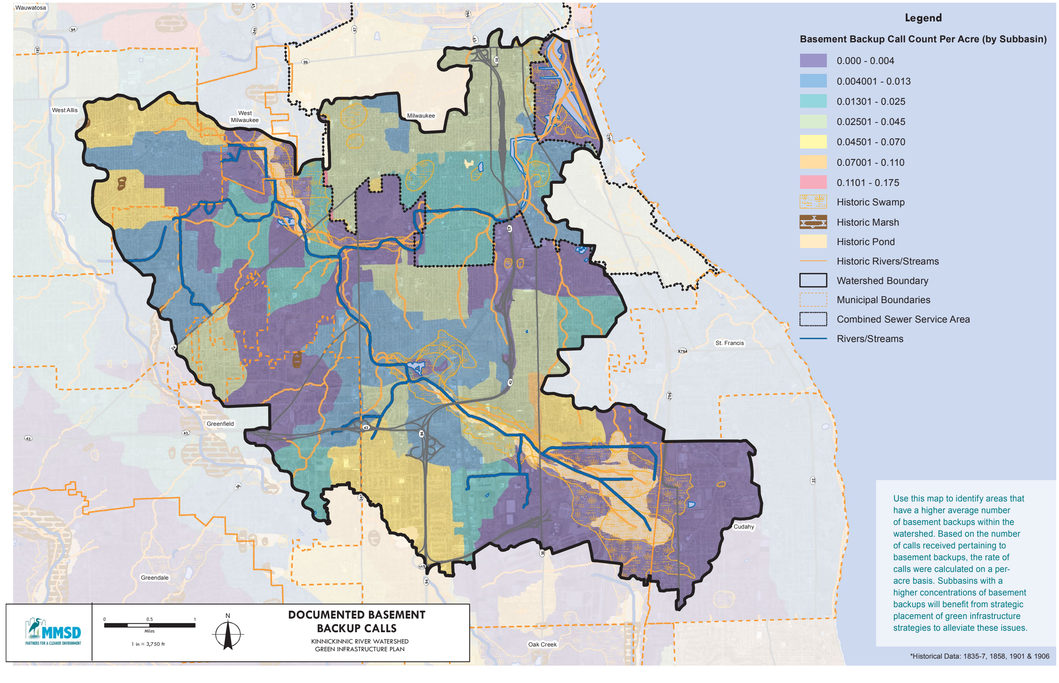


FIGURE A-10. HYDROLOGIC SOIL GROUPS



Use this map to identify the types of soils for areas within the watershed. Green infrastructure strategies that are dependent on infiltration are highly dependent on the type of soil for a given location, which affects both the effectiveness and cost of a particular strategy. Some soil types are well-suited for infiltration, while some are not.

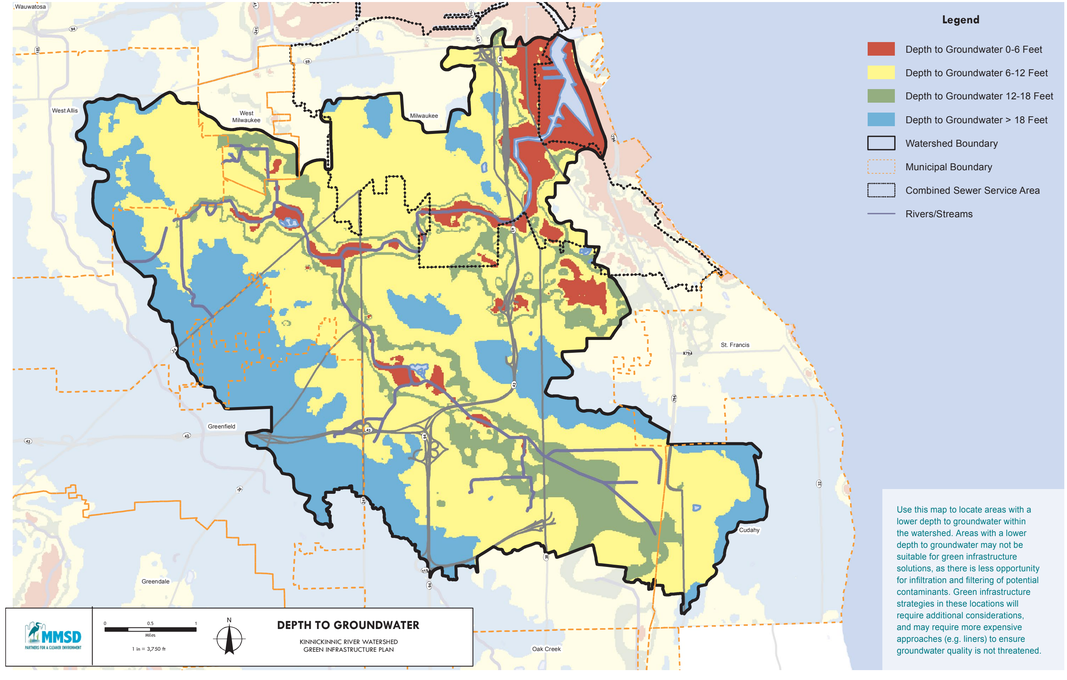
FIGURE A-11. DOCUMENTED BASEMENT BACKUP CALLS



Use this map to identify areas that have a higher average number of basement backups within the watershed. Based on the number of calls received pertaining to basement backups, the rate of calls were calculated on a per-acre basis. Subbasins with a higher concentrations of basement backups will benefit from strategic placement of green infrastructure strategies to alleviate these issues.

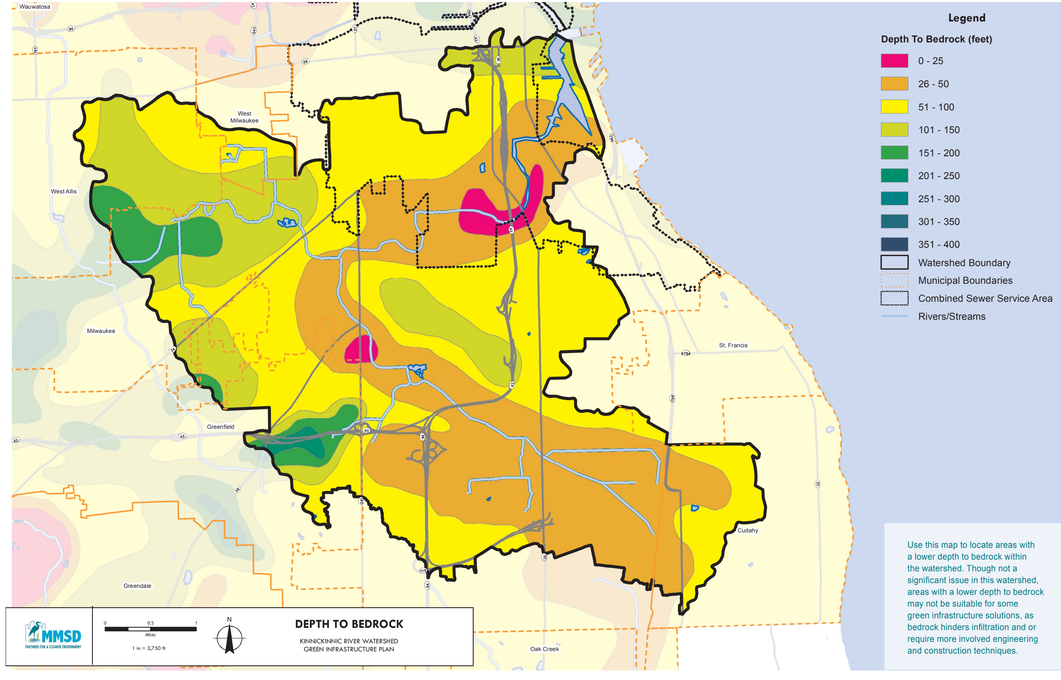
*Historical Data: 1835-7, 1858, 1901 & 1906

FIGURE A-12. DEPTH TO GROUNDWATER



Use this map to locate areas with a lower depth to groundwater within the watershed. Areas with a lower depth to groundwater may not be suitable for green infrastructure solutions, as there is less opportunity for infiltration and filtering of potential contaminants. Green infrastructure strategies in these locations will require additional considerations, and may require more expensive approaches (e.g. liners) to ensure groundwater quality is not threatened.

FIGURE A-13. DEPTH TO BEDROCK



Use this map to locate areas with a lower depth to bedrock within the watershed. Though not a significant issue in this watershed, areas with a lower depth to bedrock may not be suitable for some green infrastructure solutions, as bedrock hinders infiltration and or require more involved engineering and construction techniques.

FIGURE A-14. MMSD JURISDICTIONAL STREAM REHABILITATION LOCATIONS WITH 1,000-FT. BUFFER

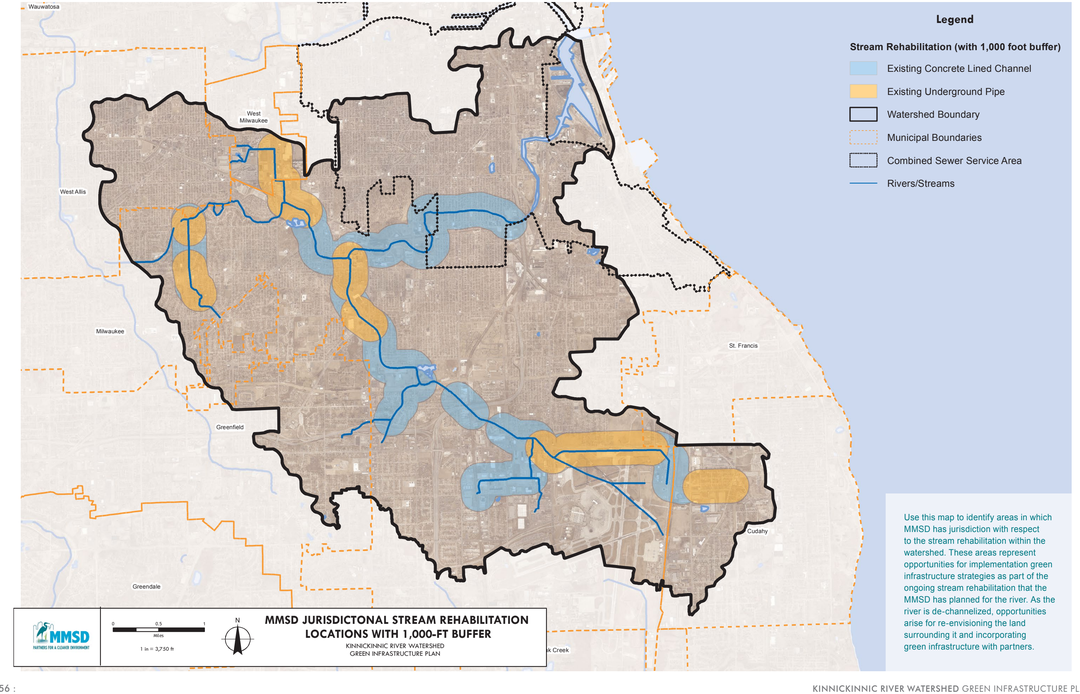


FIGURE A-15. HISTORIC STREAMS

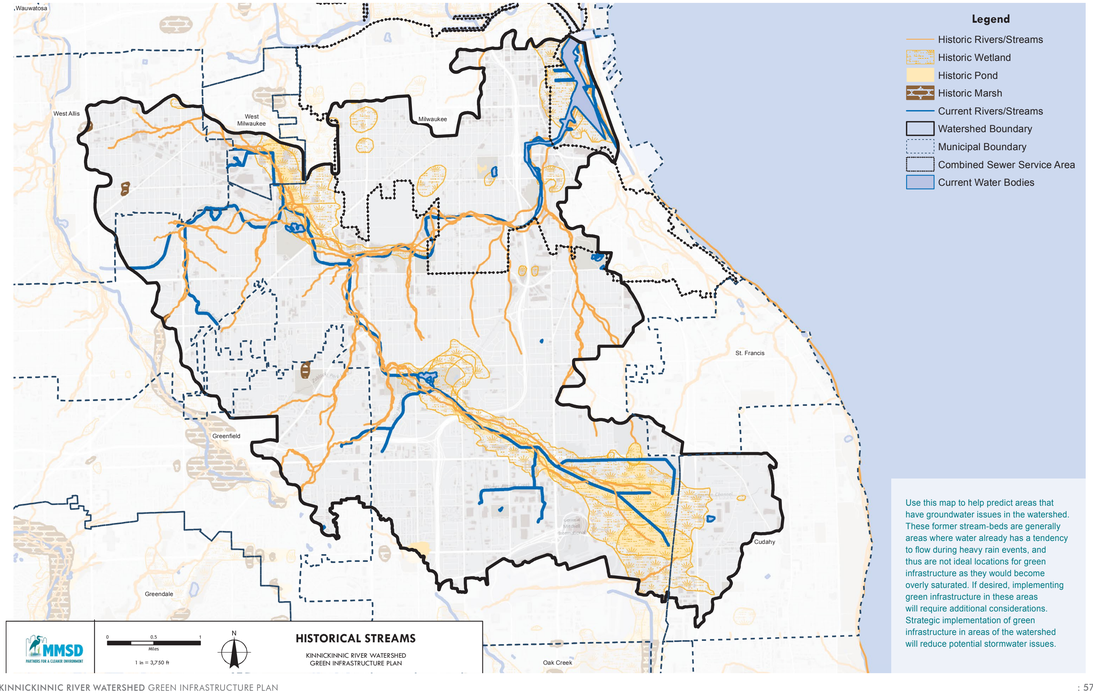
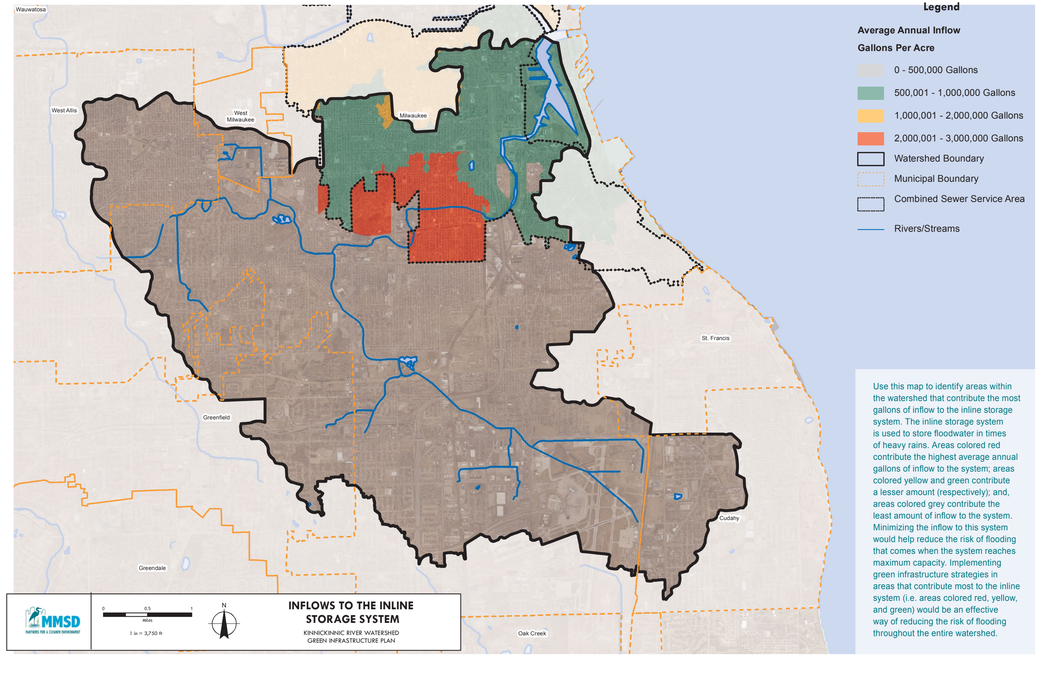
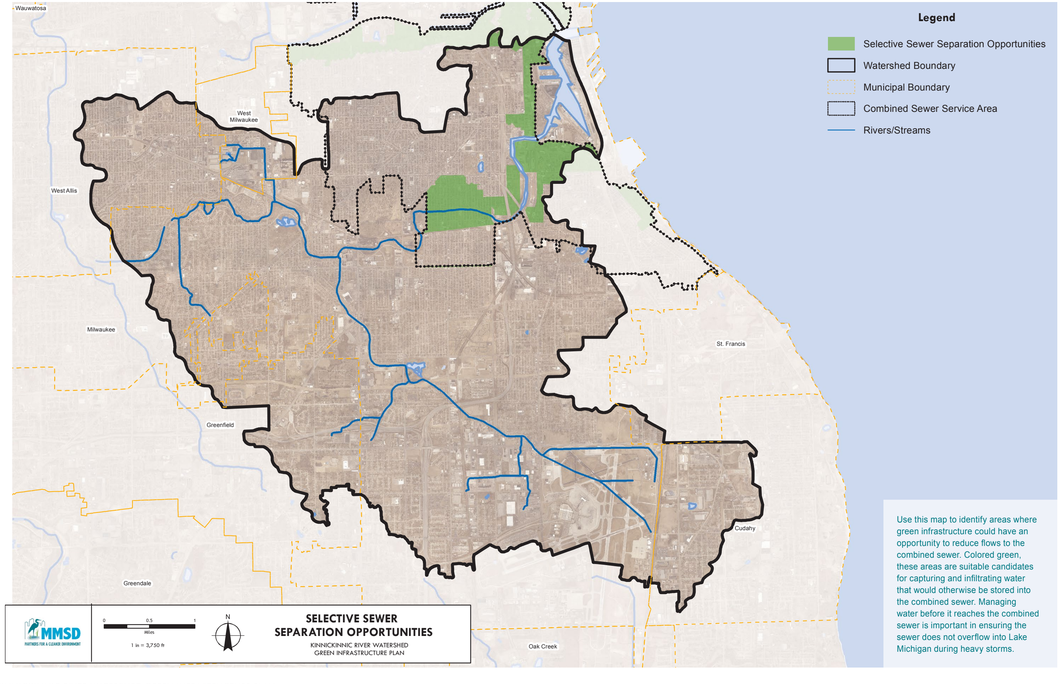


FIGURE A-16. INFLOWS TO THE INLINE STORAGE SYSTEM



Use this map to identify areas within the watershed that contribute the most gallons of inflow to the inline storage system. The inline storage system is used to store floodwater in times of heavy rains. Areas colored red contribute the highest average annual gallons of inflow to the system; areas colored yellow and green contribute a lesser amount (respectively); and, areas colored grey contribute the least amount of inflow to the system. Minimizing the inflow to this system would help reduce the risk of flooding that comes when the system reaches maximum capacity. Implementing green infrastructure strategies in areas that contribute most to the inline system (i.e. areas colored red, yellow, and green) would be an effective way of reducing the risk of flooding throughout the entire watershed.

FIGURE A-17. SELECTIVE SEWER SEPARATION OPPORTUNITIES



Use this map to identify areas where green infrastructure could have an opportunity to reduce flows to the combined sewer. Colored green, these areas are suitable candidates for capturing and infiltrating water that would otherwise be stored into the combined sewer. Managing water before it reaches the combined sewer is important in ensuring the sewer does not overflow into Lake Michigan during heavy storms.

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