TIF 97 Stormwater Management Plan

Prepared for the Traverse City Downtown Development Authority

Draft Submittal for Review

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AECOM
10850 Traverse Highway
Suite 3365
Traverse City, MI 49684

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Stormwater Management in Traverse City

Pollution from stormwater runoff has been identified as a threat to the health of Grand Traverse Bay. Pollutants can accumulate within a water body and harm aquatic species, such as macroinvertebrates and fish, and negatively impact human health by threatening water quality. As stewards of the Grand Traverse Bay Watershed, the City of Traverse City intends to implement a Stormwater Management Plan for TIF 97 (see **Figure 1**), which supplements stormwater management documents that cover the entire city. The TIF 97 area encompasses a significant portion of the downtown Traverse City area. This plan proposes a multitude of structural best management practices (BMPs) to treat stormwater for water quality based on identified priority areas.

Figure 1. TIF 97 District Noted In Green

Purpose

The purpose of this project is to develop a stormwater management plan for the City of Traverse City's TIF 97, which discharges to the Boardman River and ultimately Grand Traverse Bay. Focusing on the quality of stormwater which discharges to the Grand Traverse Bay, as opposed to volume or flood control, is the primary stormwater driver in the downtown area. Thus, the focus of the plan will be on technologies that improves the quality of stormwater. The report is divided into four sections. These are:

- Background information on stormwater control ordinances and funding mechanisms. This section is intended to provide a broad background on approaches to managing the impact to water quality and funding capital and operation and maintenance improvements to the stormwater system.
- Watershed characterization of the TIF 97 area. This section documents our evaluation of the constraints and opportunities for BMPs in the TIF 97 area. It includes data analysis for characteristics relevant to BMPs and water quality such as, land use, soil type, existing contamination sites, water bodies, and pollutant sources. This information was used to refine the types of BMPs that are applicable to the downtown area.
- A description of BMPs that are broadly applicable to the TIF 97 and downtown area. This section describes various BMPs and provides a discussion of their benefits and includes example applications and expected costs. These BMPs represent options suitable to the downtown area that will improve water quality.
- A conceptual capital improvement plan for the downtown areas that focuses on adding BMPs to benefit water quality in publicly owned areas. This supplements work already completed by OHM and the City. Its focus is on providing an example of what could be implemented in the near term planning time frame for improving the water quality of stormwater from the downtown area.

City’s Goals for Stormwater Management

The City of Traverse City updated their stormwater management plan in 2017. Stormwater runoff has been identified as a threat impacting water quality of Grand Traverse Bay (City of Traverse City, 2017). In addition, the Grand Traverse Bay Watershed Plan indicates that one of the City’s goals is to protect and improve the quality of water resources within the City that impact Grand Traverse Bay (City of Traverse City, 2017 and TWC, 2005).

These goals are advanced by the City through implementation of a stormwater ordinance and a groundwater protection ordinance as well as the investment in the operation and maintenance of the City’s stormwater system. The recently completed SAW Grant Project demonstrates the need for continued investment in the City’s stormwater system.

DDA’s Stormwater Goals for Downtown District

The DDA’s focus is on providing and sustaining a thriving downtown district in Traverse City. While managing stormwater is not intrinsically a part of this, there are aspects of stormwater management that are relative to this overarching goal. The areas where stormwater management and DDA goals overlap are:

- Having and maintaining the Boardman River and West Grand Traverse Bay as a high quality natural resource is a major driver for a thriving downtown. Thus, managing the stormwater impacts from the City is critical to meeting the DDA’s larger goals.
- Streetscaping and aesthetics of the downtown are important to visitors and business owners. Many stormwater BMPs can be integrated into or may impact the aesthetic of downtown streetscaping and therefore the DDA needs to be involved in designing and selecting BMPs.
- As the downtown area undergoes development and redevelopment some sites will be have more difficulty meeting the stormwater requirements of the City. It would be a benefit to DDA goals and developers to have stormwater management options that provided greater benefit at the same or lower costs. Alternative ordinance and funding mechanisms can support this flexibility.

Summary and Recommendations

Through the course of this project our team summarized data from several sources, reviewed a number of stormwater ordinances and funding mechanisms, spoke with the City’s engineering staff and Ad hoc stormwater committee, and developed recommendations for BMPs suitable for the City’s downtown area.

Discussions with City staff and attendance at the ad hoc stormwater committee made it clear that stormwater management is a priority with the City, but that there are several challenges currently facing the City with the primary challenge being funding. The City needs a dedicated funding source for needed capital improvements as well as ongoing operation and maintenance activities. A stormwater utility would provide a consistent level of funding based on community priorities that would be shared equitably among landowners throughout the City.

Most of the TIF 97 and downtown area is impervious. This is mainly buildings, parking areas and roads. The primary green space is along the water front with smaller areas along the river. Approximately half of the area is classified as transportation related which includes roads, alleys, parking, and sidewalks; and about 20% is buildings. This land use results in most of the runoff volume and pollutant load is generated from these areas. Therefore stormwater BMPs should focus on treating runoff from these areas. Specifically, BMPs that address runoff quality from buildings (18.7%), parking lots (19.2%) and roads and alleys (17.6%) are needed to affect change in stormwater quality.

Stormwater controls can take the form of site specific retrofits to existing infrastructure or more regional approaches. The review provided includes descriptions and case studies for a variety of BMPs that could be added to the existing infrastructure as retrofits (tree boxes, curb bumpouts and more regional approaches such as the green streets concepts that could be applied as part of future designs to provide more regionalized stormwater treatment. In addition, we have provided information on the cost, treatment capabilities and uses for each BMP type.

Finally, the report concludes with a conceptual capital improvement plan that allocated the budget recommended by OHM to specific BMPs within the TIF 97 area. The analysis used the BRE scores and watershed characterization data and resulted in potentially feasible locations for 116 BMPs that would treat 31% of the TIF 97 area. Treating nearly a third of the TIF 97 area would have a positive benefit to water quality and would likely reduce the volume of runoff which would decrease the capital costs for new stormwater conveyance.

Stormwater Ordinances and Funding Mechanisms

Examples of Stormwater Ordinance Implementation

A stormwater ordinance is a law passed by a municipal government to establish minimum stormwater management requirements and controls. These conditions are designed to protect and safeguard the general health, safety, and welfare of the public residing in the watersheds within its jurisdiction. Specifically, successful stormwater management involves preventing flooding from impacting community property and public health, protecting receiving water integrity and quality by minimizing water pollution caused by the impervious surface runoff of stormwater, and ensuring that stormwater management measures are satisfying municipal codes and standards for reliability and performance. Additionally, a stormwater ordinance is designed to ensure that the stormwater management measures are properly maintained and funded.

While many local programs are building stormwater ordinances to meet increased regulatory requirements, such as Phases I and II of the National Pollutant Discharge Elimination System (NPDES) municipal stormwater permit program, there are additional factors to consider in determining appropriate ordinance goals and purposes for a given community. Studies on community demographics can indicate areas of rapid growth, redevelopment opportunities, and anticipated future growth, which allows the ordinance to target developments of common size and this knowledge gives an indication of type and size of developments in the community. A community considering a stormwater ordinance should also gain an understanding of the impaired waterbodies in a region and the local pollutants of concern. Additionally geographical information such as precipitation, land use and cover, floodplains, and areas prone to flooding can further help indicate areas that would be best benefited by stormwater management requirements and runoff reducing infrastructure. Once the stormwater management needs of a community are defined, a stormwater ordinance is created, taking into account each factor.

The EPA provides encompassing public guidance documents and tools that provide step by step recommendations for creating stormwater ordinances and sample formats. The basic elements of a stormwater ordinance include a regulatory structure, design, development review process, maintenance plan, and inspection and enforcement process. See **Table 1**.

Table 1. Stormwater Ordinance Content Overview [1]

Section 1 – General Provisions
Purpose, Applicability, Development of a Stormwater Design Manual
Section 2 – Definitions
Section 3 – Permit Procedures and Requirements
Development Application Requirements, Application Review Fees, Application Procedure, Permit Duration
Section 4 – Waivers
Waiver Requirements, Fee in Lieu of Stormwater Management Practices
Section 5 – General Performance Criteria for Stormwater Management
Stormwater Management Criteria
Section 6 – Specific Performance Criteria for Stormwater Treatment Practices
Stormwater Treatment Criteria or reference to stormwater design manual
Section 7 – Requirements for Stormwater Management Plan Approval
Stormwater Management Plan Required for All Developments. Stormwater Management Concept Plan Requirements, Final Stormwater Management Plan Requirements, Performance Bond/Security
Section 8 – Construction Inspection Provisions
Notice of Construction Commencement, As Built Plans, Landscaping and Stabilization Requirements
Section 9 – Maintenance and Repair Requirements
Maintenance Easement and Covenants, Inspection of Stormwater Facilities, Right-of-Entry for Inspection, Records of Installation and Maintenance Activities, Failure to Maintain Practices
Section 10 – Enforcement and Violations
Violations, Notice of Violation, Stop Work Orders, Civil and Criminal Penalties, Restoration of Lands, Holds on Occupation Permits

Developing specific stormwater management criteria is essential for the creation and implementation of a stormwater ordinance. This information can be included in stormwater ordinance itself however EPA suggests that stormwater ordinance should reference a stormwater design manual for specific stormwater design criteria. The stormwater design manual can then be altered when new information or new technology is developed and the stormwater ordinance can retain its original structure and language. A stormwater design manual would include information regarding stormwater quantity and quality target treatment requirements as well as green infrastructure strategies available to perform this treatment and the levels at which treatment is possible. See **Table 2**.

[1] Hirschman, D, J. and Kosco, J. 2008. Managing stormwater in your community a guide for building an effective post-construction program. Center for watershed protection Web. https://www3.epa.gov/npdes/pubs/stormwaterinthecommunity.pdf

Table 2. Content of Stormwater Design Manual[2]

Introduction • Purpose of Manual • Relationship to Local Stormwater Ordinance
General Stormwater Management Information • Why Stormwater Matters • General Principles for Stormwater Management • How Local Conditions Affect Stormwater Management
Stormwater Management Criteria • Stormwater Management Criteria • Special Stormwater Design Criteria for Sensitive Receiving Waters
Stormwater BMP Selection • Approach to Stormwater BMP Design and Selection • Stormwater BMP Selection Guidance and Selection Matrices • List of Recommended Stormwater BMPs • Use of Proprietary Stormwater BMPs
Stormwater BMP Standards and Specifications • Site Requirements/Feasibility • Conveyance • Pretreatment • Treatment • Landscaping • Safety Features • Maintenance Reduction Features
Stormwater BMP Design Methods and Computations • Acceptable Hydrologic, Hydraulic, and Water Quality Models • Required Modeling and Design Assumptions • Design Examples
Stormwater Credit Program Information • Available Low-Impact Development (LID) Credits and Applications • Credit Computation Procedures − LID Fact Sheets (if not included in Specifications section)
Appendices (e.g. Design Tools and Resources) • Approved Plant Lists • Computer-Aided Design and Drafting (CADD) Details • Soil and Geotechnical Investigation Guidance • Other technical support for local program

Stormwater ordinances, given the creation of a comprehensive stormwater management design manual, are effective in providing the necessary function of stormwater management for a city but their ultimate success is also dependent on the ability to enforce the elements of the ordinance.

Enforcement measures are often planned alongside inspection and maintenance requirements of the stormwater ordinance and various options of seeking compliance should be included as to provide flexibility in different circumstances. Necessary inspection methods are usually determined for the construction, as-built certification, and maintenance of permanent stormwater controls structures. Additionally the minimum reporting requirements of these inspections as well as a clear definition of the parties responsible for inspections and their frequency should be included in the ordinance. In some cases, the penalties and enforcement measures for failed stormwater ordinance compliance can be combined with construction-phase control (of sediment and erosion) and illicit discharge penalties. While these types of penalties, including stop work orders, may be suitable during active construction of stormwater

[2] Hirschman, D, J. and Kosco, J. 2008. Managing stormwater in your community a guide for building an effective post-construction program. Center for watershed protection Web. https://www3.epa.gov/npdes/pubs/stormwaterinthecommunity.pdf

controls, post-construction penalties, being on the scale of civil penalties, may require different enforcement tools. Some municipalities will offer less severe methods at first such as verbal or written warnings. See **Table 3**.

Table 3. Types of Penalties to Include in Stormwater Ordinance[3]

Type	Description
Notice of violation (NOV)	Written notice served on the responsible party stating the cause of the violation, remedial steps to be taken, a schedule for compliance, and consequences for noncompliance (e.g., stop work, revoking of permits, and pursuit of civil and/or criminal penalties).
Stop work order	Provision for the enforcing agency to stop work on a site if the responsible party fails to comply with an NOV. A stop work order is more effective for erosion and sediment control (construction phase stormwater) than for post-construction stormwater.
Civil penalties or charges	Civil penalties can impose charges for specific violations. The ordinance can include a schedule of civil penalties (specific charges linked to specific types of violations), and inspectors can use this schedule in "ticket book" fashion when in the field. Civil penalties provide more flexibility than criminal penalties.
Criminal Penalties	Criminal penalties establish violations as misdemeanors, subject to specific fines and/or imprisonment. Each day the site is not in compliance is considered a separate violation. Although criminal penalties represent the biggest "hammer" in the enforcement toolbox, most programs resort to them rarely and could find it difficult to garner the political support to use such penalties.
Withholding other permits or approvals	Perhaps the biggest motivator to comply during the construction process is withholding certificates of occupancy or other approvals until all measures have been properly installed. This tool would not apply to long-term maintenance, however, and might also present timing challenges for the applicant and jurisdiction (e.g., site work lags behind building and occupancy).
Revoking or suspending other permits or approvals	This tool is similar to withholding permits, but it applies to permits or approvals that have already been granted (e.g., building or grading permits). The appropriate permit or authorization can be suspended until the required actions are taken, at which point the permit is reinstated. This tool can be quite effective, but implementing it usually takes political support.
Performance Bonds	Performance bonds are not an enforcement tool in the strict legal sense, but many programs use them to motivate compliance. Bonds can be particularly useful for a stormwater program because their duration can cover the proper installation of stormwater measures plus a reasonable period thereafter to ensure that practices function properly. The bond concept can also be expanded to maintenance in the form of a maintenance bond, escrow, or other financial guarantee that must be posted by the responsible party. In the ordinance, the performance bond section would likely not be in the penalties section but rather in the plan submission and review section.

Additionally, stormwater ordinance implementation success requires a definitive funding source for the practices involved. Common sources include: stormwater utilities, general funds, Clean Water State Revolving Fund (CWSRF) loans, fees, taxes, grants, debt financing, local improvement districts, and developer participation, additional fees (impact, plan review and inspection, fee in-lieu of onsite construction, system development fees or connection charges).[4]

[3] Hirschman, D, J. and Kosco, J. 2008. Managing stormwater in your community a guide for building an effective post-construction program. Center for watershed protection Web. https://www3.epa.gov/npdes/pubs/stormwaterinthecommunity.pdf

[4] Hirschman, D, J. and Kosco, J. 2008. Managing stormwater in your community a guide for building an effective post-construction program. Center for watershed protection Web. https://www3.epa.gov/npdes/pubs/stormwaterinthecommunity.pdf

The selection of a stormwater management financing measure will be dictated by local needs but one factor in the decision making process is the desired stormwater infrastructure maintenance plan. Typical maintenance responsibilities include routine items, such as mowing or removing sediments, trash, and debris from stormwater BMPS, and structural items, such as broken or degrading stormwater conveyance infrastructure. A maintenance program is created to assign responsibility to for these items, whether to property owners and homeowners or to the local program, as described by the stormwater ordinance. The most common approach is the combination of both sources. See **Table 4.**[5]

Table 4. Types of Stormwater Control Maintenance Program

Characteristics	Typical Annual Budget Range (2006 costs)	Typical Funding Sources
Private Maintenance • Less costly for local program • Often neglected • Legal and program tools needed to establish responsibility • Strong outreach and education needed	$5K to $100K	• General fund • Plan review and inspection fees • Maintenance bonds
Local Program Maintenance • Owners may be responsible for routine tasks • High budget and staffing commitment	$100K to $1.5M	• Stormwater Utility • Other utility (e.g. sewer) rates • Transportation maintenance funds • General fund
Hybrid Approach • Local government maintains public facilities and private parties maintain private property • Cost-effective • Requires local government budget and staffing	$50K to $300K	• Stormwater utility • Capital improvement plan • General Fund

While the design of a stormwater ordinance is community specific and involve many considerations, guidance documents and tools from the EPA as well as publications from professional organizations provide step by step insight into the process. Successful implementation of a stormwater ordinance is best achieved while consulting these documents. See **Table 5**.

[5] Ibid.

Table 5. Stormwater Ordinance Implementation Timeline

Milestone	Appropriate Parties	Time Frame
1. Assess existing codes – zones, subdivision, drainage, stormwater.	▸ Stormwater authority ▸ Planning/community development department ▸ Stakeholder group	3-6 months
2. Determine permit commitments for stormwater ordinance.	▸ Stormwater authority ▸ State MS4 coordinator	1 week
3. Identify relevant state and/or regional model ordinance.	▸ Stormwater authority ▸ State/regional agencies ▸ State MS4 coordinator ▸ Stakeholder group	1 month
4. Make decisions about programmatic integration with erosion and sediment control, illicit discharge detection and elimination, and land use planning.	▸ Stormwater authority ▸ Other local departments involved with aspects of the stormwater program ▸ Planning/community development department ▸ Stakeholder group	6 months – 1 year
5. Devise and execute a public and stakeholder participation strategy for ordinance development and adoption.	▸ Stormwater authority ▸ Outreach expert (internal or external) ▸ Legal staff ▸ Local leadership ▸ Other internal and external stakeholders	1-3 years
6. Examine options and make decisions about applicability threshold, exemptions, waivers, and design criteria.	▸ Stormwater authority ▸ Stakeholder group ▸ Consultant, if appropriate	3-6 months
7. Determine whether the ordinance should allow or require low-impact development measures through variances and/or in design criteria.	▸ Stormwater authority ▸ Stakeholder group	3-6 months
8. Determine whether off-site or watershed projects are an appropriate site compliance mechanism in the community.	▸ Stormwater authority ▸ Stakeholder group ▸ Watershed organizations ▸ Consultant, if appropriate	1-2 years
9. Project annual plan review, inspection, and maintenance work loads based on applicability threshold and development rates. Translate to budget and staffing needs.	▸ Stormwater authority ▸ Public works department ▸ Planning/community development department ▸ Locality's finance/budget office	1-3 months
10. Adopt and implement the ordinance	▸ Stormwater authority ▸ Legal staff ▸ Elected officials	Entire Process: 1-3 years

Prescriptive Approach Examples

A prescriptive approach to stormwater management would include the municipality or other regulatory agency dictating a mandatory set of rules for the implementation of stormwater treatment. The city of Ann Arbor, Michigan utilizes a prescriptive approach to stormwater management by charging a stormwater fee based on the amount of impervious area.[6]

The City of Chattanooga, Tennessee unveiled a stormwater ordinance with a prescriptive approach stormwater management in November of 2014, amended 2017. The ordinance requires utilizing peak flow for sizing BMPs and infiltrating 100% of the first 1 inch of every rainfall event. If the project is unable to meet these requirements, an in-lieu mitigation fee can be paid, or providing approved BMPs to filter stormwater to remove TSS.[7]

The city of Seattle, Washington also employs a prescriptive approach for stormwater management which simply states that single-family residential projects as well as all other projects with 7,000 square feet of earth-disturbing activities with 1,500 square feet of new impervious surfaces shall infiltrate, disperse, and retain stormwater on site without causing flooding, landslide, or erosion impacts.[8]

Discretionary Approach Examples

A discretionary approach to stormwater management would involve evaluating each site on a case-by-case basis. One such example of a discretionary approach is the Discretionary Fund Rebate Program in Snohomish County, Washington. This program is voluntary, non-regulatory and "offers funding for small projects on private or public property that will provide shellfish protection benefits in Port Susan or South Skagit Bay".[9] Projects must be designed to improve quality of surface water or groundwater to qualify for funds.

Stormwater Funding Mechanisms

The costs associated with stormwater management have increased steadily in cities as a result of heightened regulatory requirements, flood control concerns, water quality issues, and development from population growth. Many communities traditionally try to fund these costs from their property tax general fund. However, these funds are limited and are not easily allocated to stormwater management improvements. This system of funding is also not equitable as property value is not a good indicator of stormwater management needs and, many times, sites having the greatest impact on the stormwater system are tax exempt.

Some municipalities find funding through system development charges where new customers of stormwater management services are charged a fee to connect to the existing system. Other options for funding include state grants and low interest loans. Increasingly, communities are opting to adopt stormwater utilities. Stormwater utilities are designed to better reflect the cost of providing stormwater management services as well as the value of these services to community members.

Stormwater Utilities

Many cities across the country have developed stormwater utility fees, operating much like electric and water utilities, to collect fees for providing stormwater control and treatment services to fund their municipal stormwater management programs. This stormwater utility fee methodology is designed to achieve an equitable, legal, and reasonable division of the costs associated with stormwater management. Stormwater utility fees, typically based

[6] City of Ann Arbor. 2008. *Stormwater utility update*. Web. https://www.a2gov.org/departments/systems-planning/planning-areas/water-resources/Documents/A2%20Stormwater%20Utility%20Update%20Report%20FINAL%20Sept%2008.pdf.
[7] Ordinance No. 13251. Sec. 31-313. New Development and Redevelopment Requirements. 2017.
[8] Director's Rule 15-2012. Chapter 1 – Introduction. 2012
[9] Snohomish County Washington, Discretionary Fund Rebate Program. Web. https://snohomishcountywa.gov/1208/Discretionary-Fund-Rebate-Program

on property type and size, are charged to both tax-exempt and non-exempt properties and are calculated based on the runoff contribution of each site.

In order to legally adopt a stormwater utility fee funding structure, the stormwater utility fee must be distinguished from a tax, fulfilling the following three requirements defined by the Michigan Supreme Court in the 1998 Bolt vs City of Lansing case:

- The fee must be proportional to the runoff contribution of each property charged.
- The fee amount must be correlated to the cost of the service provided and not serve a revenue-generating purpose.
- The service must be characterized as "voluntary" where property owners can refuse or limit their use of the service.

The next three sections outline how municipalities can achieve these criteria.

Stormwater Fee Structure Rate Design and Assessment

For billing and fee determination purposes, municipalities must define a method of calculating the stormwater runoff contributions from parcels served by the stormwater system. Common methods include the Equivalent Residential Unit (ERU), Intensity of development (ID), and Equivalent Hydraulic Area (EHA) methods.[10] Since impervious coverage is the key factor influencing peak stormwater runoff, each of these methods takes this value into account while some incorporate additional contributing factors. The appropriate billing system for a stormwater utility can follow one of these example structures or can be designed with other considerations in order to best accommodate the needs of the community.

The ERU method is the most a common fee determining technique, implemented by 80 percent of stormwater utilities, and is based entirely on the amount of impervious area on a parcel. Usually, a fixed billing rate is determined for the impervious area representing the average residential property, known as the ERU, and all residential properties are charged this amount. In some cases, this rate can be tiered to represent more specific residential impervious areas in order to improve the fee equitability. The impervious areas on non-residential parcels are calculated individually and the property owners are charged the flat rate for the number of ERUs that the area represents.

The ID method accounts for both pervious and impervious area by assigning fees based on the proportion of impervious area to total area (development intensity) of each site. The calculated development intensity of each site falls into a category of development that is defined by a percentage range. A rate is set for each percentage range and the property owner is billed at a sliding scale. **Table 6** outlines an example of an ID rate structure. Since this method accounts for sites with pervious and undeveloped land it can be more equitable than the ERU method, however it features broad categories and has the potential to discourage the usually desired urban infill.

[10] United States Environmental Protection Agency. 2008. *Funding stormwater programs*. Web. https://www3.epa.gov/npdes/pubs/region3_factsheet_funding.pdf

Table 6. Intensity of Development Rate Structure Example [11]

Category (Development Intensity Range)	Rate Per Month, Per 1,000 ft^2 of Total Site Area
Vacant/Undeveloped (0%)	$0.08
Light Development (1% to 20%)	$0.12
Moderate Development (21% to 40%)	$0.16
Heavy Development (41% to 70%)	$0.24
Very Heavy Development (71% to 100%)	$0.32

The EHA method also uses both pervious and impervious area in stormwater fee calculations but charges parcels according to individual measurements of these areas and the amount of runoff they generate. While the EHA and ID methods are deemed to be more equitable than the ERU method, they require a more time consuming approach to billing unit determination and can be harder to explain to customers.

Stormwater Fee Determination

Once an appropriate method has been outlined to determine parcel runoff contribution, the stormwater utility must set the fee amount. In order to avoid fiscal shortfalls, these fees must be designed to cover the entire operating cost of the stormwater utility while complying with regulations and not generating revenue. The basic equation for establishing a base fee rate is expressed below:

$$\text{Base Rate} = \frac{\text{Total Anticipated Stormwater Expenses}}{\text{\# Of Equivalence Units In The Municipality}}$$

Table 7 depicts an example method of calculating total anticipated stormwater expenses and the resulting base rates. As stormwater user fees can provide a stable funding stream that allows for long range scheduling of capital improvements and operations, these investments should also be included in the calculations if applicable.

[11] United States Environmental Protection Agency New England. 2009. *Funding Stormwater Programs*. Web. https://www3.epa.gov/region1/npdes/stormwater/assets/pdfs/FundingStormwater.pdf

Table 7. Example Budget, Rate, and Fee Escalation Schedule for a Hypothetical Community [12]

FIRST 5 YEARS	**1**	**2**	**3**	**4**	**5**
1. PROGRAM COSTS					
Maintenance of Drainage Systems	$50,000	$50,000	$300,000	$315,000	$330,750
Stream Assessments/Watershed & Drainage Studies	$500,000	$500,000	$50,000	$100,000	$100,000
Maintenance of BMP Facilities	$50,000	$50,000	$375,000	$750,000	$787,500
Program Administration	$100,000	$100,000	$300,000	$300,000	$300,000
Dam Safety inspections and related studies	$25,000	$25,000	$25,000	$25,000	$25,000
Dam Safety maintenance and upgrades	$0	$0	$0	$0	$0
NPDES Phase II Implementation	$250,000	$250,000	$200,000	$200,000	$250,000
CIP Projects	$0	$0	$0	$0	$0
Plan Reviews and Inspections	$800,000	$800,000	$800,000	$800,000	$800,000
Stream Restoration & Stabilization Projects	$0	$0	$0	$0	$0
LID Retrofits	$0	$0	$0	$0	$0
Floodplain Management	$50,000	$50,000	$50,000	$50,000	$50,000
Water Quality Monitoring	$0	$0	$0	$0	$0
Soil & Water Conservation District programs	$10,000	$10,000	$10,000	$10,000	$10,000
Utility Billing System Implementation	$100,000				
Repayment to Utilities Fund			$175,000	$175,000	
Total Program Costs	**$1,935,000**	**$1,835,000**	**$2,285,000**	**$2,725,000**	**$2,653,250**
2. REVENUES OTHER THAN STORMWATER UTILITY FEES					
Plan Review & Inspection Fees	$800,000	$800,000	$800,000	$800,000	$800,000
General Fund Revenues	$0	$0	$0	$0	$0
Additional Source 1	$0	$0	$0	$0	$0
Additional Source 2	$0	$0	$0	$0	$0
Total Revenues Other Than Stormwater Utility Fees	**$800,000**	**$800,000**	**$800,000**	**$800,000**	**$800,000**
3. REVENUES REQUIRED FROM STORMWATER UTILIITY FEES					
(1 MINUS 2)	$1,135,000	$1,035,000	$1,485,000	$1,925,000	$1,853,250
4. ESTIMATED STORMWATER UTILITY					
Number of ERUs	47,952	49,391	50,873	52,399	53,971
Rate/Month/ERU	**$1.97**	**$1.75**	**$2.43**	**$3.06**	**$2.86**

Before committing to a stormwater utility fee, the municipality should identify whether a fee assistance program is needed and how the implementation of one would affect the estimated customer contributions. When determining the structure of a fee assistance program, many municipalities charge the fee to all properties and offer rate relief for those that qualify. These rate relief programs should be designed to fit the specific needs of a city and its citizens. Some municipalities implementing a large stormwater service fee have offered weaning assistance to property owners who are hit the hardest by the transition to the new fee structure, extending the time frame that the new fee becomes fully implemented. Other municipalities have offered discount programs for certain categories of property owners. Around 24 percent of utilities nationwide offer stormwater discounts for property owners considered elderly, low income, or disabled or for properties that qualify as educational institutions and religious organizations.[13] The expected adoption of assistance programs and fee waivers should be taken into account when calculating the stormwater fee funding necessary in order to maintain the targeted level of service.[14]

[12] Ed Beadenkopf & Christine Worley, URS Corporation. 2017. *The basics of stormwater utilities*. Web. http://www.mafsm.org/MAFSM/wp-content/uploads/2017/01/2008_SW_Utilities.pdf.

[13] Black and Veatch, 2016 Stormwater Utility Survey, at 15, available at https://pages.bv.com/rs/916-IZV611/images/2016-Stormwater-Utility-Survey.pdf.

[14] Hammer, R., Valderrama, A. 2018. *Making it Rain; Effective Stormwater Fees Can Create Jobs, Build Infrastructure, and Drive Investment in Local Communities*. NRDC. Web. https://www.nrdc.org/resources/making-it-rain-effective-stormwater-fees-can-create-jobs-build-infrastructure-and-drive.

Stormwater Credit Programs

To make stormwater management services voluntary, many utilities offer a credit program that incentivizes property owners to retrofit and install green infrastructure or other stormwater management structures on their property. Utilizing property area for approved BMPs, such as infiltration basins, permeable pavers, or manufactured treatment devices, lessons the capacity on the municipal stormwater system by capturing runoff before it enters the storm sewer system while improving water quality.

These resulting improvements in pollution and runoff impact can be related to the chosen fee structure in order to determine the appropriate fee rate reductions. Credits can also be designed to include educational programs for residents, businesses and municipal employees. Cities have the flexibility to set up these programs to align with region specific stormwater concerns and needs, their developed fee structure, and the budget available for the oversight of the program.

Traverse City's Stormwater Ordinance

Overview of Existing Ordinance

The City of Traverse City's existing stormwater control ordinance requires that on-site stormwater control facilities be constructed to treat for water quality and flood control.[15] The ordinance outlines a general requirement of treating 2.5 inches of rain over all impervious surfaces to treat for water quality, while flood control practices must pass the 10-year storm event. The ordinance also requires a minimum treatment of the first-flush, equivalent to the first one-half inch of runoff. Furthermore, where a downstream outlet such as an open channel or storm sewer is unacceptable, a flood control BMP shall be installed such that the increase in runoff volume generated by the proposed project is stored. The required volume shall be calculated by compared the undeveloped to developed condition for the 25-year, 24 hour frequency storm event.

Despite the existing stormwater ordinance, in practice, the ordinance is more discretionary. In the downtown area, it is in the interest of the developer to maximize their building footprint, and therefore impervious area. This practice can make stormwater treatment more complicated and require turning to more unconventional and expensive methods such as sub-surface storage or green roofs. Because of this, the City will negotiate an in-lieu payment in exchange for a waiver to the stormwater ordinance. The City is then able to use these funds at the developer's behalf to treat stormwater in another area.

Using this discretionary method of enforcing the stormwater ordinance is positive in the sense that the City is able to obtain more money for stormwater projects. However, this method is also inequitable between developers and not fully transparent. Furthermore, there is currently no method of tracking the negotiated payment in association to the amount of area that is not being treated.

Stormwater Utility Recommendations for Traverse City Downtown District

In conjunction with the City of Traverse City, OHM Advisors developed a Stormwater Asset Management Plan in 2017.[16] This document analyzed the existing stormwater conveyance system including the structural condition of storm sewer pipes, manholes, catch basins, and outfalls. OHM then created a model of the existing storm sewer system to identify undersized pipes. Based on their analysis of the existing system, OHM developed a plan for future work to be done on the storm sewer system which includes the operation and maintenance of the existing system,

[15] City of Traverse City. 2004. *Traverse City Ground-Water Protection and Storm-Water Control Ordinance Guidelines*. Web. http://www.traversecitymi.gov/downloads/stormwater_ordinance_guidelines.pdf

[16] OHM Advisors. *Traverse City Stormwater Asset Management Plan.* 2017. Web. http://www.traversecitymi.gov/downloads/final_compiled_tc_sw_amp.pdf.

replacement of aging infrastructure, and the installation of volume and pollutant control structural best management practices (BMPs) for stormwater treatment. By identifying a detailed list of needed investments for the City's storm sewer system, OHM Advisors came up with a proposed budget.

OHM Advisors also identified the average amount of impervious area for a single household residence in the area, called an equivalent residential unit (ERU). Then, the total amount of ERUs for the entire City of Traverse City was calculated. OHM then took the difference between the proposed and existing stormwater budgets, and divided by the total number of ERUs in the City. The study findings show that a monthly fee of $7 per ERU will close the gap between the existing and proposed stormwater budgets.[17]

This study, including the existing infrastructure assessment and proposed budget, will provide a framework for the capital improvement plan presented in this report. There are three schedules for the proposed capital improvement plan: the preferred schedule of five years which is based on the stormwater utility fee proposed in the Stormwater Asset Management Plan, an aggressive schedule of three years, and a relaxed schedule of ten years. These three capital improvement plans are discussed in more detail later in this report.

It is also recommended that the city employ an incentive program for property owners to implement their own stormwater treatment. By offering an incentive, such as a reduction in the monthly fee, the City can strive to meet their water quality treatment goals while engaging stakeholders. By engaging property owners with the management of their stormwater, a sense of ownership will be instilled in the community as well as an additional opportunity for educating the public.

Barriers to Implementing Stormwater Ordinance in Downtown Area

As with any new ordinance or fee, public criticism is anticipated to arise. Although the proposed stormwater fee structure does impose a monthly fee on residences and businesses in the Traverse City area, by comparing the cost of the stormwater utility fee to other fees already incurred by property owners, it can be seen as a relatively low cost. It will be essential to educate the public on precisely where their fee dollars will be going through specific project examples and offer community benefits such as enhanced landscaping, improved aesthetics, lowering the potential for beach closures, etc. in addition to water quality benefits.

[17] OHM Advisors. *Traverse City Stormwater Asset Management Plan.* 2017. Web. http://www.traversecitymi.gov/downloads/final_compiled_tc_sw_amp.pdf.

Watershed Characterization

Approach

In order to define potential improvements to the stormwater management system in Traverse City's TIF 97 district, an analysis has been performed using site observation, an ArcMap Geographic Information Systems (GIS) model, and site characteristics such as: land use, soils, contamination, water table, and receiving water data.

TIF 97 District

The Traverse City Downtown Development Authority (DDA) was created in 1978 by ordinance of Traverse City for the purpose of ensuring healthy growth and development of the community's downtown district. The TIF 97 district was developed in 1997 by requirement of the tax increment financing and development plan implemented by the Traverse City DDA. This plan was designed and implemented to provide funds for designated public improvements through the use of Tax Increment Financing (TIF). It has addressed issues regarding economic development, pedestrian experience, land use, and historic preservation in the TIF 97 District. The purpose of this stormwater management plan is to identify the needs and opportunities for stormwater infrastructure in this same region.

The TIF 97 District is located south of West Grand Traverse Bay and its boundaries encompass a majority of Traverse City's downtown area. Bordered on the west by N Oak Street and on the east by Railroad Avenue, the TIF 97 district stretches from the coast of the bay to Boardman River and Washington Street. **Figure 1**, below, highlights the TIF 97 District in green.

Model Approach

In order to the analyze existing stormwater impacts on the TIF 97 District and the expected outcomes of potential stormwater management opportunities, a model of the region was created in ArcMap GIS. This model organized the developed and natural attributes of the TIF 97 District acquired from database information from multiple sources. Parcel and zoning information, land use area data, and storm and sanitary sewer location databases were obtained from the Department of Public Services for the City of Traverse City for the downtown district specifically. Data regarding the geological attributes of the region was obtained from the United States Department of Agriculture (USDA) site. This information was viewed using the Soil Data Viewer add in on ArcMap GIS and can be used to determine the suitability for green infrastructure opportunities on the site. Michigan GIS Open Data downloads provided wetland, hydrography, road, and railroad data for the site. Imagery of the site was obtained from Google Earth. **Figure 2** shows several layers of key infrastructure in the TIF 97 District.

Land Use

The TIF 97 District area is approximately 141 acres and accommodates buildings, roads, parking lots, sidewalks, and green space, as well as the Boardman River and West Traverse Bay beachfront. **Table 4**, below, outlines the division of land use for the TIF 97 district. Two thirds of the total area is impervious with the largest contributions of impervious area comprised of parking lots, buildings, and roads. The remaining third of the region consists primarily of green space with a quarter of this area being water (the Boardman River) and beachfront along West Grand Traverse Bay.

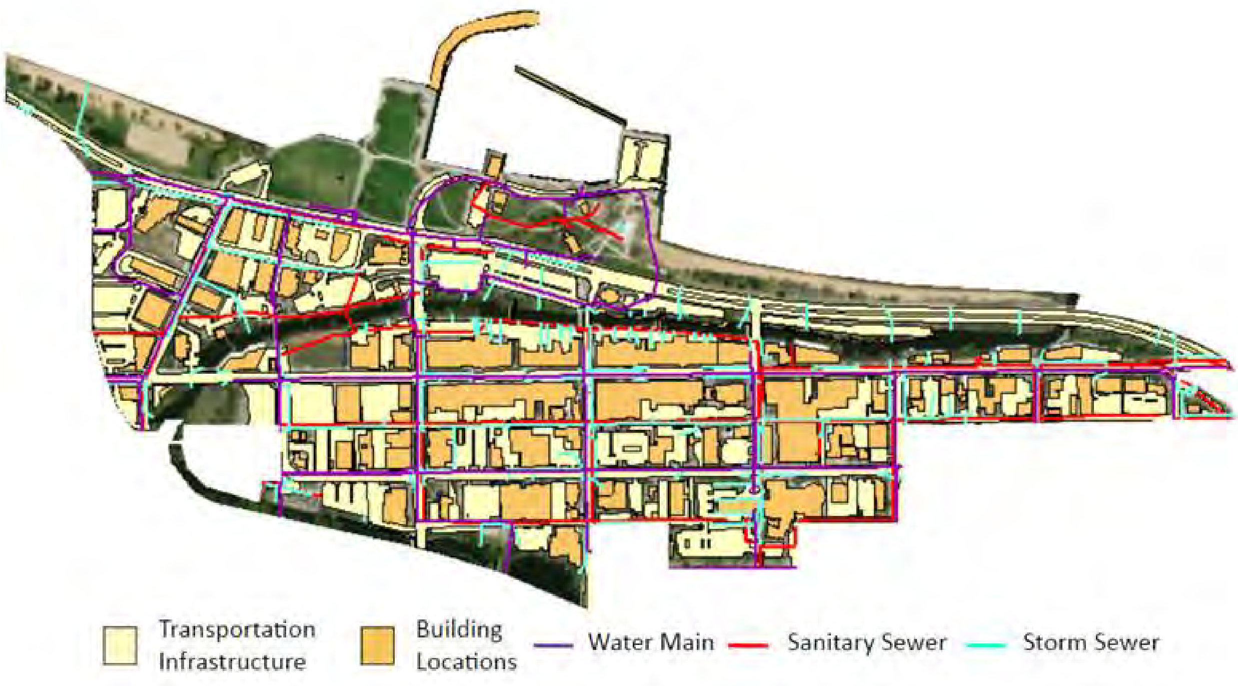

Figure 2. GIS Sample Model – City Data

Table 8. TIF 97 Land Use Values

Building		
Roof	23.7 acres	16.8%
Other(patio/deck/pier/dock)	2.6 acres	1.8%
Subtotal, Building Area = 26.3 acres		***18.7%***
Transportation		
Road	22.6 acres	16%
Alley	2.2 acres	1.6%
Parking	27.1 acres	19.2%
Sidewalk	13.1 acres	9.3%
Other(median/parking island)	2.1 acres	1.4%
Subtotal, Transportation Area = 67.0 acres		***47.5%***
Subtotal, Impervious Area (Building + Transportation) = 93.3 acres		***66.2%***
Green Space	35.9 acres	25.5%
Water (Boardman River)	8.6 acres	6.1%
Beach	3.2 acres	2.3%
Subtotal, Pervious Area = 47.7 acres		***33.8%***
Total,141 acres		**100%**

Soils

The soil data for the TIF 97 region was accessed through the United States Department of Agriculture (USDA) database. The primary soil type for the region is Lake Beach and Eastport Sand with a small amount of Roscommon mucky loamy sand. **Figure 4** shows the proportion of the soils in the region and where they are located in the TIF 97 District. **Table 5** outlines the characteristics for each type of sand present in the TIF 97 region.

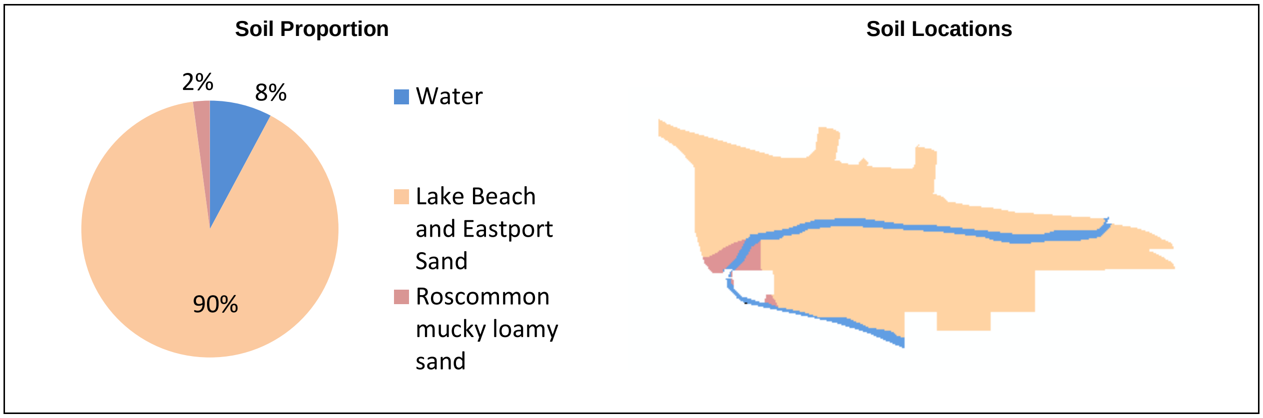

Figure 3. Classification, Proportion, and Location of Soil Types in TIF 97 District

Table 9. TIF 97 District Soil Characteristics

Soil Characteristics	Lake Beach And Eastport Sand	Roscommon Mucky Loamy Sand
Landform	Beach ridges, dunes	Depressions on lake plains, depressions on outwash plains
Slopes	0 to 6 percent	0 to 2 percent
Hydrological soil group	A	A/D
Natural drainage class	Excessively drained	Poorly drained
Depth to water table	More than 80 inches	About 0 inches
Ksat – *Capacity of the most limiting layer to transmit water*	High to very high (5.95 to 19.98 in/hr)	High to very high (5.95 to 19.98 in/hr)
Frequency of ponding	None	Frequent
Frost-free period	70 to 150 days	70 to 140 days
Typical Profile	0 to 60 inchers: sand	0 to 3 inches: mucky loamy sand 3 to 60 inches: sand

Due to its well-drained drainage class, Lake Beach and Eastport Sand, in general, accommodate many of the design requirements for stormwater control measures and shows good potential for green infrastructure development in the TIF 97 District.

Existing Site Contamination

Brownfield Redevelopment and Environmental Management information was found through the Michigan Department of Environmental Quality's Environmental Mapper system. It is important to be aware of existing contamination when planning for the installation of stormwater best management practices. Because these systems facilitate the infiltration of stormwater into the ground, it is not suggested that they be placed near contaminated soils or underground storage facilities. Doing so may enable contaminations to migrate, endangering surrounded soils and water supplies. In general, the TIF97 area has several sites with open "Notice of Approved Environmental

Remediation". These include two active tanks, and several leaking underground storage tanks that are regulated under Part 213. See **Appendix A** for an assessment of existing contamination.

Water Table

Since many structural best management practices rely on infiltrating stormwater through the ground, it is important for the water table to be several feet below the bottom of the BMP to ensure proper drainage. Since the water table fluctuates seasonally and annually, it is also important to include a few feet (1-3) as a factor of safety when determining the maximum depth of the BMP. See **Figure 5** for the distance to the water table in the TIF 97 area. Note that the area within the dark green has very shallow groundwater and further investigation should be done if infiltration practices are selected in these areas. The area in the light green which represents between 9 and 28 ft. to groundwater should be acceptable for the placement of infiltration BMPs. But, again, further investigation should be done when selecting for and designing BMPs to validate the water table.

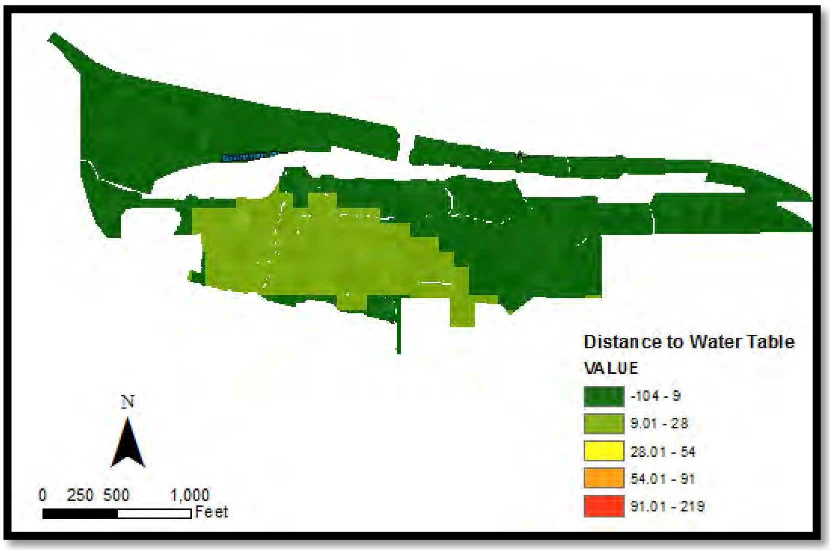

Figure 4. TIF 97 District Depth to Water Table

Receiving Waters

Stormwater runoff in the TIF 97 district either enters the Traverse City sanitary sewer system where it is transported to the City-owned Water Reclamation Facility for treatment or enters the storm sewer system where it is discharged into the surrounding water bodies. In some cases, stormwater falling on the site may runoff the site and drain directly into the Boardman River and West Grand Traverse Bay. **Figure 6** below identifies the contributing watershed areas for the each of the city's discharge points, as presented in the City's Stormwater Management Report. [18]

[18] City of Traverse City Engineering Department. 2007. *2007 Stormwater Management Report*. Web. http://www.traversecitymi.gov/downloads/2007_report_ver_2016_updated_282016.pdf

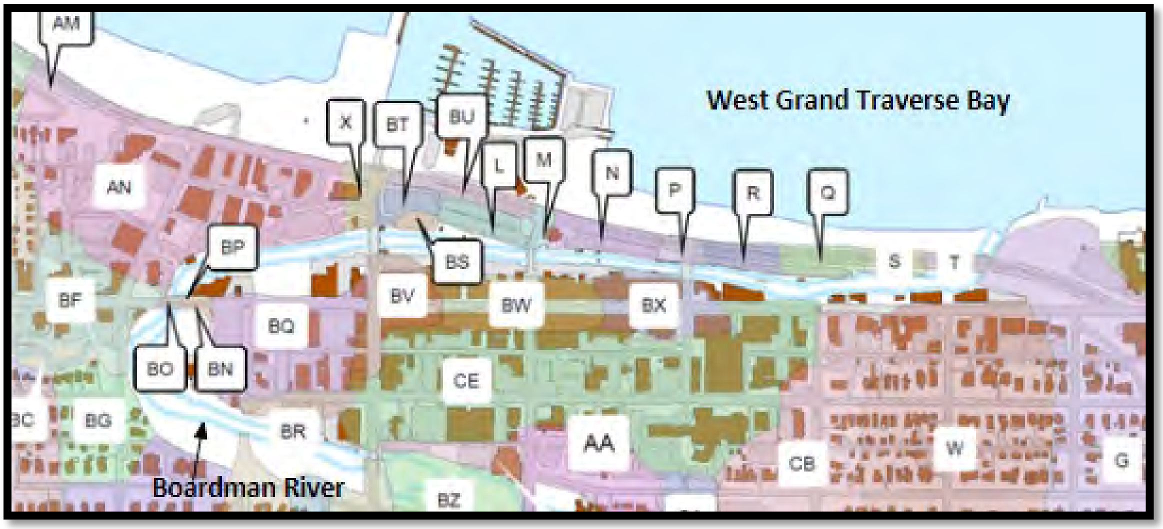

Figure 5. Drainage Areas in TIF 97 Outlet into Boardman River and West Grand Traverse Bay

Observation Approach

In addition to the desktop analysis of TIF 97, AECOM and Drummond Carpenter staff completed a site walk of the TIF 97 district during which the goals were to identify non-diffuse pollutant sources, determine areas of opportunity for the development of stormwater best management practices (BMPs), note new developments, and validate watershed boundaries. Site observation data was collected by taking notes and photos. This information was then plotted into the GIS model. **Figure 6** and **Figure 7** depict the collected data points. The sections below describe the pollutant sources that were located and the opportunities that were identified during the site walk.

Figure 6. GIS Model with West Site Walk Data Points

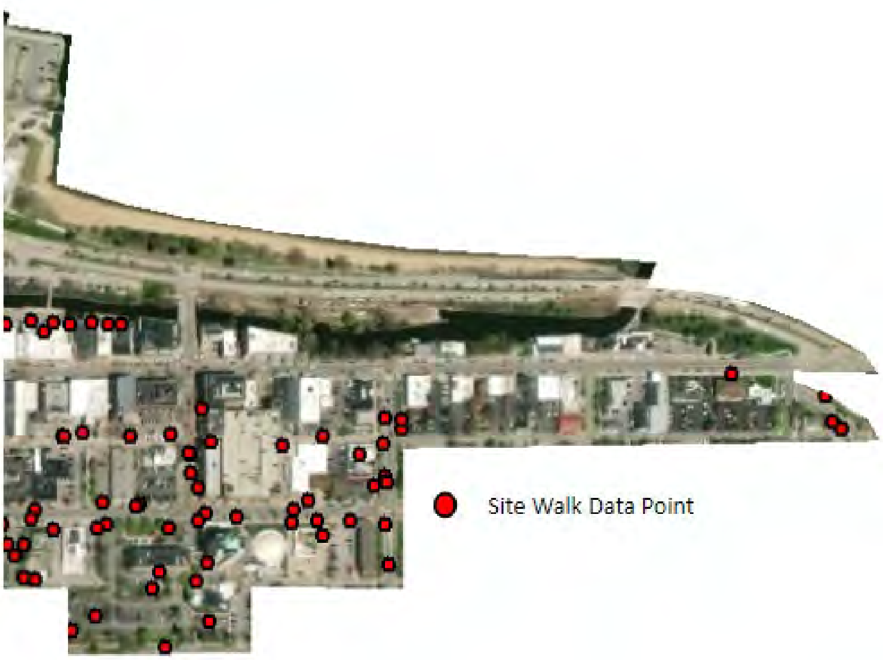

Figure 7. GIS Model with West Site Walk Data Points

Pollutant Sources

Common pollutants that can enter stormwater runoff and impair receiving waters and community health include suspended solids, nitrogen and phosphorus, pathogens and bacteria, metals, and oil and gas. The adverse effects of these pollutants include:

- Suspended particles that block the sunlight from penetrating water limiting the growth of aquatic species
- Heavy metals that can be toxic to marine life and humans
- Organic matter and nutrients that create algae and deplete dissolved oxygen in water
- Bacteria and disease causing organisms carried by urban storm water runoff into waters used for water supplies, fishing and recreation

While most of these pollutants are commonly found throughout an urban region, location specific pollutant sources should be examined before selecting a method of stormwater control to incorporate into the area. **Table 7** lists the typical sources of these contaminants.

Table 10. Contaminant Sources for Urban Pollutants [19]

Contaminant	Contaminant Sources
Suspended Solids	Streets, lawns, driveways, roads, construction activities, drainage channel erosion … atmospheric deposition
Nitrogen	Lawn fertilizers, automobile exhaust, soil erosion, animal and yard waste, detergents, atmospheric deposition
Phosphorous	
Pathogens/bacteria	Septic systems, animal waste, leaky sanitary lines, lawns, roads
Metals	Automobiles, bridges, industrial areas, soil erosion, corroding metal surfaces, atmospheric deposition
Oil and Gas	Roads, driveways, parking lots, vehicle maintenance areas, gas stations

The primary stormwater pollutants in this area that can enter waterways and air originate from parking lots, roadways, and rooftops. Other non-diffuse pollutant sources include restaurants, outdoor eating locations, dumpsters, sediment deposits, and dry cleaners. See **Figure 8** the locations of several pollutant sources in the TIF 97 District.

[19] United States Environmental Protection Agency. 1999. Preliminary Data Summary of Urban Storm Water Best Management Practices. Web. https://www.epa.gov/sites/production/files/2015-11/documents/urban-stormwater-bmps_preliminary-study_1999.pdf

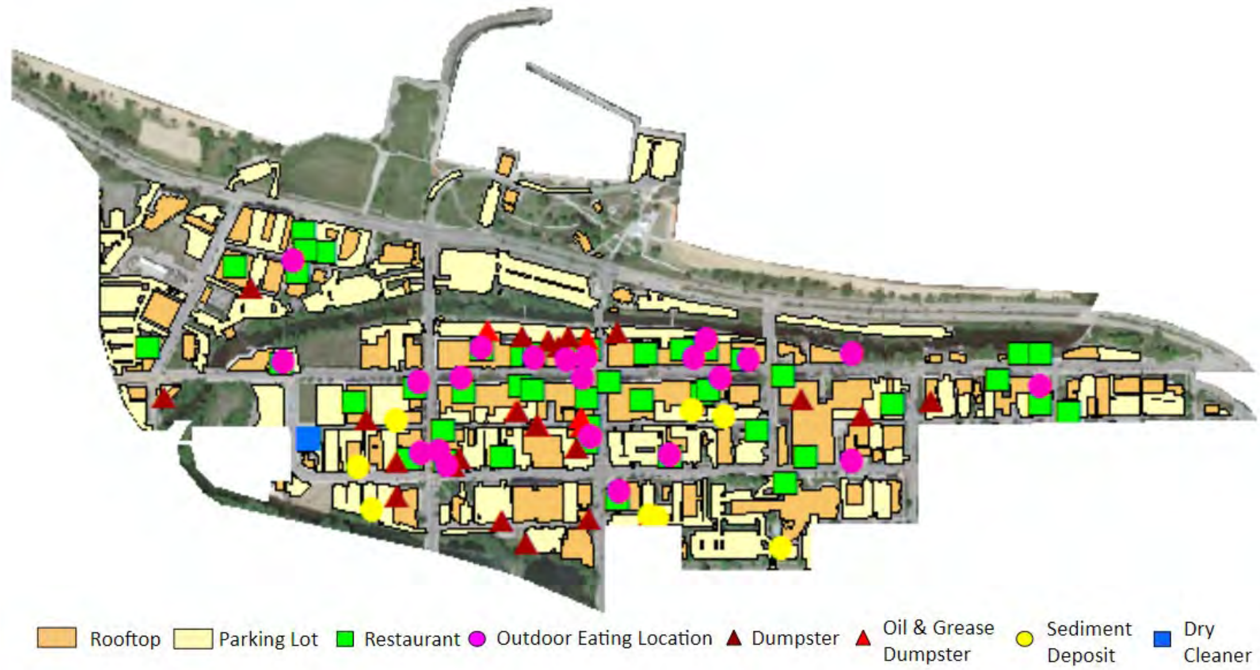

Figure 8. Pollutant Source Type and Locations in TIF 97 District

Non-Diffuse Pollutant Sources

A non-diffuse pollution source is defined as a single identifiable source of pollution. Non-diffuse sources of pollution in the TIF 97 District include: dumpsters, outdoor eating locations, sediment deposits, restaurants, and dry cleaners. A discussion of each of these non-diffuse sources of pollution is presented below.

Dumpsters

The downtown Traverse City area is comprised of commercial spaces and restaurants. There are many dumpsters in this area to accommodate waste from these businesses, including receptacles specifically designed for oil and grease. When left uncovered, these dumpsters can become a concerning source of pollution, especially if the dumpster stores oil and grease. In addition to contaminants found in traditional dumpsters including food waste and organic materials, oil and grease dumpsters, pollutants that are detrimental to the environment. During the initial site walk of the TIF 97 District, 28 dumpsters were located, 7 of which were designed specifically for oil and grease. See **Figure 9** for more detail.

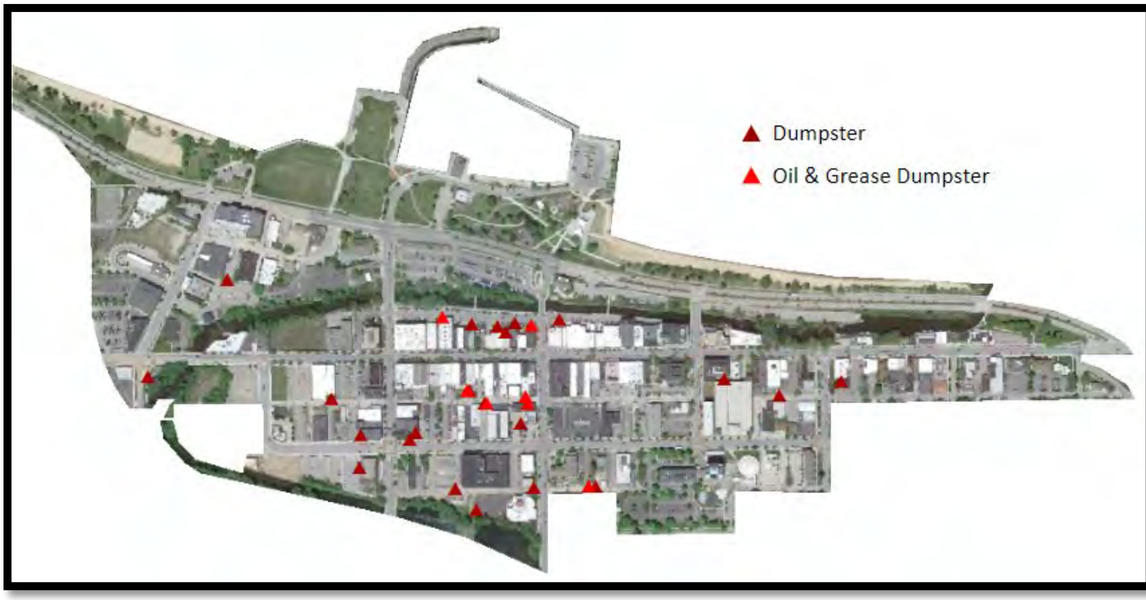

Figure 9. Dumpster Locations in TIF 97 District

Outdoor Eating Locations

Areas designed for outdoor dining are also a potential pollutant source because food waste, oil and grease, non-biodegradable cleaners, and other trash can contaminate stormwater runoff can easily enter the environment and be washed into water bodies during storm events. Furthermore, in the presence of food, animals and, therefore, animal waste can increase in these areas. During the initial site walk of the TIF 97 district, 22 locations were found with outdoor seating areas. See **Figure 10** for more detail.

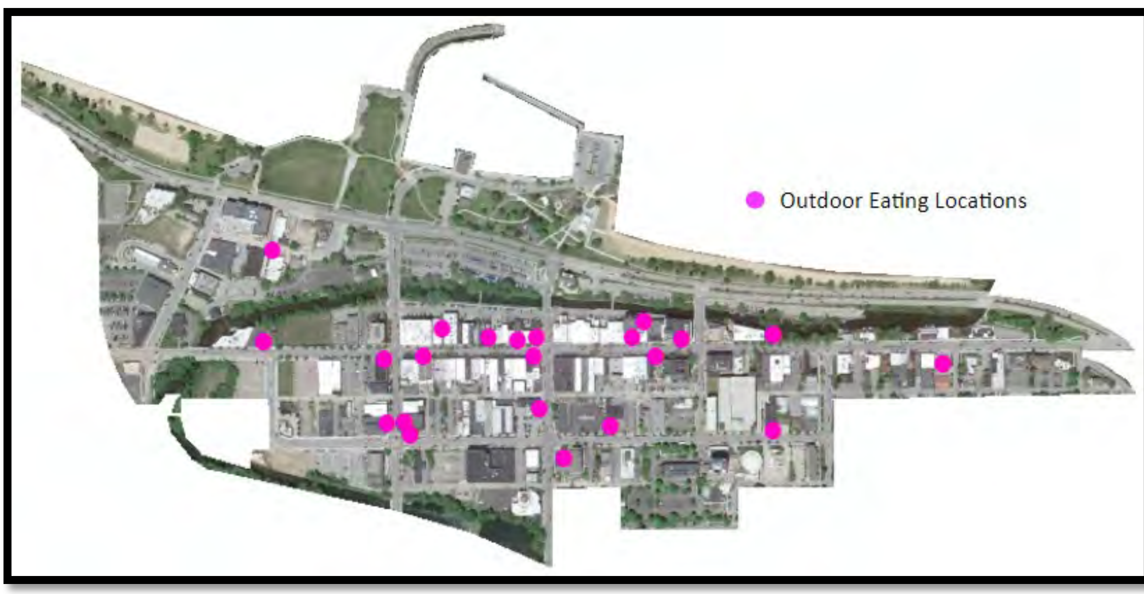

Figure 10. Outdoor Eating Locations in TIF 97 District

Sediment Deposits

During the initial site walk of TIF 97, several sediment deposits were found. These deposits have the potential to become a pollutant source during a storm event, which can impair the quality of receiving waters. **Figure 11** and **Figure 12** depict some of the sediment sources found in the TIF 97 District. The sediment deposits found during the site walk tended to be located near and around storm sewer catch basins in parking lots, dumpsters, alleyways, and areas of construction. A total of eight sediment deposits were found during the site walk, as shown in **Figure 13**.

Figure 11. Sediment in Alley

Figure 12. New Construction Sediment Deposit at the corner of W Front St and Pine St

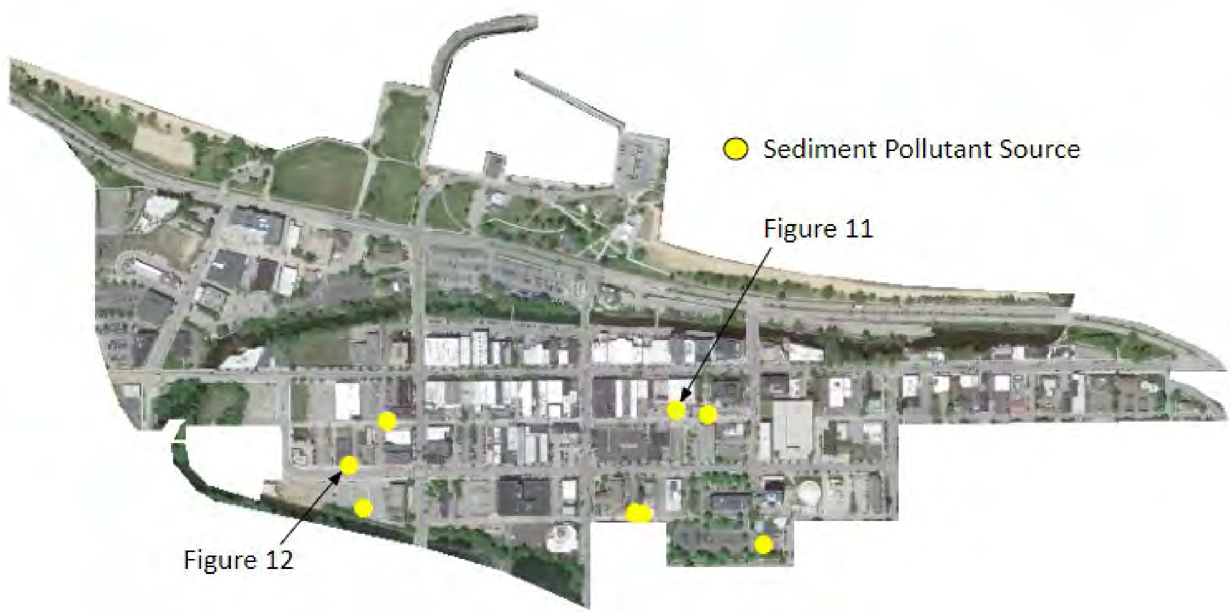

Figure 13. Sediment Deposit Locations in TIF 97 District

Dry Cleaning

There is a single dry cleaner located within TIF 97. According to the Environmental Protection Agency (EPA), the primary cleaning solvent used by dry cleaning operations is Perchloroethylene (PERC) which is a powerful antioxidant and can be released to the environment through the air, water, land, or groundwater. Although most dry cleaners use a small amount of this chemical annually, the cumulative impact from the facilities can be significant. In addition to ensuring proper chemical storage, using environmentally friendly alternatives is an option for ensuring these facilities do not negatively impact air and water quality.[20]

Diffuse Pollutant Sources

Diffuse source pollution is any source of pollution that cannot be traced to a single source. Primary examples of diffuse sources including parking lots, rooftops, and roads. These surfaces can collect sediment which pollutants (including heavy metals and hydrocarbons) sorb to. During storm events, these particles as well as the attached pollutants can flush into water bodies.

Transportation-Related Pollutant Sources

Parking lots and roadways are sources of pollution due and can accumulate heavy metals and other toxins that are residual from the presence of cars in these areas. In the TIF 97 District, 27.1 acres, or 19.2%, of land is covered by parking lots, and an additional 24.8 acres, or 17.6%, is covered by roads and alleyways. Additionally, miscellaneous transportation surfaces such as sidewalks, medians, and parking islands cover 15.2 acres of area, or 10.7%, of the TIF 97 area. See **Figure 14** for detail.

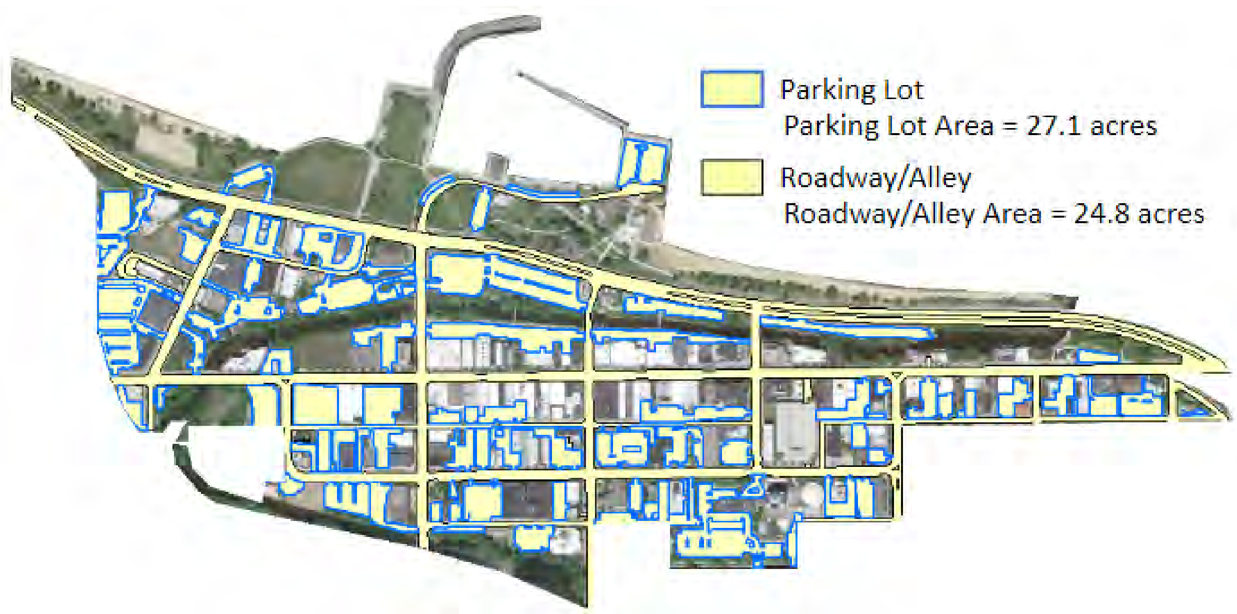

Figure 14. Parking Lot Locations in TIF 97 District

[20] Environmental Protection Agency. 2016. *Dry Cleaning Sector*. Web. https://www.epa.gov/sites/production/files/2016-04/documents/dry_cleaning_final_v4.pdf.

Rooftop Pollutant Sources

In the TIF 97 District, roughly 23.7 acres or 17% of the land area is comprised of buildings. Stormwater which falls on buildings roofs each year can accumulate heavy metals that can be found in roofing materials. This pollutant source can be minimized by lessening the surface area of buildings and roof, using newer, environmentally conscious roofing materials, and by retrofitting these roofs with green roofs. **Figure 15** shows the locations of all rooftops in TIF 97.

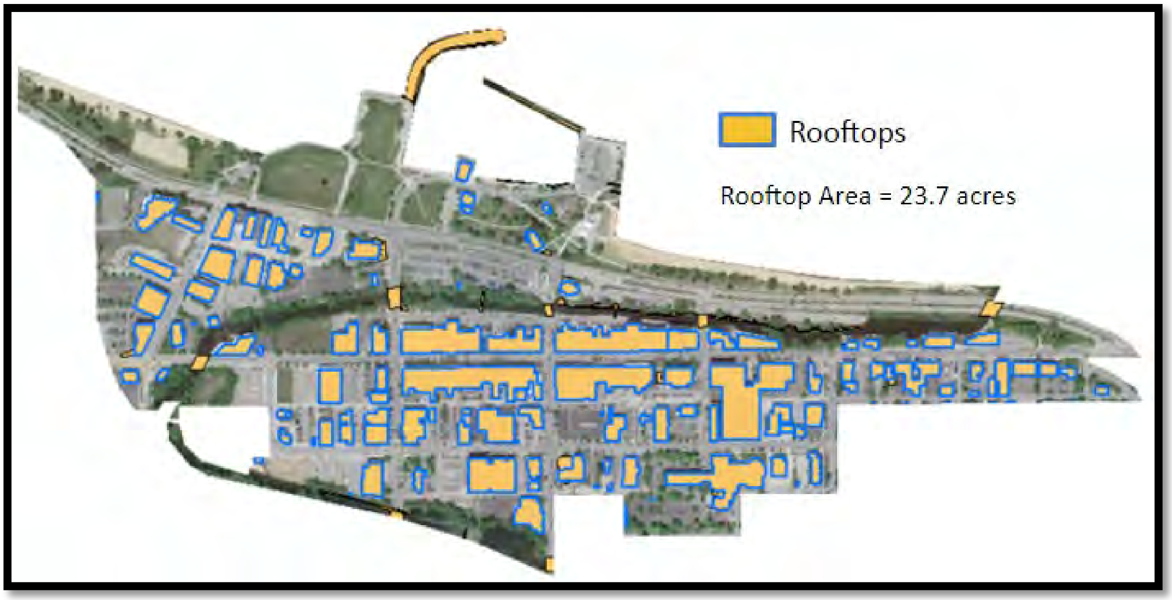

Figure 15. Rooftop Locations in TIF 97 District

Potential Stormwater BMPs for Downtown District

This section will detail the selection criteria for stormwater BMPs and the types and descriptions of the BMPs designed to meet these criteria.

BMP Characteristics

Stormwater BMPs are designed and implemented to serve purposes critical to managing urban stormwater runoff. BMP design objectives include:

- Reducing the volume of stormwater runoff entering the sewer system after storm events.
- Minimizing peak discharge (the maximum flow rate of runoff entering the storm/sanitary sewer system).
- Improving the quality of water going into the system and the environment.

Cities with combined sanitary and sewer systems focus on achieving the first two objectives due to the tendency for sewer water discharges to the environment when the system reaches capacity. While these objectives also hold importance in relation to the Traverse City municipal storm sewer system, the third objective carries the most weight in the BMP type decision making process. Traverse City's vast water supplies are critical to the health and livelihood of the city and can be greatly impacted by the quality of the entering stormwater. Therefore, it is recommended that the City focus on BMPs which have medium to high water quality treatment capabilities. **Table 12** has a comparison of the most commonly used BMPs and the level at which they meet each objective.

Table 11. Pollutant Removal Efficiencies of BMPs [21]

BMP Type	Stormwater Quality Function - Typical Pollutant Removal				Stormwater Quantity Function	
	Suspended Solids	Nitrogen	Phosphorous	Oil/Gas	Peak Rate	Volume Reduction
Infiltration Basin	HIGH	MED	MED/HIGH	-	HIGH	HIGH
Pervious Pavement	HIGH	LOW	MED/HIGH	-	HIGH	HIGH
Bioretention (Rain Garden)	HIGH	MED	MED	-	MED	MED/HIGH
Dry Well	HIGH	LOW/MED	MED/HIGH	-	MED	MED
Green Roof	MED	MED	MED	-	MED	M ED/HIGH
Manufactured Treatment Device	VARIES	VARIES	VARIES	HIGH	-	-
Vegetated Swale	HIGH	LOW-HIGH	MED	-	LOW/MED	LOW/MED
Subsurface Infiltration Bed	HIGH	LOW	MED/HIGH	-	HIGH	HIGH
Tree Box Infiltration	HIGH	HIGH	HIGH	-	-	-
Downspout Planter Box	MED	LOW/MED	LOW/MED	-	MED	HIGH

See **Appendix B** and the individual BMP descriptions, below, for more details about each BMP type presented.

[21] Southeast Michigan Council of Governments. 2008. Low impact development manual for Michigan: a design guide for implementers and reviewers. Web. https://semcog.org/Reports/LID/files/assets/basic-html/page-1.html

Rain Gardens

Background

Rain gardens, also called bioretention cells, are shallow, vegetated basins that collect and absorb stormwater runoff from rooftops, sidewalks, and streets. Stormwater is allowed to slowly seep back into the ground, and pollutants (particularly nitrogen and phosphorous) are captured by plantings. This BMP reduces stormwater runoff, improves water quality, and enhances landscapes. Nearby streams and lakes are preserved because stormwater runoff and pollutants are trapped by the rain garden. Rain gardens with native plant selections also require fewer chemicals than turf grass lawns and even regular gardens, further improving the quality of infiltrating water. Furthermore, rain gardens offer a habitat for insects and birds. See **Figure 16**, below, for a conceptual rendering of a rain garden.

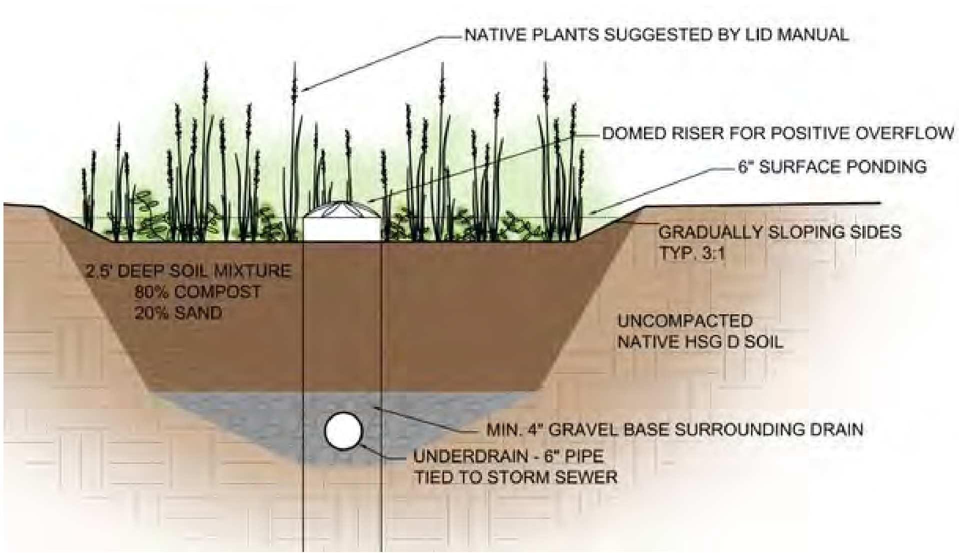

Figure 16. Conceptual Rendering of a Rain Garden (Drawing From Drummond Carpenter)

Use in TIF 97 District

Rain gardens are flexible in design, including shape and size, which make them desirable for use in urban areas. They can be incorporated into parking lots, placed along roads and sidewalks, and used in larger open green spaces to capture, filter, and infiltrate the stormwater runoff from the surrounding regions. Rain gardens are suitable for the TIF 97 district due to the well-draining soils and space constraints.

Benefits

Scientific literature discusses how rain gardens are effective at the removal of pollutants. In one such study, nitrate removal was 78% and lead removal was over 90%.[22] Rain gardens are also landscape features which improve the aesthetics of an area while also treating stormwater. Because rain gardens are often placed in areas with high visibility, they also offer an opportunity to educate the public about stormwater management.

[22] Davis, A., Stack, R., Kangas, P., Angle, J. 2001. Water quality improvement using rain gardens: University of Maryland studies. Web. http://www.swrcb.ca.gov/rwqcb2/water_issues/programs/stormwater/muni/mrp/rain%20garden%20quality%2004-11.pdf

Considerations

A typical rain garden will have an engineered soil mixture, deep-rooted native plants and grasses, and an overflow structure that will lead to an outlet, if needed. Rain gardens may or may not have a liner or filter fabric, depending on the condition of site soils. These systems are typically designed to drain within four hours after a 1" rain event. Therefore, selected plants must be able to withstand flooding and drought.

Rain gardens can be designed such that they are appropriate for construction in contaminated soils. All contaminated soils on the sides of the basin would be excavated and disposed of in a Type II landfill. An impermeable membrane layer would be placed between the garden and contaminated soils. The space remaining between the impermeable layer and the contaminated soils will be backfilled with clay to prevent water from infiltrating laterally. The bottom of the garden would extend to a depth below contaminated soils. This way, water would be allowed to infiltrate vertically into the ground via the bottom of the basin through clean soils.

Cost

Rain gardens are typically low cost and depending on the application and site conditions, can range from $20-30 per square foot.[23], [24]

Case Study

A series of rain gardens throughout the neighborhoods of St Paul, Minnesota has been proven effective in managing the area's stormwater. In this case, eight rain gardens were constructed to achieve water quality goals of reducing phosphorous loads to the downstream water body and eliminate residential flooding. The project budget was $20,000 for the design and $100,000 for construction. These rain gardens infiltrate 238,666 ft^3 of runoff and remove 3.72 lbs. of Total Phosphorous and 1,780 lbs. of TSS, annually. Residents of the area have noticed additional benefits such as community building and environmental education as a result of the rain gardens. [25]

A local rain garden installation in Suttons Bay, MI has also proven to be an effective way to treat stormwater. For this design, a total of 18 rain gardens were installed throughout the village, along with infiltration trenches and a wetland system installed at the outlet for additional treatment. The 18 rain gardens cost $86,000 for construction. The system as a whole was designed to capture 97.5% of all storm events. As a result of this project, a plume that was once visible after each rainfall events has been eliminated.[26]

Permeable Pavement

Background

A permeable pavement system consists of a porous pavement surface course placed over a porous media base course that serves as a storage reservoir placed over uncompact subgrade to facilitate stormwater infiltration. The base course storage reservoir may consist of a stone bed of uniformly graded, clean, and washed course aggregate with a void space of approximately 40 percent or other pre-manufactured structural storage units. The

[23] Brennan. A. Cost analysis of low impact development best management practices. Web. https://epa.ohio.gov/portals/41/storm_workshop/lid/crwp_lid_cost%20study.pdf

[24] University of Rhode Island. Create a rain garden: preventing water pollution in your community. Web. https://web.uri.edu/riss/files/Abridged_ServiceManual.pdf

[25] American Society of Landscape Architects. Green Infrastructure & Stormwater Management Case Study: Arlington Pascal Stormwater Improvement Project – Neighborhood Raingardens. Web. https://www.asla.org/uploadedFiles/CMS/Advocacy/Federal_Government_Affairs/Stormwater_Case_Studies/Stormwater%20Case%20193%20Arlington%20Pascal%20Stormwater%20Improvement%20Project%20-%20Neighborhood%20Raingardens,%20St%20Paul,%20MN.pdf.

[26] The Watershed Center Grand Traverse Bay. *Suttons Bay Stormwater Project*. Web. https://www.michigan.gov/documents/deq/5-Uren-Suttons_Bay_Rain_Gardens_491828_7.pdf.

pervious pavement system may consist of porous asphalt, pervious concrete, permeable paver blocks, or reinforced turf/gravel. However, the permeable paver blocks are the recommended system.

Pervious pavement can be substituted for traditional pavement in parking areas, sidewalks, and streets with lighter traffic. Systems are designed to treat water by removing pollutants such as total suspended solids, total phosphorous, motor oils, total nitrogen, zinc, and copper. These pollutants become trapped in the pervious pavement, preventing them from infiltrating into groundwater, while allowing stormwater to pass through. Pollutants containing hydrocarbons and metals are broken down by micro-organisms that grow inside paver void spaces. Pervious pavement also provides runoff quantity control. It acts solely as a conveyance measure that delivers the surface course runoff to the subgrade soils. In addition, the broken stone storage bed serves only to temporarily store the runoff transmitted through the surface course.

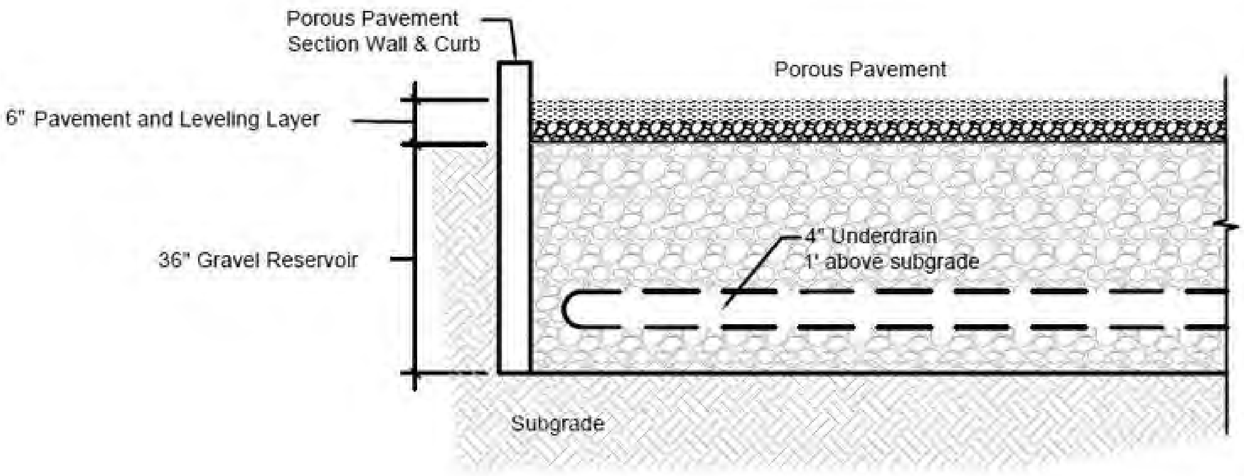

Figure 17. Permeable Pavement Cross Section, Figure from Drummond Carpenter

Use in TIF 97 District

Approximately two-thirds of the land area in the TIF 97 District is covered in an impervious surface. 29% of that area is used for parking while 24% is comprised of roadways. These statistics indicate that much of the entire TIF 97 District could be suitable for the installation of pervious pavement which can maximize nutrient removal from water before it reaches waterways and reduce rainwater runoff. Pervious pavement offers an opportunity to, in essence, reduce this amount of impermeable area, and mimic pre-development site conditions by allowing stormwater to infiltrate into the ground. These pavers are best in permeable soils with shallow or flat slopes. See **Figure 17** for locations identified that were identified as suitable for pervious pavements.

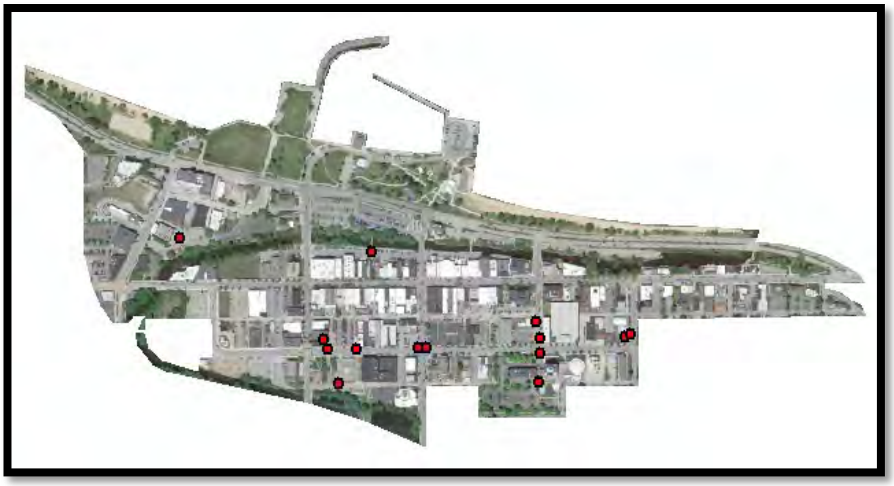

Figure 18. Potential Permeable Pavement Locations

Benefits

There are other advantages to pervious pavement, as well. This technology recharges underlying aquifers and reduces peak flows and flooding, contributing to healthier stream ecosystems. Furthermore, pervious pavers can increase road safety because they offer better skid resistance.

Pervious pavement systems can be designed such that they can be constructed in contaminated soils. If an impermeable layer were constructed between the bottom of the pervious pavers and contaminated soils, storm water would not be able to infiltrate. An underdrain within the pervious pavement layers would capture water and discharge to a drywell.

Considerations

If pervious pavement systems not properly designed and maintained, they can easily fail. These systems must be routinely vacuumed to prevent clogging and should be inspected several times following construction, and annually thereafter. Pervious pavement systems are also not appropriate for areas with heavy traffic flows. Pervious pavement systems are also more expensive than traditional pavement surfaces. Location is also a key consideration in the design of permeable paver system. Designing a system near a building foundation or basement is not appropriate.

Cost

Since permeable pavement is used as an alternative for impervious surface such as a roads, parking lots, and sidewalks, it is important to compare the costs of pervious materials with traditional paving materials. **Table 13** compares the costs, lifetime, and treatment capacity of different types of pervious and impervious material.

Table 12. Pavement Type Comparison

Pavement Type	Permeable Pavers	Permeable Concrete	Permeable Asphalt	Traditional Concrete	Traditional Asphalt
Materials Cost (per square foot)	$5-$10	$2-$7	$0.50-$1	$1-$3	$0.50-$1.5
Longevity	20-30 years	20-30 years	15-20 years	25-50	15-30
Permeability	2 feet per day	10 feet per day	6 feet per day	-	-
Stormwater volume retention	34-100%	99-100%	25-100%	-	-

Case Study

In 2009, the sidewalks along Marquette Ave in Minneapolis, pictured below in **Figure 18**, were retrofitted to better manage stormwater and maintain and improve the region's aesthetic qualities. The project included the construction of 15,000 square feet of permeable pavers in tandem with a bio filtration system and 190 trees. This system is designed to reduce stormwater runoff from the surrounding 5.5 acres and store 21,600 ft^2 of stormwater from each rain event. It also is expected to achieve the following pollutant removal efficiencies: 80% P, 60% total N, >90% metals.

Figure 19. Pervious Pavers in Sidewalk at Marquette Ave in Downtown Minneapolis

Tree Boxes

Background

Tree boxes are a type of surface infiltration that maintain or enhance aesthetics while adding stormwater infiltration and storage capabilities. Tree boxes allow for infiltration and storage in a confined linear space. The tree boxes are a combination of underground storage (in the form of media) interspersed with tree boxes that will provide storage and treatment, pictured below in **Figure 19** and **Figure 18.**[27] Stormwater not infiltrated or stored (i.e. overflow) will discharge into the existing storm sewer network. Using tree boxes maintains parking and pedestrian access while reducing stormwater runoff and total suspended solids.

Use in TIF 97 District

Storm trees, defined above as tree box infilitration (also called tree box filters), funtion as mini bioretention cells placed within an inlet drainage structure. The installation of storm trees, defined above as tree box infiltration, is an opportunity for stormwater management throughout the entire TIF 97 District. Each tree would not only help

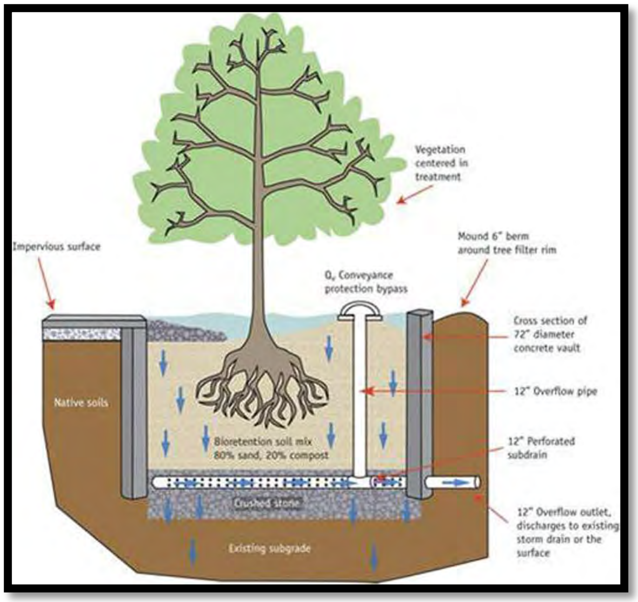

Figure 21. Tree Box Design

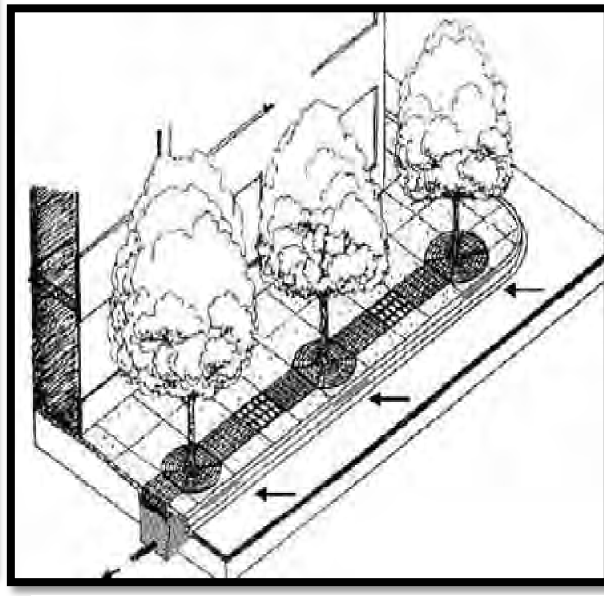

Figure 21. Underground Storage and Tree Box

reduce stormwater runoff, but also have a high treatment capacity for total suspended solids, metals, oils and grease, and pathogens. The latter water quality benefits are the main motivator for using this technology in the TIF 97 District and this focus . This focas on water which impacts the sizing design which does not have to be as large as a water runoff control BMP would need too.

This space saving consideration makes a tree box a good fit for an urban area such as this one. These trees also fit well into Traverse City's existing landscape as they can directly replace the trees that currently line many of the city streets. In the event of street retrofits and construction, storm trees can easily be incorporated into the design, thus making them a good option for achieving desired water quality and runoff control benefits. Unfortunately, many times, the trees used as part of tree box infiltration are shorter than city street trees which can compromise the visual apeal of the street landscaping. This concept is still relatively new, however, and new types of trees are being considered for use with this technology.

Benefits

According to testing of the StormTree system by a third party, these systems are expected to remove 85% of influent TSS, 48% of Nitrogen, 63% of Phosphorous, 60% of Total Metals and 85% of oil and grease.[28] Tree boxes can also be installed in contaminated soils. The sides of the box would be lined with an impermeable liner and

[27] University of New Hampshire, Stormwater Center. 2009. 2009 Biannual Report.
[28] StormTree. 2017. Web. http://www.storm-tree.com/index.html#about.

backfilled with clay to prevent water from infiltrating laterally. The bottom of the tree box would be placed below the depth of soil contamination so storm water could infiltrate into clean soils. This prevents stormwater from infiltrating laterally, but allows infiltration into clean soils. Contaminated soils that would need to be excavated to install the tree box must be disposed of in a Type II landfill. Clean soils would be placed within the tree box using a ratio of 80% sand and 20% compost.

Considerations

Safety is a key design element for street trees. Only areas for which the trees will not impede the vision of drivers or pedestrians at crosswalks. Additionally, street trees are best suited for streets which have existing curb and gutter or storm sewer systems.

Cost

The cost of a storm tree depends on the upstream drainage area, inlet configuration, and grate type. For the smallest and simplest storm tree configuration, the cost including installation is approximately $17,500.

Case Studies

The Maplewood Mall in Maplewood, Minnesota has a 35 acre parking lot which underwent redesign and reconstruction in 2009. The stormwater runoff was captured using 200 trees in tree trenches and another 175 trees placed in rain gardens. Stormwater tree trenches were designed using the Stockholm Tree Trench Method for Stormwater and utilized angular granite to support pavement over the trench. It was redesigned to capture one inch of runoff from 90 percent of the parking lot area. The design is also expected to reduce sediment loads by 90 percent and phosphorus loads by 60 percent.[29]

In a project completed by Drummond Carpenter and AECOM, six Storm Tree Boxes were installed along E Nagonaba St in Northport, MI. This project was implemented in a downtown area to enhance the streetscape and to capture stormwater runoff in an area with no existing storm sewer. The project also included an underground reservoir system to capture and infiltrate stormwater. Overall, the project was designed to capture and infiltrate a 1 inch rainfall event and to improve water quality in Grand Traverse Bay.

[29] Minnesota Pollution Control Agency. 2018. Case studies for tree trenches and tree boxes. Minnesota Stormwater Manual Case studies for infiltration. Web. https://stormwater.pca.state.mn.us/index.php?title=Case_studies_for_tree_trenches_and_tree_boxes

Figure 22. StormTree in Northport, MI, Photo by AECOM

Green Roofs

Background

Vegetated roofs, or green roofs, are conventional rooftops that include a thin covering of vegetation, allowing the roof to function more like a vegetated surface. The overall thickness of the vegetated roof may range from 2 to 12 inches, typically containing multiple layers consisting of waterproofing, synthetic insulation, non-soil engineered growth media, fabrics, synthetic components, and foliage.

There are two principal types of green roof systems: intensive and extensive. Intensive systems usually consist of large plants such as trees and shrubs growing in deep soil medium, **Figure 24**. Intensive systems may also include hard landscape elements such as heavy planters, pathways, and sitting areas to provide a pleasant user space for building occupants to enjoy outdoors. Intensive green roof systems typically have design loads in the range of 40 to 200 pounds per square foot which often require substantial structural upgrades to retrofit existing buildings. Extensive green roofs, **Figure 23**, consist of small plants in shallow trays with a lightweight growing medium. Additional features are generally limited to pavers and aggregates intended to provide a walking surface to service the trays. With design loads in the range of 10 to 40 pounds per square foot, these systems are often installed on existing roof structures. Determination of the viability of an extensive green roof retrofit requires a roof specific verification of building structural and membrane integrity.

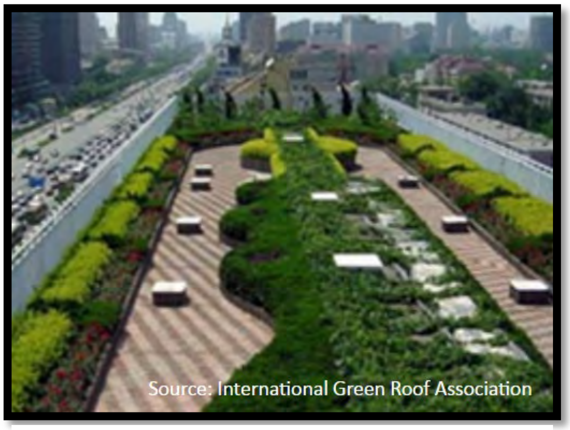

Figure 24. Intensive Green Roof System

Figure 23. Extensive Green Roof System

Use in the TIF 97 District

Green roof technology has the capacity to answer many of the stormwater management needs of cities by retaining and naturally filtering rainwater while also improving surrounding air quality, promoting energy efficiency, and diverting landfill waste along with accomplishing many other benefits. The premise of this technology is the reduction of impervious space from which many urban environmental and health concerns stem. This impervious space, rooftop area, being reduced is, in many cases, previously unused which further encourages its widespread adoption. However, in order to implement, green roofs require specific and more advanced roof and building structures as well as a large initial investment. These considerations can make green roofs harder BMPs to implement and are most likely why they are not commonly found in the TIF 97 District. Still, many cities and countries have successfully incorporated green roof technology to the point of being a common building feature and this technology. This technology certainly has potential in Traverse City which has a total of 23.7 acres of rooftop. See **Figure 25** for rooftop locations within TIF97.

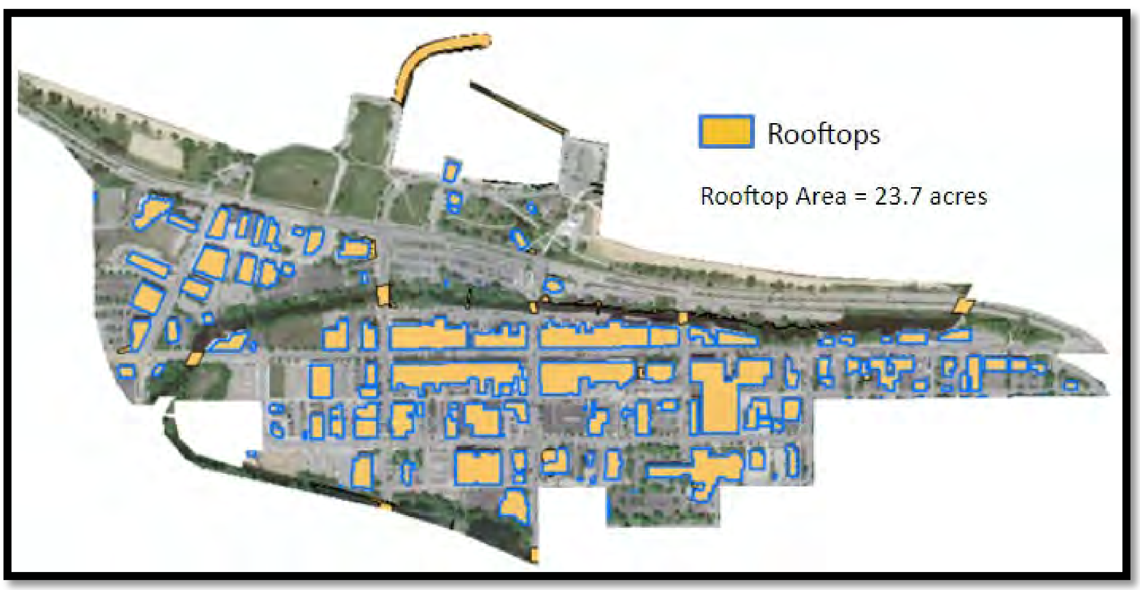

Figure 25. Rooftop Area in the TIF 97 District

The 23.7 acres of rooftops account for a quarter of the total impervious area in the TIF 97 District. Roughly 10 percent of this area is publically owned. It is estimated that, on average, 22% roof area is unusable for green room systems, due to space allocation for mechanical systems, it is estimated that 18.5 acres of space would be available for green roofs in TIF97.

The costs associated with the implementation of 18.5 acres of green roof are estimated to be between $12 million and $16 million. These estimates take into account the costs of structural analysis and the potential costs of roof replacement. They would be altered on a case by case basis.

Benefits

Establishing plant material on rooftops provides numerous ecological and economic benefits including stormwater management, energy conservation, mitigation of the urban heat island effect, increased longevity of roofing membranes, as well as providing a more aesthetically pleasing environment to work and live. Green roofs can also cool buildings compared to traditional roofs, see **Figure 26**.[30] A major benefit of green roofs is their ability to retain 60-100 percent of stormwater they receive. Green roofs also are able to remove 52% of ozone, 27% of nitrogen dioxide, and 14% of particulate matter.[31] In addition, green roofs have a longer life-span than standard roofs because they are protected from ultraviolet radiation and the extreme fluctuations in temperature that cause roof membranes to deteriorate. A vegetated roof has a life expectancy of 60 years, three times longer than a traditional roof.

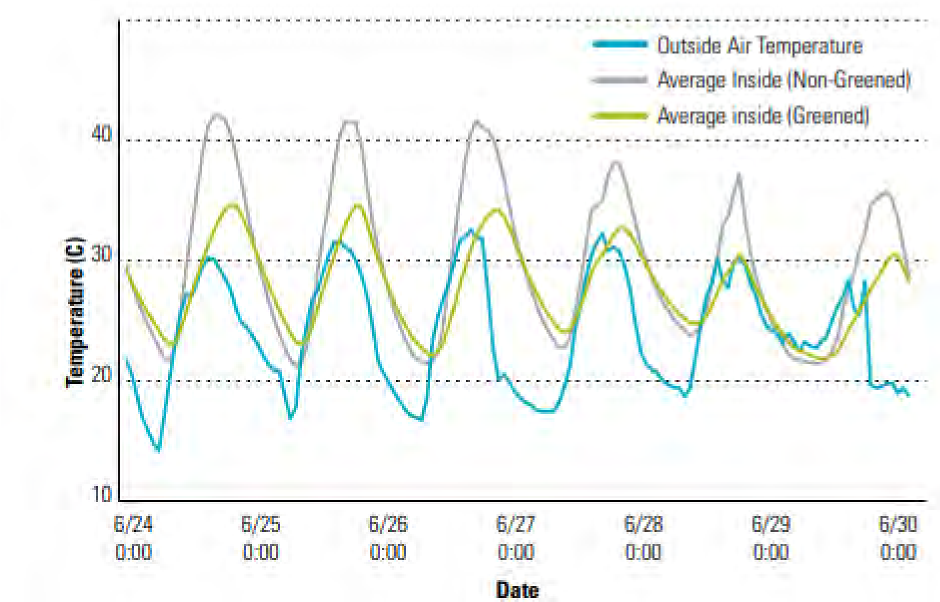

Figure 26. How Green Roofs Can Cool Buildings

Considerations

While a green roof can readily be incorporated into new construction, retrofitting an existing roof requires substantial investigation and analysis. The first step in retrofitting a building with a green roof is to determine the

[30] Penn State Center for Green Roof Research (2009). "Green Roof Fact Sheets: Air Conditioning,"
[31] Yang, J., Yu, Q., Gong, P. 2008. Quantifying air pollution removal by green roofs in Chicago. Atmospheric Environment. 4(31). p. 7226-7273.

existing structures load-bearing capacity. A green roof exerts additional load on the roof structure including dead loads (such as growing medium and mature plant) and live loads (such as wind, rain, snow and foot traffic). It is necessary to have a structural engineer review the existing building and roof structure to determine if there is extra load bearing capacity within the existing structural system. Since upgrade of the load bearing capacity of building structure or roof structure is often both technically difficult and cost prohibitive, a lack of excess load bearing capacity in the existing structure and roof often eliminates the possibility of a green roof retrofit.

Plant species is another key consideration for the success of green roofs. Factors in plan selection include local climate, and in particular the average high and low temperatures, rainfall, wind, and irradiance levels at the green roof site. Additionally, aesthetics, type and depth of media, and installation and maintenance methods will impact plant selection.[32]

Cost

Typical green roofs cost between $20 and $25 per square foot. Based on the constraints in place today for surface treatments these costs are not unreasonable.

Case Study

Chicago City Hall installed a 20,300 square foot green roof in 2001 to help mitigate urban heat island effect and improve air quality. In addition, it also reduces stormwater runoff and conserves energy within the building. The roof catches 75% of a 1 inch rainfall before releasing runoff into the sewers. This project is a retrofit consisting of 20,000 plants of more than 150 varieties of plants.[33,34]

Figure 27. Chicago City Hall Green Roof

In 2006, St. Clair County Community College became the first community college in the state to install a vegetated roof. Since then, four other vegetated roofs have been added on other buildings on campus as part of an extensive

[32] Getter, K., Rowe, B. 2008. Selecting plants for extensive green roofs in the United States. Michigan State University. Web. https://www.canr.msu.edu/uploads/resources/pdfs/selecting_plants_for_extensive_green_roofs_(e3047).pdf

[33] Greenroofs.com, LLC. 2019. Chicago City Hall. Web. https://www.greenroofs.com/projects/chicago-city-hall/

[34] City of Chicago. 2019. City Hall's Rooftop Garden. Web. https://www.chicago.gov/city/en/depts/dgs/supp_info/city_hall_green_roof.html

retrofit project. The extensive vegetated roofs are used as an education tool for the College and have been shown to capture the first inch of rainfall.[35]

Infiltration Basins/ Infiltration Reservoirs

Background

Infiltration basins are shallow depressions designed to temporarily store water, allowing it to infiltrate through permeable soils and recharge groundwater aquifers. Infiltration basins are typically used in areas with highly permeable soils, so as to only provide temporary storage. By storing stormwater runoff, there is a reduction in the peak runoff and the total volume of runoff. Stormwater leaves the basin via infiltration, evaporation, or emergency overflow structures. Pollutants are removed from stormwater through settling, filtering of runoff, and breakdown via biological and chemical activity.

Infiltration reservoirs perform similarly to infiltration basins but are underground so may be more practical for the downtown Traverse City area. Infiltration reservoirs with infiltration will only be possible in areas with well-draining soils and no contamination.

Use in the TIF 97 District

Tradition infiltration basins are challenging to incorporate in urban areas. They require more space than many other stormwater BMPs and, for this reason, they are not currently used in many places throughout the TIF 97 District. However, they are useful in achieving high pollutant removal and volume reduction efficiencies and should be considered for use in unused green/open spaces and in new development where existing vegetation can be preserved. Where space allows, a traditional infiltration basin should be prioritized over underground storage systems due to their ability to provide water treatment.

Benefits

Scientific literature has shown removal efficiencies of 55% for total suspended solids, 51% for phosphorous, 65% for nitrogen, and 96% for fecal coliforms for traditional infiltration basins.[36] An underground infiltration reservoir would have minimal water quality benefits but would be highly effective at treating for water quantity.

Considerations

Traditional infiltration basins should only be constructed in areas with well-draining underlying soils because they must infiltrate or drain stormwater in less than 48 hours. If the existing soils are poor and do not allow for adequate infiltration, an underdrain may be installed at an additional cost to the project.

Underground infiltration reservoirs should also only be constructed in areas with well-draining surrounding soils and no contamination due to migration concerns.

Costs

Traditional infiltration basins are expected to cost between $20 and $25 per square foot. Costs will vary based on site characteristic and basin size and design. Underground storage basins are more expensive than surface stormwater treatment methods, however, may be cost effective in areas where land is not available. It has been

[35] Greening Detroit. 2011. “St. Clair County Community College.” Web. https://www.greeningdetroit.com/member/st-clair-county-community-college/

[36] Birch,G., Fazeli, M., Matthai, C. 2005. Efficiency of an infiltration basin in removing contaminants from urban stormwater. Web. http://www.ncbi.nlm.nih.gov/pubmed/15736873

estimated that the range of costs for underground storage reservoirs is between $3 and $10 per cubic foot of water storage.[37]

Case Study

An infiltration basin in Roseville, Minnesota was proven to be effective in the treatment of stormwater. Annually, the basin is estimated to remove 0.57 lbs. of dissolved Phosphorous and 262 lbs. of TSS from influent stormwater. This system, which has a drainage area of 0.85 acres cost $47,000 to construct and treats approximately 1,100 ft^3 stormwater per year.[38]

The Black Hills neighborhood in Grand Rapids spent $175,000 on green infrastructure during a street reconstruction project. The project included infiltration basins in Kensington Park and along Dorchester Avenue. The infiltration basins are used in conjunction with other green stormwater infrastructure including bioretention and porous pavement.[39]

Manufactured Treatment Devices

Background

As cities are designed with the intention of maximizing the available space that can be used for accommodating increasing numbers of people, many times it is not possible to meet the increasing stormwater management needs with large natural systems. Manufactured treatment devices (MTDs) such as hydrodynamic separators, filtration devices, and high flow bio-media devices are applicable for these ultra-urban sites to achieve pretreatment and water quality benefits in space constrained locations. They do not store runoff water or reduce peak runoff flow. Separation devices that include a sediment deposition sump with chambers, baffles, or weirs to treat sediments and trap trash, oil, grease, and other contaminants. Filtration devices are used when discharging water to impaired waterbodies or to meet total max daily load (TMDL) requirements. They include a sedimentation chamber that targets the treatment of sediments, nitrogen, phosphorus, metals, and bacteria. Catch basin inserts are another type of MTD that are design for locations with limited space. They can include filter media to treat oil, grease, hydrocarbons, and heavy metals.

Use in the TIF 97 District

Two-thirds of TIF 97 District is covered in impermeable surfaces. Many of the permeable surfaces are located along the West Grand Traverse Bay coast, indicating that Traverse City's downtown area is primarily impervious. From an economic standpoint, higher building, road, and parking lot density can be beneficial to the city, but this lack of open space can make stormwater management challenging in the area that requires the most control measures. MTDs should be considered for use throughout the TIF 97 District as pretreatment for other stormwater BMPs or to improve water quality in space constrained locations. They can also be considered for areas with physical constraints, such as high groundwater levels or poor soils, and in redeveloped areas.

Benefits

Manufactured treatment devices come in many different designs to serve different purposes on a site. Many of these devices are designed to efficiently treat total suspended solids (TSS), achieving over 80% removal efficiency. They can also treat oil, grease, nutrients, metals, and bacteria at lower efficiencies. These devices are especially useful for sites having space constraints or physical restraints such as high groundwater levels or poorly draining

[37] Lake Superior Streams. *Underground storage*. Web. http://www.lakesuperiorstreams.org/stormwater/toolkit/underground.html
[38] Minnesota Pollution Control Agency. 2018. Minnesota Stormwater Manual Case studies for infiltration. Web. https://stormwater.pca.state.mn.us/index.php?title=Case_studies_for_infiltration
[39] WMEAC.2018. *Next to Grand Rapids road projects, bioswales bloom*. Stormwater Journal, Watershed, Watershed Education, WMEAC News. Web. https://wmeac.org/next-to-grand-rapids-road-projects-bioswales-bloom/2018/

soils, to treat stormwater onsite where traditional, non-structural BMPs cannot be used. They are applicable for use in redeveloped areas and for existing areas with local water quality concerns. With proper maintenance, MTDs tend to have long lifetimes, however, they do require regular maintenance or their pollutant removal efficiency is diminished.

Considerations

While MTDs have the potential to provide high TSS treatment, regular maintenance, usually involving the removal of trash and sediment, is required to achieve design removal efficiencies. Device efficiency is also maximized by correctly sizing the device based on the drainage area along with the sediment size and loading rate of the design storm runoff.

MTDs do not provide water volume control benefits and may have to be used as pretreatment for other BMPs on sites requiring runoff volume reduction. These devices are also not appropriate as stand-alone treatment for runoff from hotspots areas. During large rainstorms, these devices may scour and washout contributing additional pollutants to runoff water.[40]

Cost

Costs associated with achieving water quality treatment with MTDs will vary according to the treatment flow capacity, device type and brand, and site installation requirements. These costs can range from $3,000 to $40,000 per unit and installation.

Case Study

The Ohio-Kentucky-Indiana Regional Council of Governments and Mill Creek Watershed Council utilized manufactured treatment devices as part of the Mill Creek restoration initiative. The Vortechs System was used in two demonstration projects, one at Sysco Food Services in Cincinnati and another at Hamilton County Engineer's office. Vortechs is a hydrodynamic separator that is used for capturing and removing sediment, hydrocarbons, trash and other debris from parking lot runoff.[41]

Saugatuck Center for the Arts in Saugatuck, Michigan is surrounded by about nine acres of urban land. Runoff from those nine acres is treated by an oil-and-grit separator which removes over 80 percent of the sediment and nutrients. The site also has a public garden that treats rainwater runoff, porous pavers in the adjacent city parking lot, and a rain garden and vegetated swale series to treat city parking lot runoff. These systems treat and reduce runoff to Kalamazoo Lake.[42]

Downspout Planter Box

Background

Downspout planter boxes are decorative garden planters filled with gravel and soil which accept and manage stormwater from roof downspouts, **Figure 27**, This BMP can offer an aesthetically pleasing addition to buildings while also providing storm water retention and a reduction of storm water peak flows during rain events. Planter boxes also filter sediment and pollutants as stormwater infiltrates through the soils and vegetation.

[40] Massachusetts Stormwater Handbook. Proprietary Stormwater BMPs. Volume 2: Technical Guide for Compliance with the Massachusetts Stormwater Management Standards. Ch 4. Pg 1-15.
[41] Contech. 2019. Mill Creek Restoration. Web. https://www.conteches.com/knowledge-center/case-studies/details/slug/mill-creek-restoration
[42] SEMCOG. 2008. Low Impact Development Manual for Michigan: A Design Guide for Implementors and Reviewers. Southeast Michigan Council of Governments Information Center. Detroit, MI.

Planter boxes can follow multiple different designs based on the site's roof drainage and stormwater system, soil infiltration rates, and whether the site is contaminated. They have overflow and under drains. Flow is diverted to the overflow drain when the water level in the box floods the soils and vegetated media. The underdrain will direct storm water that has filtered through the planter box to a storm drain. The box can also be placed on a pervious paver base to allow storm water to infiltrate into the ground once it has passed through the planter box.

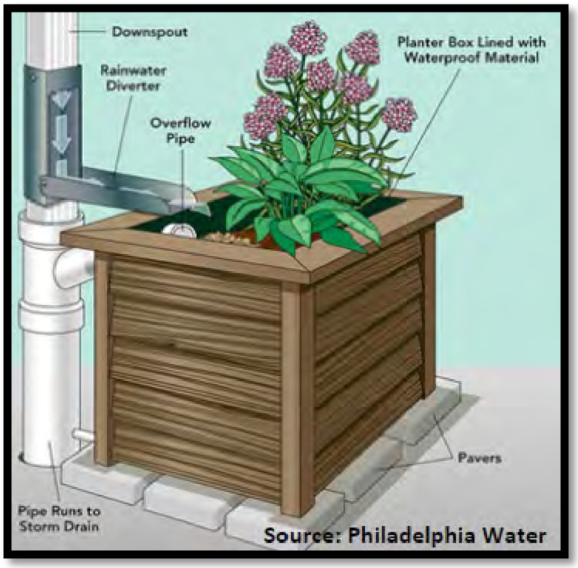

Figure 28. Downspout Planter Box Design [43]

Use the TIF 97 District

Many restaurants and businesses throughout the TIF 97 District have landscaping, intended to serve aesthetic purposes, which can be better designed to incorporating stormwater management techniques. Many times, when the landscaping is raised, sometimes in planter boxes, it can more easily be designed or retrofitted to be a downspout planter box.

Downspout planter boxes have a similar appearance to a conventional planter box, however, they are designed to filter and infiltrate stormwater runoff. This design is easiest to construct with new construction due to the ability to design the roof drainage system to drain through downspout to the planter box as buildings with sloped roofs or internal drainage systems are not easily able to apply this technology. The Park Place Hotel and Conference Center, a recently renovated building in the TIF 97 District, is an example of a location that could have implemented downspout planter boxes with the redesign of the building. Additionally, existing planter beds surrounding the Towne Plaza restaurant represent a missed opportunity to implement downspout planter boxes. **Figure 28**, shows the elevated landscaping beds at these two developments.

[43] Monaghan Township. *Downspout Planters.* Web. http://www.monaghantownship.com/stormwater_management/downspout_planters.asp

Figure 29. Existing Planters in TIF 97 District: Towne Plaza (Left) and Park Place (Right)

Benefits

Downspout planter boxes have a small footprint and have high applicability in urbanized areas. Additionally, planter boxes have both stormwater runoff reduction and water treatment capabilities. Research on this BMP indicates that planter boxes can remove 70%-90% of total suspended solids, 20%-50% of ammonia, and 30%-70% of phosphorous.[44] They can be sized to infiltrate runoff from up to 15,000 ft^2 of runoff. The addition of these systems also enhances site aesthetics and habitat. See **Figure 29** for existing planter boxes and downspouts in the TIF 97 District.

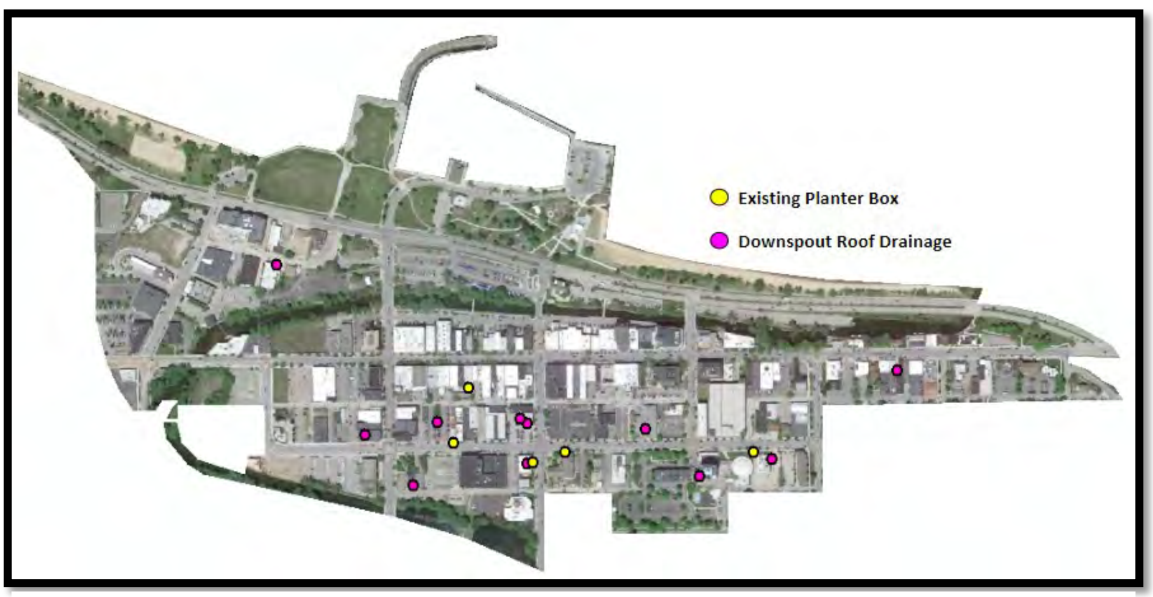

Figure 30. Existing and Potential Downspout Planter Box Locations in TIF97 District

[44] Zhang, R., Zhou, W., Field, R., Tafuri, A., Yu, S., Jin, K. 2009. Field test of best management practice pollutant removal efficiencies in Shnzhen, China. Environment Science Engineering China. 3(3). p. 354-363.

Considerations

The temperature variations in Northern Michigan, such as the freeze/thaw cycle, can contribute to the degradation of systems such as a downspout planter box. To combat this issue on a recent project for Munson Medical Center, AECOM installed a switch which allows stormwater runoff from roof drains to enter the box during warm periods and allow stormwater to bypass the system during colder periods and enter the storm sewer system.

Cost

The cost of a planter box for a recent installation in Traverse City, on the campus of Munson Medical Center, cost between $5,000 and $6,000. A photograph of this project is shown in **Figure 30.**

Figure 31 - Planter Box at Munson Medical Center

Case Study

Ten Milwaukee residents added StormGUARDen stormwater planters to reduce runoff as part of a 2017 grant from The Water Council in Milwaukee. These planter boxes combine bioretention with cistern storage within the stormwater planter. Most of the residences had narrow lots, limited greenspace, and were facing difficulties treating disconnected downspouts. Milwaukee Metropolitan Sewerage District is planning on working with residents to add downspout planter boxes.[45] See **Figure 32**.

[45] Behm, Don. 2018. Some Milwaukee residents to get free state-of-art garden boxes to help prevent combined sewer overflows. Journal Sentinel. Web. https://www.jsonline.com/story/news/local/milwaukee/2018/06/12/mmsd-promotes-green-infrastructure-prevent-combined-sewer-overflows/684867002/

Figure 32. Planter Boxes in Milwaukee

As part of the Kids Creek Restoration Project, the Munson Medical Center's Building 29 improvements include rain garden, pervious pavement and downspout planter boxes. The planter boxes are placed at the bottom of the buildings downspouts to collect and filter the rainwater and snowmelt from the building's roof.[46]

Figure 33. Munson Medical Center Planter Boxes

[46] DiFranco, Shelli. 2015. Munson Building 29 Stormwater Improvements Complete. The Watershed Center Grand Traverse Bay. https://www.gtbay.org/2015/11/11/bldg29/

Bioswales

Background

A bioswale is a drainage ditch filled with vegetation, compost, and/or riprap which removes pollutants from stormwater runoff. A typical bioswale installation might occur along the edge of a parking lot or roadside where pollutants from automobiles can be captured and removed from storm water before discharging to a water body or storm sewer. Bioswales also apply well in parking lots due to their narrow design and because they can have a nearly straight channel alignment.

Bioswales can be enhanced by using native plantings for vegetation. Native plants offer deep root structures which can increases pollutant removal and increases infiltration. Native vegetation also requires less maintenance including watering and the application of fertilizers and pesticides, once established, than turf grass. See **Figure 31**.

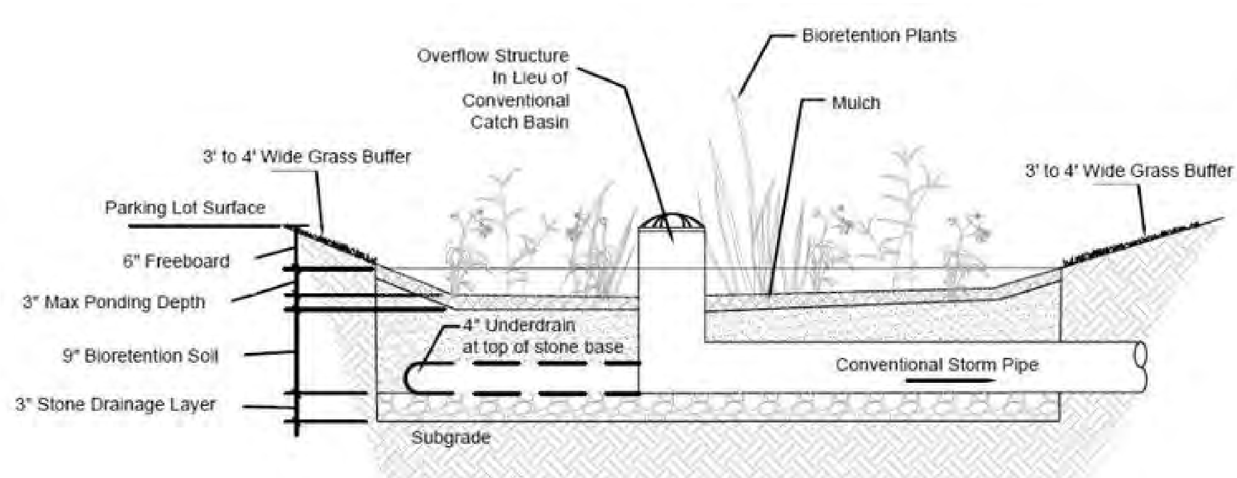

Figure 34. Bioswale Detail, Figure from Drummond Carpenter

Use in the TIF 97 District

Bioswales are typically shallow and narrow, which is an advantage in areas with scarce open spaces, such as the TIF97 District. Bioswales are also typically applied in parking lots, which make up approximately 19% of the TIF97 District. Therefore, this BMP should be applicable in a wide range of spaces within the downtown Traverse City area.

Benefits

The bottom of the bioswale is gently sloped so as to maximize the detention time of water, increasing the pollutant removal. Pollutants including silt, lead, chromium, phosphates, nitrates, heavy metals, pathogens, and pesticides are typically removed from bioswales. Scientific literature indicates removal efficiencies of 73% for total suspended solids, 40% for total nitrogen, and 45% for total phosphorous for bioswales. Furthermore, runoff can be reduced by approximately 50% from a vegetated bioswale.[47]

Considerations

Soils in areas surrounding a bioswale and backfill should be able to provide adequate infiltration. Past projects have indicated an ideal rate of soils infiltration to be greater than one-half inch per hour. Furthermore, the preferred shape of the bioswale is parabolic or trapezoidal with side slopes no steeper than 3:1.

Cost

Bioswales favorably compare in cost to other BMPs. Cost estimates indicate that bioswales can cost approximately $40-50 per linear foot.

Case Study

Indiana Memorial Union Parking Lot #2 has a bioswale installed to improve the sustainability of the campus and reduce flooding issues. It has 2 feet of bioretention soil mix composed of approximately 1/3 compost, 1/3 topsoil, and 1/3 sand. The bioswale is planted with fox sedge, bear tongue, and purple coneflowers.[48]

In 2005 a bioswale was constructed as part of the A. Alfred Taubman Student Services Center landscaping at Lawrence Technological University. The bioswale is 3 feet deep and consists of native grasses and shrubs over engineered soils designed to filter water runoff. The bioswale was designed to handle a 10-year storm event before overflowing into existing stormwater systems.[49]

Figure 35. Lawrence Technologcal University Bioswale

[47] New Hampshire Department of Environmental Services. 2008. New Hampshire Stormwater Manual. Web. http://des.nh.gov/organization/divisions/water/stormwater/manual.htm
[48] Talbot, Peter. 2017. "Bioswale installation will help slow flooding." Indiana Daily Student. Web. https://www.idsnews.com/article/2017/10/bioswale-installation-will-help-slow-flooding
[49] Lawrence Technological University. 2019. Stormwater Institute LID Tour. Web. https://www.ltu.edu/water/tour.asp

Cisterns / Rainwater Harvesting

Background

Rainwater is not something that must simply be managed but is also something that can be used to fill ongoing needs of a site. It most common application is in its reuse. Stormwater that is captured on a site can be reused for non-potable needs such as irrigation, toilet flushing, water supply for onsite fountains or ponds, and water supply for cooling systems. These methods of water reuse are most common due to the ability to use the water without previously treating it. This water can also be treated onsite in order to use for the properties potable water needs.

Cisterns are used to collect and store rooftop runoff for water reuse. They are similar in concept to rain barrels but have a larger water storage capacity from 100 to 10,000 gallons. They can be constructed aboveground or buried underground and are appropriate for use in urban areas where implementing other stormwater BMPs may not be feasible. However, since the implementation of a cistern is most appropriate for properties with significant outdoor water needs, if reused water is being used for irrigation, it is important to analyze which BMPs would best be incorporated into the area. It is also important to perform a water budget analysis incorporating anticipated water inflow and usage as cisterns are most effective when designed to meet a specific water need for reuse.[50]

Use in the TIF 97 District

There are opportunities for rainwater harvesting and reuse throughout the TIF 97 District and the implementation of a cistern can be considered for nearly all sites. However, many of the locations identified include private property and businesses. Therefore, these BMPs should be considered by property owners in the downtown area but are not necessarily proposed for the purposes of this report.

Benefits

Reusing water is beneficial for the surrounding environment and the property owner as it reduces stormwater discharges, lessens stress on water sources, and reduces the amount property owners are paying the municipality.

Considerations

The feasibility of a cistern to capture the stormwater from a site depends on the available space for its placement, the applicable purposes for stormwater reuse, and the site's roof drainage system. Cisterns have large footprint that may not be available on many urban sites and may not be available next to the building and the roof downspout. However, since cisterns can be stored underground and away from a building, these constraints can be minimized.

Water can be reused for potable purposes at nearly every site given the necessary permits have been obtained and requirements met. These uses tend to be more costly to implement but allow for water reuse at nearly any building site. More commonly, rainwater is used for non-potable purposes such as irrigation. Using rainwater for irrigation, however, indicates the need for landscaping and greenspace present on the potential sites for cistern implementation. This greenspace should also be considered for the use of other stormwater BMPs.
An additional consideration involves the sites current roof drainage system. Buildings with existing disconnected downspout systems are the easiest to connect to a cistern system as they do not require large amounts of construction. Buildings having a sloped roof without downspouts or internal downspouts are possible to connect to a cistern but this process would be more costly and time intensive due to the need for additional construction. In these cases it would be easiest to implement a water reuse system for a building that is being renovated. Retrofit

[50] Pennsylvania Department of the Environment. 2006. Pennsylvania Stormwater Best Management Practices Manual.

situations also allow for an easier method of piping the system so that stormwater can be used for non-potable uses in the building. Below gives some examples of how cisterns could be incorporated into sites in the TIF 97 District.

Cost

The cost of rainwater harvesting systems is extremely variable based on the storage needs of the site. Typical costs for a 5,000 to 10,000 gallon system range from $9,000 to $20,000.[51]

Case Study

Rainwater is captured, filtered and UV treated for reuse at the City Hall and Public Safety complex in Cottage Grove, MN. In 2012, a cistern was installed to collect runoff from 0.9 acres of rooftop for use a fountain and in irrigation systems for the 7 acre site. The runoff volume controlled by the system is approximately 570,000 gallons per year and the estimated pollutant reductions per year are 1.5 pounds of phosphorus and 282 pounds of suspended solids.[52]

The Botanic Garden Visitor Center in Traverse City is a LEED building that has water collection from the v-shaped roof and storage in a cistern. The cistern provides water for watering the gardens and is screened to keep the water clean and mosquito free. It can be hooked up to hoses or to fill watering cans and has an over-flow system for large storm events. The Botanic Gardens also have native landscaping areas.

Figure 36. Rainwater harvesting in Traverse City. Photo by Rachel Pieschek - Drummond Carpenter

[51] RainHarvest Systems. Web. https://www.rainharvest.com/complete-systems/5000-10000-gallons.asp
[52] Minnesota Pollution Control Agency. 2018. “Case Studies for Stormwater and Rainwater Harvest and Use/Reuse.” Minnesota Stormwater Manual Case studies for infiltration. Web. https://stormwater.pca.state.mn.us/index.php?title=Case_studies_for_stormwater_and_rainwater_harvest_and_use/reuse

Underground Storage

Background

Underground storage systems are designed to temporarily store stormwater runoff following a storm event, discharging it at a controlled rate through a hydraulic outlet structure to a downstream conveyance system. An underground detention facility can consist of pipes or manufactured underground chambers, vaults, plastics grids, or stone systems that can be installed underground and accessed for maintenance. These types of systems are described below in **Figure 33**.

Figure 37. Underground Storage System Types

Underground storage systems are becoming a more common technique for managing stormwater volume and flow rate in urban areas where space constraints limit the use of other stormwater BMPs such as infiltration basins. They can be installed under many different impervious land uses such as parking lots and tennis courts. They do not provide water treatment and usually are used in tandem with other structural BMPs design to improve water quality. Underground storage systems are associated with higher implementation costs but can be cost effective in areas where land is limited and expensive. They should not be considered for standalone treatment when surface-based BMPs are practicable.[53]

Use in the TIF 97 District

As Traverse City's downtown district is becoming more densely populated, there are few locations with large open green spaces that are appropriate for the implementation of infiltration basins to store and treat stormwater coming from the increasing areas of impervious area. Underground storage systems should considered for use under parks, parking lots, roads, or other land uses where surface BMPs are impracticable. Installed systems should be used in a treatment train with other structural BMPs that provide water treatment. These systems are the easiest to implement as part of new construction or retrofit construction.

Benefits

Underground stormwater storage systems are beneficial for use in urbanized areas because they do not take up above-ground space. Additionally, these systems can offer peak flow reduction and volume attenuation.

[53] Underground BMPs. Urban Drainage and Flood Control District Urban Storm Drainage Criteria Manual Volume 3. June 2012. Web. https://udfcd.org/wp-content/uploads/2014/07/T-11-Underground-BMPs.pdf

Considerations

The implementation of underground stormwater storage facilities is discouraged unless other stormwater BMP options are unfeasible based on site constraints. They are not intended for water quality treatment but the addition of a structural pretreatment device (MTD) can help provide water quality treatment.

Cost

The costs of underground storage units for stormwater treatment vary depending on the chose type. For example, pipe storage can vary between $5 and $7 per cubic foot, while chamber storage can be between $5 and $9 per cubic foot. Pre-case concrete vault storage is slightly more expensive, at $10-$15 per cubic foot.

Case Study

Kentuckiana Medical Center, LLC in Clarksville, Indiana has an underground stormwater storage system installed in 2008. Underground storage was chosen to maximize the available land and parking an underground storage system was used instead of an aboveground retention pond. The system had the constraint of shallow depth and is composed of a plastic chamber system called ChamberMaxx. It holds 49 cubic feet of storage in each of the 690 chambers.[54]

The use of an underground storage system proved successful for a car dealership in Lansing, MI. By converting an existing detention pond used for the retention of stormwater into an underground storage tank, the dealership was able to pave over this system and add 60 additional parking spots, which is very important for a car dealership. This project also offered an alternative of 25% more storage capacity without the costs associated with a detention pond.[55]

Green Street Concept

The term "Green Streets" represents a concept or a program that incorporates stormwater BMPs and other sustainability features into the design methodology of streets. Thus, it is not a singular BMP, but rather an approach to design that could potentially incorporate the BMPs described elsewhere in this report. Green streets are described here because they represent an approach that could be used to consistently implement BMPs into future infrastructure improvements in a cost effective and coordinated way.

Background

In many cities, over two-thirds of the area is covered with impervious surfaces and this percentage is growing as cities become more heavily and densely populated. These impervious surfaces, specifically roads, sidewalks, and parking spots, are the greatest contributors of sediments (TSS) and metals to stormwater runoff which eventually ends up in surrounding waterbodies. Urban stormwater runoff from right-of-way (ROW) areas (roads, sidewalks, and parking spots) can be a threat to the quality of these waters and the health of the community. The Green Street concept addresses this major source of pollution in cities. This concept is a design methodology that incorporates stormwater BMPs along with other sustainable features into traditional streets.

Green streets implement varieties of stormwater BMPs that can operate together to retain, filtrate, and treat stormwater in order to reduce the amount of runoff entering waterways and improve the quality of runoff that does. These BMPs can include bioretention, street trees, infiltration trenches, and permeable pavements. The design of a green street should not only improve its stormwater management function but also address the street's walkability

[54] Contech. 2019. Medical Plaza Way. Web. https://www.conteches.com/knowledge-center/case-studies/details/slug/medical-plaza-way
[55] Triton Stormwater Solutions. Underground Stormwater System Maximizes Car Dealer Parking. Web. http://www.tritonsws.com/pdfs/case-studies/champion-jeep-dealership.pdf

and bike-ability and promote community health by improving surrounding air quality and minimizing other environmental effects, **Figure 34** below, outlines many of the features of green streets.

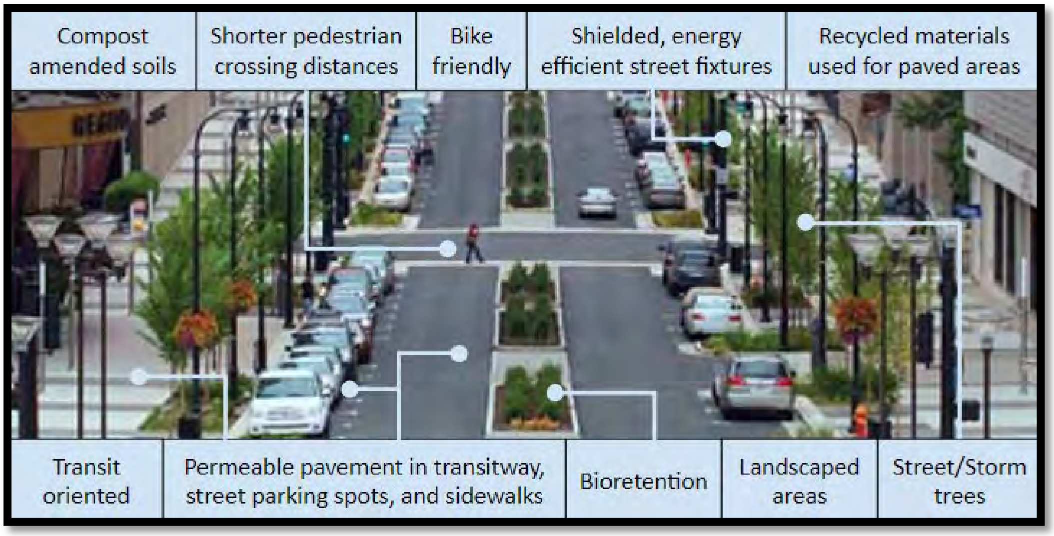

Figure 38. Green Street Structure

Use in the TIF 97 District

The ROW area in Traverse City's TIF 97 District includes the sidewalk to sidewalk areas that also include roads and parking, see **Figure 35** below. Making up one third of the TIF 97 District and half of the region's impervious cover, this area totals 47 acres. The stormwater impact of 47 acres of impervious surface annually equates to 30 million gallons of runoff containing more than 10 tons of sediment and 60 pounds of phosphorus. Combining stormwater BMPs for use in the ROW areas throughout the TIF 97 District can target reducing these numbers to protect the region's water resources while also enhancing community health and prosperity.

Figure 39. Example Right-Of-Way (ROW) in TIF 97 District

Benefits

One of the main purposes of implementing green streets is to provide stormwater management functions. The use of multiple BMPs in one area helps to retain and infiltrate stormwater, reducing the amount of runoff and the associated transport of pollutants to stormwater conveyance systems. It is estimated that green streets can reduce the peak flow of runoff by 80-94% and the amount of TSS, organic pollutants, and heavy metals concentrations in this runoff by 90% (City Parks Alliance, Portland). In effect, the goal of green streets is to restore predevelopment hydrology to the extent possible, helping protect the environment and local water quality, while accommodating the construction of roads, sidewalks, and parking, all necessary features of a city.

Green streets also can provide benefits that are not associated with stormwater. The addition of rainwater capturing greenspaces creates aesthetic value that can create a sense of place for pedestrians. Pedestrians are also benefitted by the shorter road crossing distances present in the design of green streets as they tend to be safer. The safety of bikers in the district can also be improved through the addition of bike lanes in roads.

Considerations

Discussed previously, there are several site considerations before choosing a street to retrofit. These considerations include ROW area, road slope, amount of impervious cover, adequately draining soils, utility conflicts, and residential lot frontage. While these factors indicate regions where green streets will function properly and have the most beneficial impact, there are others that can also limit the success of green streets and ultimately hinder a project from starting.

Green streets face challenges of incorporating BMPs while still meeting road standards due and require a large source of funding. There are several funding resources that other projects in Michigan have drawn from to help supplement project costs of green streets. Some of these sources include the state revolving fund, Great Lakes Restoration Initiative, and EPA Section 319.[56]

Cost

Green streets are extremely variable in green street installation depending on the size and nature of the installation. However, for reference, the City of Portland installed stormwater street planters to replacing impervious area with greenspace. This project has a catchment area of approximately 7,500 ft^2 and cost $38,850.

Case Study

Chicago, Illinois has a Green Alley Program which was created to solve pavement wearing and flooding issues on alleys. The designs help reduce localized flooding and recharge groundwater by infiltrating up to 80% of the rainwater landing on the alley each year. The average project cost per alley was $150,000 and incorporated full and partial reconstruction of alleys. The alley designs were for a 2-year 24-hour rainfall event and typically had drainage areas of less than 1 acre. [57,58]

Stormwater runoff from Lake Street in Whitehall, Michigan travels directly into White Lake. In order to reduce runoff contamination, a 2,800 ft. section of Lake Street was designed to capture and treat the first inch of rain from storm

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[56] Karll, K. 2014. Green Streets Overview. SEMCOG. Web. https://www.allianceof downriverwatersheds.com/wp-content/uploads/2014/10/adw_conference_karll.pdf

[57] Southeast Michigan Council of Governments (SEMCOG). 20. "Great Lakes Green Streets Guidebook – A Compilation of Road Projects Using Green Infrastructure." Web. https://semcog.org/desktopmodules/SEMCOG.Publications/GetFile.ashx?filename=GreatLakesGreenStreetsGuidebookSeptember2013.pdf

[58] Chicago Department of Transportation. 2010. "The Chicago Green Alley Handbook." Web. https://www.chicago.gov/dam/city/depts/cdot/Green_Alley_Handbook_2010.pdf

events. The project incorporated BMP technologies including permeable brick pavers in parking areas and pervious concrete at intersections, and was lined with bio-swales, bioretention, and wetlands.[59]

Figure 40. Lake Street Pervious Concrete Intersection and Bioswale. Image from https://www.youtube.com/watch?v=Qxf3T2oGqGM

Construction Site and Barren Land Sediment Control

Background

Construction sites and locations of barren land are often associated with exposed soils that can easily enter the stormwater system in the stormwater runoff coming from the site. This runoff then leads to the discharge of high levels of sediment into waterways and results in poor water quality. Uncontrolled runoff from construction sites has been shown to have a TSS concentration ranging from 3,000 to 7,000 mg/l and annual loads of 3 tons per acre contributing area per year. **Table 10** compares this value to other land uses.

Table 13. Typical TSS Loading from Runoff by Urban Land Use [60]

Land Use	Commercial	Parking Lot	High-Density Residential	Low-Density Residential	Freeway	Industrial	Park	Construction
TSS (lbs./acre-yr)	1000	400	420	10	880	860	3	6000

[59] Karll, K. 2014. Green Streets Overview. SEMCOG. Web. https://www.allianceof downriverwatersheds.com/wpcontent/uploads/2014/10/adw_conference_karll.pdf
[60] North American Lake Management Society. 2007. Fundamentals of Urban Runoff Management. Web. https://yosemite.epa.gov/oa/eab_web_docket.nsf/Attachments%20By%20ParentFilingId/77FFADF0D8FEB2E485257C62005376F2/$FILE/Att%2013%20%20Fundamentals%20of%20Urban%20Runoff.pdf.

When proper stormwater BMP techniques are used, this TSS level in runoff can typically be reduced by at least an order of magnitude. The most effective way to control sediment erosion and contamination is to vegetate the area in order to cover the soils. Vegetation protects the soil from the wind, slows site runoff, and filters sediment from runoff, making it much harder for stormwater runoff to collect high levels of sediment. Watering bare soil sites when moderate to high winds are expected is also a measure for controlling wind soil erosion. Perhaps the most common method of reducing sediment pollution from exposed soil is the use of sediment control barriers such as silt fences and compost filter socks. These barriers are used to stop runoff from the site from entering the stormwater system. They have the potential to achieve high sediment removal efficiencies but must be installed correctly in order to function to their maximum extent. Polymers can also be added to compost filter socks for increased sediment removal efficiencies.

Use in the TIF 97 District

While not common, there are several sites throughout the TIF 97 District that are currently under construction or have been left barren. Of the eight locations found with sediment deposits, five of these locations, highlighted in **Figure 37**, were areas of exposed soil. These sites have the potential to be contributing large amounts of sediment into the stormwater system which would result in the contamination of the Boardman River and West Grand Traverse Bay. In order to improve stormwater runoff quality, these sites should either be vegetated or accommodate the addition of sediment control barriers. Fortunately, most of the sites are small having quick and inexpensive sediment control solutions.

Figure 41. Exposed Soil Locations

Figure 38 and **Figure 39** depict exposed soil and sediment deposit examples.

Figure 42. Sediment Deposit In Parking lot

Figure 43. Exposed Soil

Benefits

Sediment control barriers such as compost filter socks and silt fencing are inexpensive methods to remove sediments from runoff by slowing runoff and acting as a filter as water passes through. Silt fences and compost filter socks achieve similar total and soluble phosphorus removal efficiencies of between 55-65%. However, if polymers are added to compost filter socks, these removal efficiencies increase to 93-99%.[61] With the addition of polymers, sediment removal efficiencies increase to 91-98%.

Considerations

Must be used for sheet flow and not be treating channelized flow.
In order to achieve the maximum reduction of sediment from stormwater runoff the sediment control barriers must be installed properly, inspected regularly, and repaired when necessary. Compost filter socks have limitations regarding the maintenance requirements of the compost quality which affects the biological stability and particle size distribution. They must also be placed with sufficient ground contact to prevent untreated stormwater from flowing under the treatment.[62]

Cost

The costs of sediment control measures, such as vegetation, filter strips, or compost filter socks, on sites with exposed soil tend to be lower than those for the traditional BMP technology required to achieve the same TSS reduction impact. Filter strips cost between $2.09-$2.89 per linear foot and compost filter socks range from $3.00-$3.50 per linear foot. [63] These sediment control techniques are best suited for temporary, large construction projects. The smaller areas of exposed soil, usually found in parking lot medians or sidewalk areas, tend to be better suited for the addition of vegetation to the soil. Sod material and installation costs range from $0.90 to $2.00 per ft^2.[64] Native vegetation seed costs less than $0.05 per ft^2. [65]

Case Study

When silt fence is properly installed and maintained, this practice is effective at holding back sediment. In one study, 85% of sediment grain sizes larger than 595 microns were held back by a silt fence system.[66]

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[61] Faucette L.B., Sefton, K.A., Sadeghi, A.M., Rowland, R.A. 2008. Sediment and phosphorus removal from simulated storm runoff with compost filter socks and silt fence. Journal of Soil and Water Conservation, Volume 63, Number 4.

[62] Archuleta, R.,Faucette, B.2011. *Utilization of Compost Filter Socks*. USDA. NRCS. Web. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1048852.pdf

[63] United State Environmental Protection Agency. *GreenScale Environmentally Beneficial Landscaping*. Web. https://archive.epa.gov/wastes/conserve/tools/greenscapes/web/pdf/erosion.pdf

[64] HomeAdvisor. Sod Installation Costs. Web. https://www.homeadvisor.com/cost/landscape/install-sod.

[65] University of Minnesota. 2006. *Erosion Control Costs*. Web. https://www.uwsp.edu/cnr-ap/UWEXLakes/Documents/programs/LakeShoreTraining/21.0_developing_a_cost_estimate/2006_erosion_control_costs_mn.pdf

[66] Holloway, M., *Silt fence effectiveness*. Web. https://www.southalabama.edu/geography/fearn/480page/2010/10Holloway.pdf

Street Sweeping

Background

Street sweeping is a method for cities to remove sediment and debris, such as trash and leaves, from roadways and alleys. This process not only makes streets cleaner and more aesthetically appealing, but also protects surrounding water bodies from sediment contamination by limiting the amount entering stormwater runoff. Roads and alleys are some of the most significant contributors of sediment and metals to stormwater runoff. Many times, the sediment accumulates on roads and is washed into the stormwater management system during large storm events. Street sweeping machines will remove a majority of this sediment and have multiple designs targeted at the removal of differently sized particles. Mechanical Broom sweepers are designed to be used for gross pollutant by removing debris. Regenerative-air and Vacuum sweepers can be used for both larger and smaller particles but are more efficient for small particle removal. Vacuum sweepers are designed for pollutant removal from traditional, even pavement. Regenerative-air sweepers can also pick up small particles and are used for pavement with cracks. The efficiencies of these machines will vary based on the sediment loading of the surface and type of sweeper used, but they can achieve between 35-80% removal of total suspended solids and 15-40% of nutrients.

Street sweeping is practiced in most urban areas, often as an aesthetic practice to remove sediment buildup and large debris from curb gutters. In colder climates, street sweeping is used during the spring snowmelt to reduce pollutant loads from road salt and to reduce sand export to receiving waters. Seventy percent of cold climate stormwater experts recommend street sweeping during the spring snowmelt as a pollution prevention measure.[67] The frequency and intensity of rainfall for a region are key variables in determining how streets need to be swept to obtain desired removal efficiency. Other factors that affect a street sweeper's ability to reduce nonpoint pollution include the condition of the street, its geographical location, the operator's skill, the presence of parked cars, and the amount of impervious area devoted to rooftop.[68]

Use in the TIF 97 District

Paved road and alleyways in the TIF 97 District is measured at 25 acres which accounts for 18% of the district. When including city parking lots that are also sources of sediment, metals, and nutrient pollution, these numbers increase to 35 acres and 25%. This area has the potential to contribute large sediment loads to the Boardman River and West Grand Traverse Bay. Increased sweeping efforts of the TIF 97 District roads, alleys, and city parking lots having high sediment levels can greatly reduce this impact.

Currently, the Streets Department in Traverse City is responsible for the maintenance and upkeep of 100 miles of roads and 20 miles of alleys in Traverse City. The TIF 97 District specifically includes 4 miles of this road area and 1 mile of the alley area.

In the TIF 97 District, street sweeping can have potentially the biggest impact in the alleyways. These areas are where more sediment tends to accumulate, according to AECOM's Site Investigation. Five out of eight locations identified as sediment deposits where located in alleys. Nearly 75% of undocumented catch basins were located in alleyways.

[67] Caraco, D. and R. Claytor. 1997. *Stormwater BMP Design Supplement for Cold Climates*. Center for Watershed Protection. Ellicott City, MD.
[68] Ibid.

Figure 44. Sediment in Alley, Catch Basin

Benefits

Street sweeping improves the stormwater resilience of a city in multiple ways. Clearing out debris that can block stormwater infrastructure allows runoff to properly enter the stormwater conveyance system, reducing the occurrences of localized flooding in these areas. As well as reducing the amount of sediment, debris, metal, and organic compounds found in this water. Clean streets are also more aesthetically pleasing for drivers, bikers, and pedestrians and improve the well-being of city-goers. Additionally, some studies are showing that certain sweepers can improve air quality, helping the city meet PM10 standards.[69]

Considerations

It is important to follow best practices to in order to make street sweeping as productive and efficient as possible. This can be accomplished by sweeping in early morning or in the night when there is less parking interference. Minimizing parking interference is especially important since 90% of sediments are within two meters of the curb. Additionally, it is important to know which areas have more critical dust loads so that these places can be prioritize to be done more often and before others when storms are expected. Another suggested technique is to use multiple types of sweepers for maximum pollutant removal. For example, for high loadings, it may be best to use a tandem operation, where the streets are first cleaned with a mechanical street cleaner to remove the large particles, followed by a regenerative-air street cleaner to remove the finer particles. [70]

Cost

The largest cost for street sweeping is staffing and equipment. Conventional street sweeper systems can cost between $60,000 and $120,000. Newer technologies can be more costly at an estimated $180,000. It is estimated that the life of these systems is four years. [71] Furthermore, there are private contractors that will perform street sweeping, typically charging either by the hour or by lane mile serviced.

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[69] Amato, F., Querol, X., Johansson, C., Nagl, C., Alastuey, A. 2010. *A review on the effectiveness of street sweeping, washing and dust suppressants as urban PM control methods*. Elsevier. Web. https://ac-els-cdn-com.proxy.lib.umich.edu/S0048969710004031/1-s2.0-S0048969710004031-

[70] Amato, F., Querol, X., Johansson, C., Nagl, C., Alastuey, A. 2010. *A review on the effectiveness of street sweeping, washing and dust suppressants as urban PM control methods*. Elsevier. Web. https://ac-els-cdn-com.proxy.lib.umich.edu/S0048969710004031/1-s2.0-S0048969710004031-

[71] Pollution Prevention Fact Sheet: Parking Lot and Street Cleaning. Web. http://cornwall-on-hudson.org/Stormwater%20Management/Pollution%20Prevention%20Fact%20Sheet-Parking%20Lot%20and%20Street%20Maint.pdf

Existing Stormwater BMPs in TIF 97

During the field investigation of TIF 97, seven existing BMPs were identified. See **Figure 42** for an aerial view of the existing BMPs. Currently, there is one infiltration basin, one green roof system, one tree box, one rain garden, and two manufactured treatment devices in the TIF 97 area. In total, these existing BMPs treat 2.35 acres of impervious area, which is equal to 2.5% of the total impervious area in TIF 97. See the sections below for more detail on the existing stormwater treatment systems in the TIF 97 area.

Figure 45. Existing BMPs Identified During Field Investigation

Rain Gardens - Existing Locations

Two existing rain gardens were recently constructed, in 2017, as part of the Uptown Development Condominium complex. They are picture in **Figure 43** below. Like many stormwater BMPs, rain gardens are easiest to implement as part of new construction where the landscaping and outdoor grading can more easily be designed with rain garden technology rather than trying to work around existing infrastructure. These two rain gardens further promote the concept of and relative ease of designing new construction landscaping with green initiatives in mind.

Figure 46. Rain Gardens Constructed In 2017 by Uptown Development TC, LLC

Permeable Pavement - Existing Locations

Permeable pavements are currently only being used in a couple places throughout the TIF 97 District but have opportunities to be used in retrofits of several other regions. **Figure 44** shows the location of a 3,500 ft^2 section of permeable pavement in a parking region by Boardman River and S Union St.

Figure 47. 3,500 Ft^2 of Existing Permeable Pavement in Parking Area

Tree Boxes - Existing Locations

One tree box was recently installed along Grandview Parkway just east of Park St. See **Figure 45**.

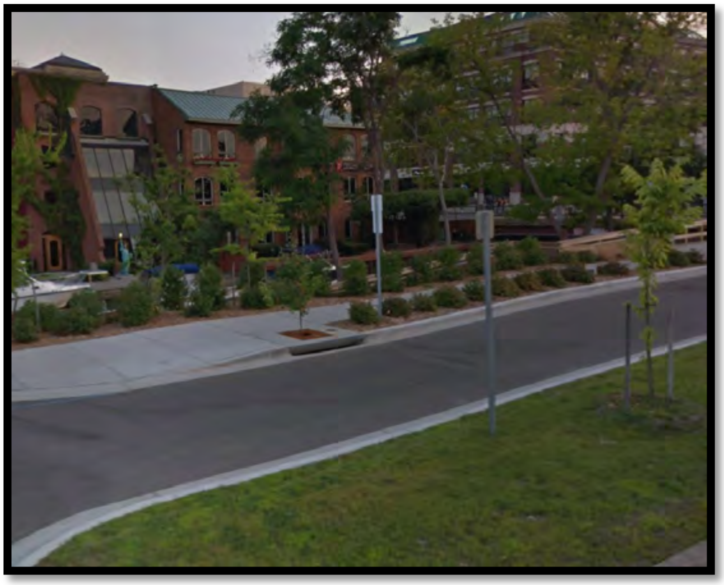


Figure 48. Existing Street Tree along E Grandview Parkway

Green Roof - Existing Locations

While green roof technology is applicable to existing structures, it is more feasible to consider it for new buildings. This feasibility is largely dependent on the ability to forgo a structural analysis since the building can be designed to withstand the loads expected from a green roof. Planning a green roof in the early stages of building construction can also allow for the development of the heavier intensive green roof which offers further capacity for rainwater retention and filtration as well as public amenity spaces. This process recently took place with the construction of Uptown Condominiums on Uptown Ct in the TIF 97 District. Completing construction in 2017, Uptown Development TC, LLC has developed a condominium complex with over 10,000 ft^2 of extensive green roof. Shown in

Figure

46.

Figure 49. 10,000+ ft^2 Extensive Green Roof on Uptown Condominiums, Constructed 2017

The green roof area, while being extensive, is highly visible from the patios and rooftop gathering areas. This view of greenspace enhances these areas like an intensive roof would be used to do. See **Figure 47** for the view from the main rooftop gathering area.

Figure 50. Rooftop Gathering Area with View of Green Roof

Other examples of green roof projects that have been successful in the Traverse City area are the intensive green roof and public space area on the Cowell Family Cancer Center (Munson Medical Center) and 4,000 ft^2 green roof on Cherry Capital Foods.

Infiltration Basin - Existing Locations

In the TIF 97 District there is one infiltration basin located west of NorthWoods Tattoo Parlour, pictured in **Figure 48.** This basin has a footprint of just over 800 ft2 with an estimated storage capacity of 600 ft^3. It is sized to retain the first inch of stormwater runoff from 95% of the 7,600 ft^2 parking lot draining to it.

Figure 51. Existing Infiltration Basin by NorthWoods Tattoo Parlour

Manufactured Treatment Devices Existing Locations

On a site walk of the TIF 97 District one manufactured treatment device, the Aquashield Aquaswirl hydrodynamic separator was located in a newly constructed catch basin in the parking lot by Panache Boutique. **Figure 49** shows the manhole and location.

Figure 52. Existing Manufactured Treatment Device in Panache Boutique Parking Lot

Applications for devices like this are present at many sites throughout the TIF 97 District. They can be used for pretreatment for other stormwater BMPs such as rain gardens, infiltration basins, and underground storage systems. They are easiest to install as part of new construction or retrofit projects as they will always cause site disruption due to their underground nature.

Stormwater Improvement Options

Structural BMP – Potential Locations

Rain Gardens - Potential Locations

Throughout the TIF 97 District, there are numerous sites that were identified as good locations for bioretention cells. There are two locations where bioretention cells have already been installed. See **Figure 50**.

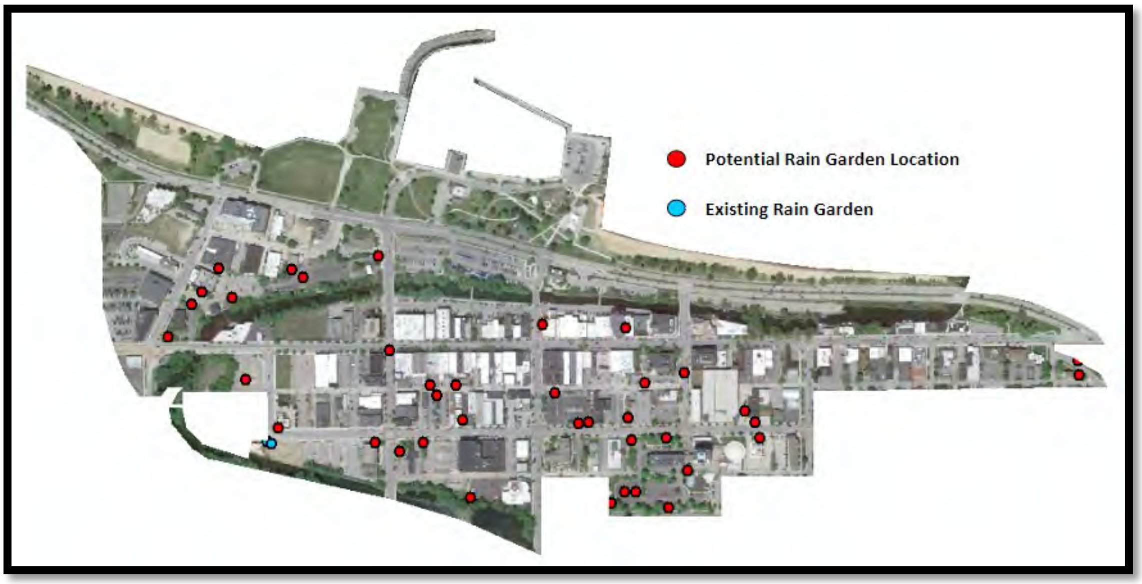


Figure 53. Potential and Existing Rain Garden Locations

Since rain gardens are usually designed to accept runoff from surrounding impervious surfaces that are being drained by gravity, it is ideal to implement rain gardens in low spots to which the surrounding areas are currently draining. This section will give a couple examples of how rain gardens can be incorporated into regions in the TIF 97 District that meet these needs and regions where they would be applicable during retrofit projects.
Located at the southeast corner of the intersection of Front and Railroad Streets, there is a 4,000 ft^2 green space, pictured in **Figure 51**. Currently a catch basin is located in the middle of this region, indicating that this area is draining water from the region surrounding and that it is already connected to the city's stormwater system, further making it an appealing location. There is a large sediment deposit around the catch basin. Adding a rain garden would hinder this pollutant source from entering waterways.

Figure 54. 4,000 ft^2 Rain Garden Opportunity Location (Just Outside Of TIF97 District)

Retrofitting this area with a rain garden is not only desirable for the reasons above but also has other benefits. The figure shows a large sediment deposit around the catch basin. Adding a rain garden would improve stormwater quality by hindering this pollutant source from entering waterways. Additionally, this location does not have the potential to become a building location and is well positioned, along the TART Trail, to have an informational sign for public education. However, it is important to note that the region looks like it may be a dumping area for snow in the winter but this is not uncommon in rain garden locations.

Implementing a roughly 4,000 ft^2 rain garden in this region would be estimated to cost from $15,000 to $25,000 and provide treatment for 0.5 acres of surrounding impervious area, achieving treatment efficiencies of around 65% for total phosphorus and 85% for total suspended solids (TSS). Additionally, the heavily trafficked area would be more aesthetically pleasing.

The green space east of the parking lot located north of Legion Park is another potential location for the implementation of a rain garden. The parking lot currently drains to the surrounding grassy/gravel region through curb cuts, shown in **Figure 53** indicating that this area could be more easily modified to include rain garden infiltration and treatment.

Figure 55. 400 ft^2 Rain Garden Opportunity Location

On this site there is approximately 400 ft^2 available for a rain garden. This stormwater best management practice (BMP) could store the runoff from 2,000 ft^2, nearly 30%, of the nearby parking lot. The resulting rain garden could have a similar appearance to the rain garden shown below **Figure 54** that was installed near the Oregon State Convention Center.

Figure 56. Rain Garden at Oregon State Convention Center

Many times, feasible locations for rain gardens are not originally sloped correctly for water to drain to the potential garden. In these cases, rain gardens are best incorporated when the area is being retrofitted. Sites where construction is already scheduled to take place are easier and more cost efficient to regrade, making a rain garden a more appealing option for stormwater control.

Throughout the TIF 97 District, there are many sites fit for rain gardens which could be retrofitted. Common opportunities in this region can be narrowed down to constructing rain gardens in Right-of-Way greenspace (that is not currently being used but may eventually be used for additional building area), parking lot islands, in landscape next to buildings, and, specifically for the TIF 97, the greenspace areas lining the river paths**. Figure 55** gives examples of these types of opportunities.

Figure 57. Types of Rain Garden Opportunities

Bumpout Rain Garden – Potential Locations

Pedestrian bumpouts (also called curb extensions and bulb-outs) are the extension of sidewalk into the parking lane of streets. They are constructed at the points where pedestrians are intended to cross the street which can be at intersection corners and at mid-block. This strategy of narrowing the roadway is designed to promote pedestrian safety by shortening the pedestrian crossing distance which decreases pedestrian exposure to vehicles and further encourages them to cross at designated crosswalks rather than cross in unmarked regions. Narrowing the roadway also increases pedestrian visibility at intersections and slows drivers. Additionally, the tighter turn radius associated with bumpouts reduces the turning speeds of cars. These bumpouts must be designed with the public transit needs of a street and the future applications of the road in mind but, when designed properly, they can be worth the additional costs.

While the primary goal of using bumpouts is to promote pedestrian safety, they also provide quality space that can be used for public space and for stormwater management strategies. The additional space that is created to make a bumpout does not need to serve the purpose of a sidewalk and ends up being an ideal location to construct a rain garden.

Rain garden bumpouts can infiltrate and filter the rainwater runoff from the surrounding sidewalk and road area while achieving the visual appeal associated with landscaping, an important feature in urban areas. They also are in high trafficked areas that allow for green infrastructure education opportunities through the addition of an informative sign. **Figure 56** shows a successful rain garden bumpout project that was completed in 2013 in Suttons Bay, MI. This rain garden included a sign to promote public awareness of stormwater control measures.

Figure 58. Rain Garden in Suttons Bay, MI

As many of the roads in the TIF 97 District have parking lanes, high pedestrian traffic, and there is not a public transit system to accommodate, this district is a good location for the installation of bumpouts and has already started to incorporate them into the current city design. **Figure 57** depicts one of these bumpouts located at the corner of Park St and State St.

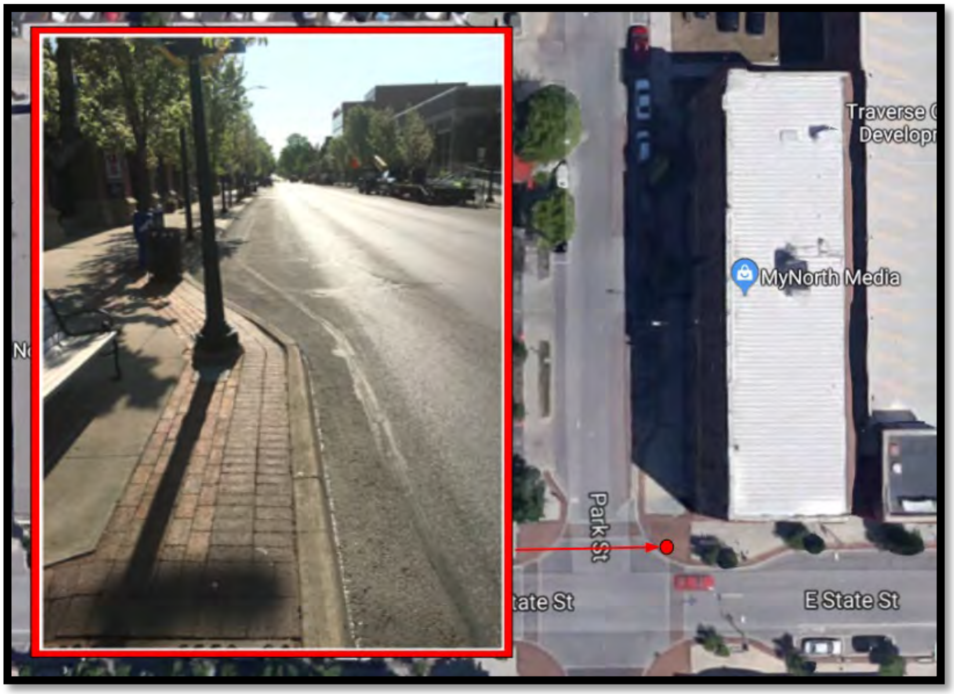


Figure 59. Bumpout at Park St. and State St., Facing East

In the TIF 97 District, there are 19 locations of existing bumpouts and at least 15 locations appropriate for the addition of bumpouts. The potential bumpout locations were designated in areas with current pedestrian crosswalks on the sides of the roads where car lanes did not extend and the additional space is either unused or being used for parking. These locations are pictured in **Figure 58** below.

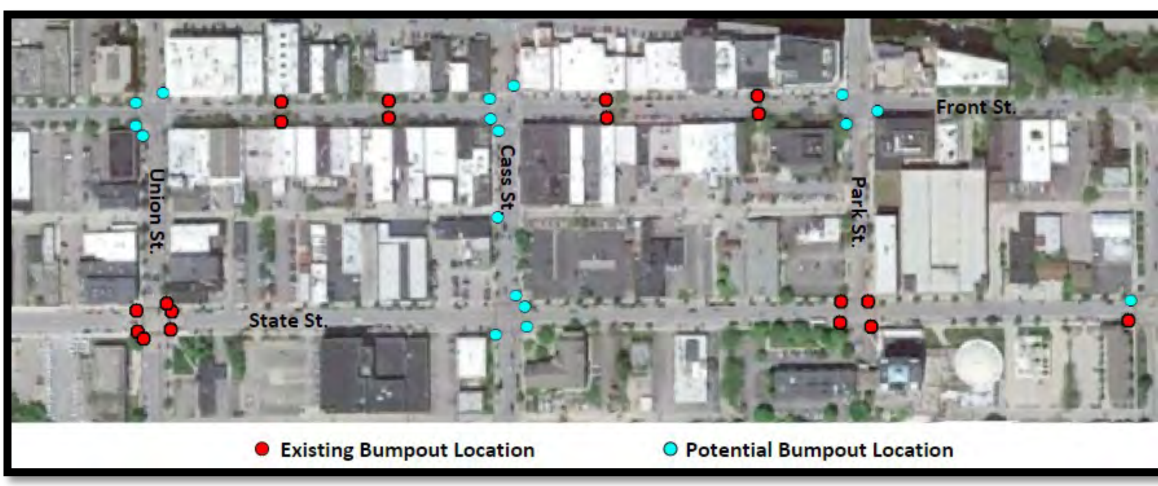


Figure 60. Potential and Existing Bumpout Locations

Incorporating rain gardens into existing and future bumpouts throughout the TIF 97 District and surrounding would most likely have a similar effect as the rain gardens project in Suttons Bay that was implemented in 2014. In this project, 18 rain gardens were installed, many of which acting as pedestrian bumpouts. **Figure 59** shows a before and after picture of one of these rain garden installations in Suttons Bay.

Figure 61. Before and After Picture, Suttons Bay, MI

Permeable Pavement - Potential Locations

Permeable pavement is not only desired for use in roads and parking lot design but also have applications in sidewalks. It is especially feasible to retrofit areas of decorative pavement or brickwork, in sidewalks as well as parking lots and roads, with permeable pavement. Permeable pavement is similar in cost to decorative paving and has aesthetic value while also providing stormwater management benefits.

In the TIF 97 District, there is over 10,000 linear feet, 29,000 ft^2, of brick paving sections in the sidewalks along city streets. This equates to five percent of the total sidewalk area.

Figure 60 depicts one of these brick paving sections. During road and sidewalk retrofits, sections of sidewalk with brick paving could be upgraded to use permeable pavers. The addition of 29,000 ft^2 of pervious pavement would be able to capture runoff from 0.22-0.65 acres of surrounding impervious area. Material costs for this project would range from $116,000-$350,000 and construction costs would be similar to those of prick pavers.

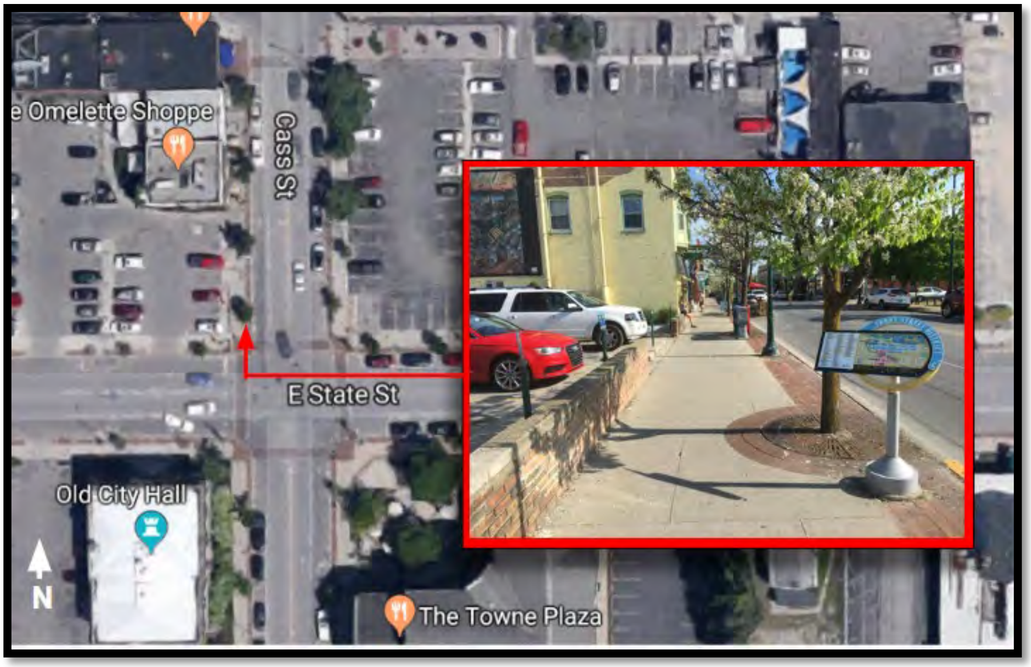


Figure 62. Opportunity for Pervious Pavement in Brick Paving Area along City Streets

There are many other opportunities for permeable pavement retrofits throughout the TIF 97 District. Some applicable locations can include parking lots, low areas, and other areas of existing brick pavement and are described in **Figure 61**. These options tend to be more location specific and would offer varying degrees of stormwater management benefits.

Figure 63. Additional pervious pavement opportunity locations

Tree Boxes – Potential Locations

Tree boxes are a suitable stormwater treatment option on any street with storm sewer. In the downtown Traverse City area, it is recommended that tree boxes not be installed along Front Street between Union St and Boardman Avenue, due to the character and aesthetics of the existing trees in this area. However, tree boxes could be a suitable option along any other street in the TIF 97 area.

Currently in the TIF 97 District there are just over 200 street trees lining the city streets in this downtown area of Traverse City. **Figure 62** dipicts one of these trees and its location.

Figure 64. Street trees along State St. at Boardman St.

Replacing some of these traditional trees with storm trees would allow for an increase in stormwater quality treatment and also maintain the existing aesthetic. At a cost of $10,000-$15,000 per street tree, it is not economical to replace every tree in the downtown area with a street tree. Furthermore, by replacing each tree downtown with a street tree, the drainage area to each tree would be very small, much less than the minimum recommended drainage area of 0.16 acres per street tree.

During the intial field investigation, several areas were identified where trees may have been in the past but are currently missing. **Figure 63** Instead of replacing these missing trees with new street trees, these locations could be used as storm tree test locations where.

Figure 65. Street Tree Opportunity

Some of the city streets in the TIF 97 District are not currently lined with street trees, as pictured in **Figure 64**. By adding street trees in these areas, the overall aesthetic of the street as well as human health and environmental benefits could be realized.

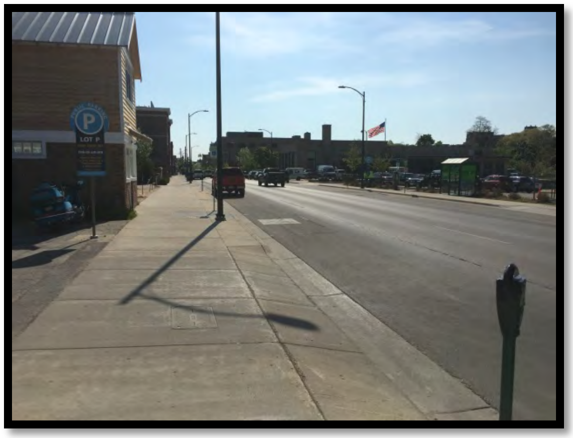


Figure 66. Street Tree Opportunity

Green Roof - Potential Locations

In an area with older, historic buildings, such as TIF 97, green roofs can be both a challenge and an opportunity. Green roofs are recommended for flat roofs less than five years old. Therefore, they can be challenging to implement on older buildings. However, if the roofing needs repairs or replacement on the older buildings, combining a roof replacement with a green roof installation can often be economical.

Infiltration Basin - Potential Locations

While few locations with large areas of unused and un-trafficked greenspace exist in the TIF 97 District, there is a location similar to the one described above that presents an opportunity to implement an infiltration basin. Next to the Bay West Antiques building and near The Workshop Brewing Company there is an approximately 1,800 ft^2 green space, pictured in **Figure 65.**

Figure 67. Possible Location for Infiltration Basin Near Bay West Antiques

This greenspace is currently not serving an aesthetic purpose and is out of the way of pedestrian traffic. This area would accommodate a roughly 3,300 ft^3 infiltration basin that would retain the first inch of stormwater runoff from the entire, 39,000 ft^2 parking lot that could drain to it. It is likely that the parking lot is not currently graded to all flow into this green space, thus this project would require a retrofit of the area.

Cistern - Potential Locations

The rooftop runoff of Chemical Bank building, located at the corner of E State St and S Union St, currently drains into the parking lot through disconnected downspouts where it travels into the city's stormwater system. The rooftop area is around 4,000 ft^2 and collects, on average, over 10,000 ft^3 of rainwater per year. The site's greenspace consists of a nearly 7000 ft^2 lawn with irrigation requirements also around 10,000 ft^3 for months May through October. If a cistern was used on this site, a large proportion of these irrigation needs could be met by reusing the rooftop runoff. Reusing stormwater in the month of July, the hottest summer month with the least amount of rain on average, 3.03 inches, results in a 58% reduction of irrigation needs. The 1000 ft^3 of captured rainwater would save the property owner $43 on the month's water bill and these values would be higher for other months. This type of system would require a 4,000 gallon cistern which would take up a 72 ft^2 area on the site. One potential location for this system is shown in **Figure 66.**

Figure 68. Potential Cistern Locations on Chemical Bank Site

Underground Storage - Potential Locations

Due to space constraints in urban areas, underground storage can be an attractive option for stormwater treatment. However, this type of treatment can be expensive. Pre-fabricated underground systems are costly themselves and when considering additional costs for excavation of materials and potential utility conflicts, these systems can often be unattractive when compared to more conventional stormwater treatment systems.

Areas where underground storage can be attractive include areas where earth disturbing activity is already planned, such as the construction of new buildings, or coupled with other utility work. Therefore, there are no specific locations outlined in this plan, but this BMP type should be considered for all new development projects and utility work.

Inexpensive Community Wide Opportunities

Covering Dumpsters

In February 2017, the EPA set new rules for Construction General Permit which affects waste containers. This rule includes that waste containers must be shielded from rainfall to decrease pollutant loads in stormwater runoff. Therefore, covering dumpsters properly should be a high priority for the City. EPA Certified dumpster covers, such as the Roll Off Dumpster Hardcover by ALCO or the ST-8200_S by TB Industries, are economical at a cost of $2,500 to $3,100 per unit[72,73]. At this cost, replacing all of 28 of the existing dumpster covers with EPA compliant covers would cost between $70,000 and $86,800.

Expand Street Sweeping: Alleys/Back Lots

As a part of the stormwater asset management plan proposed by OHM Advisors, the budget for all operation and maintenance expenditure items has increased. Therefore, in addition to the current street sweeping practices the City conducts, alleyways and back lots should be swept. These areas are known to accumulate high loads of sediment and therefore pollution due to heavy car traffic. To prevent these sediments and other pollutants from running off into adjacent water bodies, the sediment should be vacuumed and properly disposed of, just as with traditional street sweeping along main roads.

Silt Fence

At approximately $2 per linear foot, silt fence is an extremely inexpensive way to prevent sediment from construction sites from washing into nearby water bodies. **Figure 67** depicts a construction site identified during the site walk without silt fence in place. During storm events, sediment from this site will enter the storm sewer system and discharge directly to the Boardman River. Installing silt fence in this area would cost approximately $1,000 and reduce the amount of TSS entering the Boardman River by as much as 1,380 lbs. annually. Similarly, a compost filter sock could be used to allow water to pass but preventing sediments and other materials from passing through the filtration media. A compost filter sock would cost approximately $1,700 prevent up to 1,340 lbs. of TSS from entering the Boardman River, annually.

Figure 69 - Construction Site without Silt Fence

[72] ALCO Custom Covers. Web. https://alcocovers.com/product/roll-off-hardcover/.
[73] TB Industries. Web. https://www.rolloffcovers.com/shop/st-8000-s/.

Capital Improvement Plan – Stormwater BMPs

The Capital Improvement Plan (CIP) developed by OHM Advisors also established a budget for all stormwater activities. This budget has a total annual amount of $2,020,000 with $350,000 allocated specifically for infiltration BMPs for volume and pollutant control. This budget also has $25,000 budgeted annually for the installation of 5 new end of pipe treatment BMPs within a 10 year cycle. It was a goal of AECOM's to conform to budget proposed by OHM such that the fee structure that was researched and proposed by OHM was appropriate for the installation of stormwater treatment BMPs. The CIP uses the condition assessment scores developed by OHM and the AECOM site investigation to develop and refine preliminary list of projects.

To develop a CIP for stormwater management BMPs, the CIP developed by OHM for the city's storm sewer infrastructure was first consulted. As part of this report by OHM, the storm sewer pipes, manholes, and catch basins were assessed for the probability and consequence of failure. The probability of failure considers the physical condition or age of an asset, and ranged in scores from 1 (improbable) to 5 (imminent). The consequence of failure focuses on the social, environmental, and economic impacts for a community and ranged in scores from 1 (negligible) to 5 (catastrophic). Additionally, the social, environmental, and economic weights included in the consequence of failure value were weighted differently, at 25, 25, and 50%, respectfully. The probability of failure and consequence of failure assigned to each asset were then multiplied by each other to find the business risk exposure, or BRE, for each asset in the storm sewer system. The BRE ranges from 1 to 25 with a range of 1 to 4 classified as low priority, scores of 5-9 classified as medium priority, and scores of 10-25 classified as high priority. The resulting BRE scores along with an outline of the TIF 97 area are presented in **Figure 71**.[74]

Next, the results of the field investigation were used to identify the types, sizes and locations of potential BMPs. During the initial field investigation site walk, there were 148 locations identified for BMPs. Upon further review, 37 of these sites were determined to be unfeasible due to various reasons such as minimal drainage area or new construction disturbing the area. Of the remaining 111 BMPs, 24 are traditional rain gardens, 28 are rain garden bumpouts, 39 are tree boxes, 10 are permeable pavement systems, 5 are manufactured treatment devices, and 5 are planter boxes. If installed, these 116 BMPs would treat 31% of the impervious area in TIF 97. Existing BMPs treat approximately 1% of the impervious area in TIF 97. The existing and proposed BMP locations are shown in **Figure 72**.

[74] OHM Advisors. *Traverse City Stormwater Asset Management Plan.* 2017. Web. http://www.traversecitymi.gov/downloads/final_compiled_tc_sw_amp.pdf.

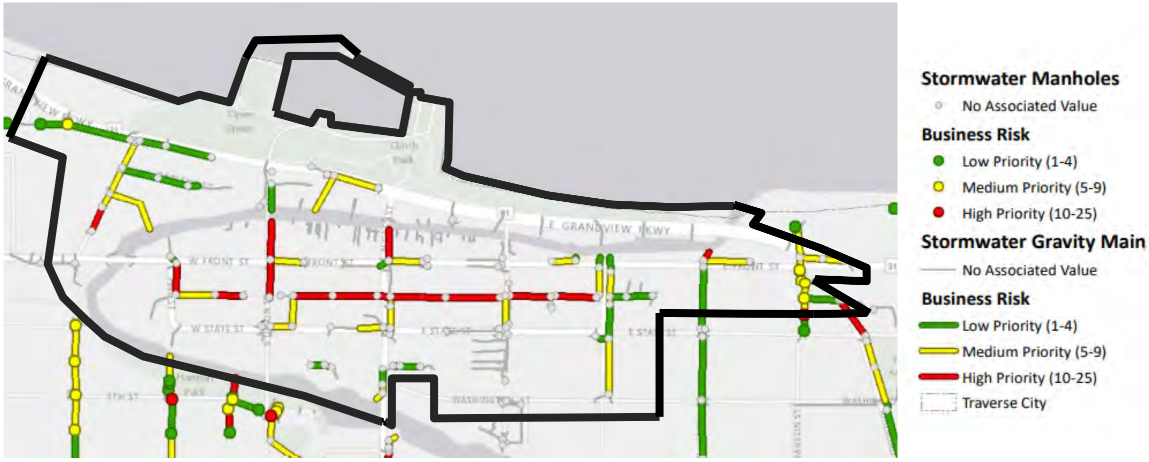


Figure 70. BRE Scores for TIF 97 District

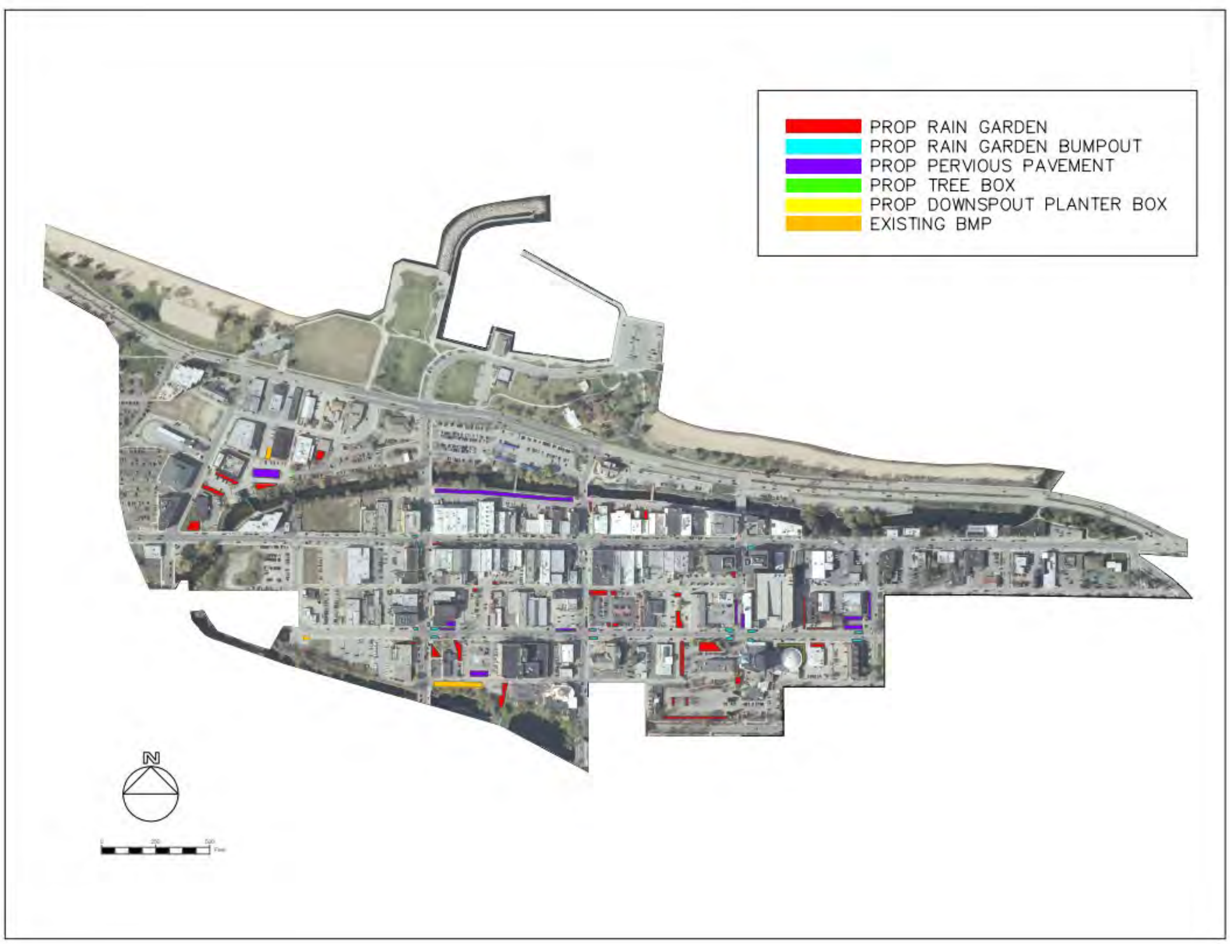


Figure 71. Existing BMPs, proposed BMPs for years 1-10 of CIP, within TIF 97 District

If these 116 BMPs are installed in a five year period, the average annual cost would be $390,600, just above the annual budget allocated by the OHM budget. Based on this, AECOM has developed three timelines for the implementation of the stormwater BMPs. The first is a five year period for installation, the preferred plan since the budget closely aligns which the budget proposed by OHM. The second is an aggressive plan for which the period of installation would be three years. The last offers the most relaxed approach for implementation and would extend the period of installation over ten years. For each CIP, priority was given to the areas identified as “High Priority” business risks in the OHM stormwater asset CIP.

The “preferred” CIP is presented first, the five year implementation period. **Table 12** shows the BMP and cost breakdown per year which **Figure 70** shows this installation spatially. A more detailed look at each sub-area in available in **Appendix C**.

Table 14. Five-Year Capital Improvement Plan Summary

	BMP Type	Area Treated (Acre)	Average Cost*	Average Cost per Impervious Area Treated ($/acre)
Year 1 *Union St, State St between Union St and Cass St* ***Subtotal = $417,200***	*4 Rain Gardens*	1.73	$110,800	$64,046
	2 Rain Garden Bumpouts	0.22	$11,400	$51,818
	11 Street Trees	1.55	$192,500	$124,194
	4 Permeable Pavements	1.00	$72,100	$72,100
	1 Downspout Planter Box	0.13	$5,500	$42,308
	1 Manufactured Treatment Device	0.26	$21,500	$82,692
Year 2 *State St between Cass St and Park St* ***Subtotal = $418,568***	*8 Rain Gardens*	2.59	$213,780	$82,541
	7 Rain Garden Bumpouts	0.96	$52,500	$54,688
	5 Street Trees	0.72	$87,500	$121,528
	2 Pervious Pavements	0.63	$32,288	$51,251
	2 Downspout Planter Boxes	0.22	$11,000	$50,000
	1 Manufactured Treatment Device	0.23	$21,500	$93,478
Year 3 *Park Place, Boardman Ave, State between Park and Boardman Ave, Front St between Boardman Ave and Union St* ***Subtotal = $465,200***	*8 Rain Gardens*	1.41	$109,400	$77,589
	15 Rain Garden Bumpouts	1.61	$72,800	$45,217
	2 Street Trees	0.19	$52,500	$276,316
	1 Permeable Pavement System	1.96	$182,000	$92,857
	1 Planter Box	0.09	$5,500	$61,111
	2 Manufactured Treatment Devices	1.38	$43,000	$31,159
Year 4 *Park lot N of Front between Union and Cass, Intersection of Union St and Front St, Front St W of Union* ***Subtotal = $423,630***	*5 Rain Gardens*	1.17	$74,000	$63,248
	6 Rain Garden Bumpouts	0.72	$37,380	$51,917
	10 Street Trees	1.38	$210,000	$152,174
	2 Permeable Pavement Systems	0.37	$75,250	$203,378
	1 Planter Box	0.61	$5,500	$9,016
	1 Manufactured Treatment Device	0.48	$21,500	$44,792
Year 5 *Warehouse District, Hall St, Front St W of Pine St* ***Subtotal = $397,630***	*6 Rain Gardens*	1.03	$178,880	$173,670
	8 Street Trees	1.17	$140,000	$119,658
	1 Permeable Pavement System	0.46	$78,750	$171,196

**Calculated by averaging the low and high cost for each BMP, and summing each BMP category.*

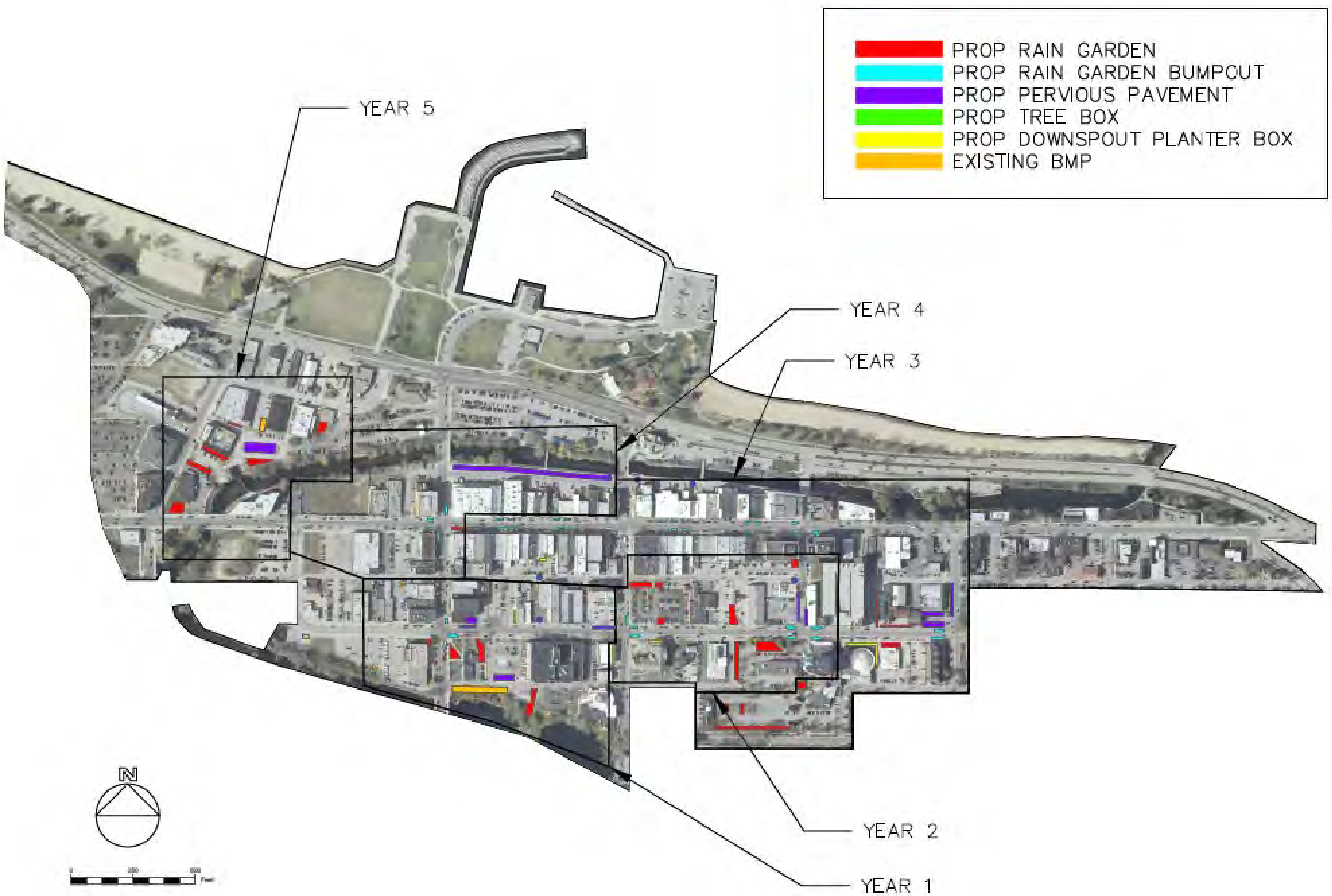


Figure 72. Five Year Capital Improvement Plan

The most aggressive CIP is presented next which has a three year implementation period and an approximate stormwater budget of $650,000. **Table 13** shows the BMP and cost breakdown per year which **Figure 71** shows this installation spatially. A more detailed look at each sub-area is available in **Appendix D**.

Table 15. Three-Year Capital Improvement Plan

	BMP Type	Area Treated (Acre)	Average Cost*	Average Cost per Impervious Area Treated ($/acre)
Year 1 *State St between Union and Park, Alleys between Front and State* ***Subtotal = $714,080***	*8 Rain Gardens*	3.49	$245,680	**$70,395**
	5 Rain Garden Bumpouts	0.61	$29,800	**$48,852**
	16 Street Trees	2.27	$280,000	**$123,348**
	4 Permeable Pavements	1.00	$72,100	**$72,100**
	4 Downspout Planter Boxes	0.44	$22,000	**$50,000**
	3 Manufactured Treatment Devices	1.40	$64,500	**$46,071**
Year 2 *State St between Park and Boardman Ave, Park Place, Front St between Union and Boardman Ave.* ***Subtotal = $707,578***	*10 Rain Gardens*	3.41	$262,300	**$76,921**
	19 Rain Garden Bumpouts	2.70	$131,740	**$48,793**
	9 Street Trees	0.81	$157,500	**$194,444**
	4 Pervious Pavements	1.01	$107,538	**$106,473**
	1 Downspout Planter Box	0.61	$5,500	**$9,016**
	2 Manufactured Treatment Devices	0.94	$21,500	**$22,872**
Year 3 *Warehouse District, Hall St, Front between Hall and Union, Parking Lot N of Front between Cass St and Union St* ***Subtotal = $697,170***	*6 Rain Gardens*	1.03	$178,880	**$173,670**
	3 Rain Garden Bumpouts	0.19	$12,540	**$66,000**
	14 Street Trees	1.93	$245,000	**$126,943**
	2 Permeable Pavement Systems	2.42	$260,750	**$107,748**

**Calculated by averaging the low and high cost for each BMP, and summing each BMP category*

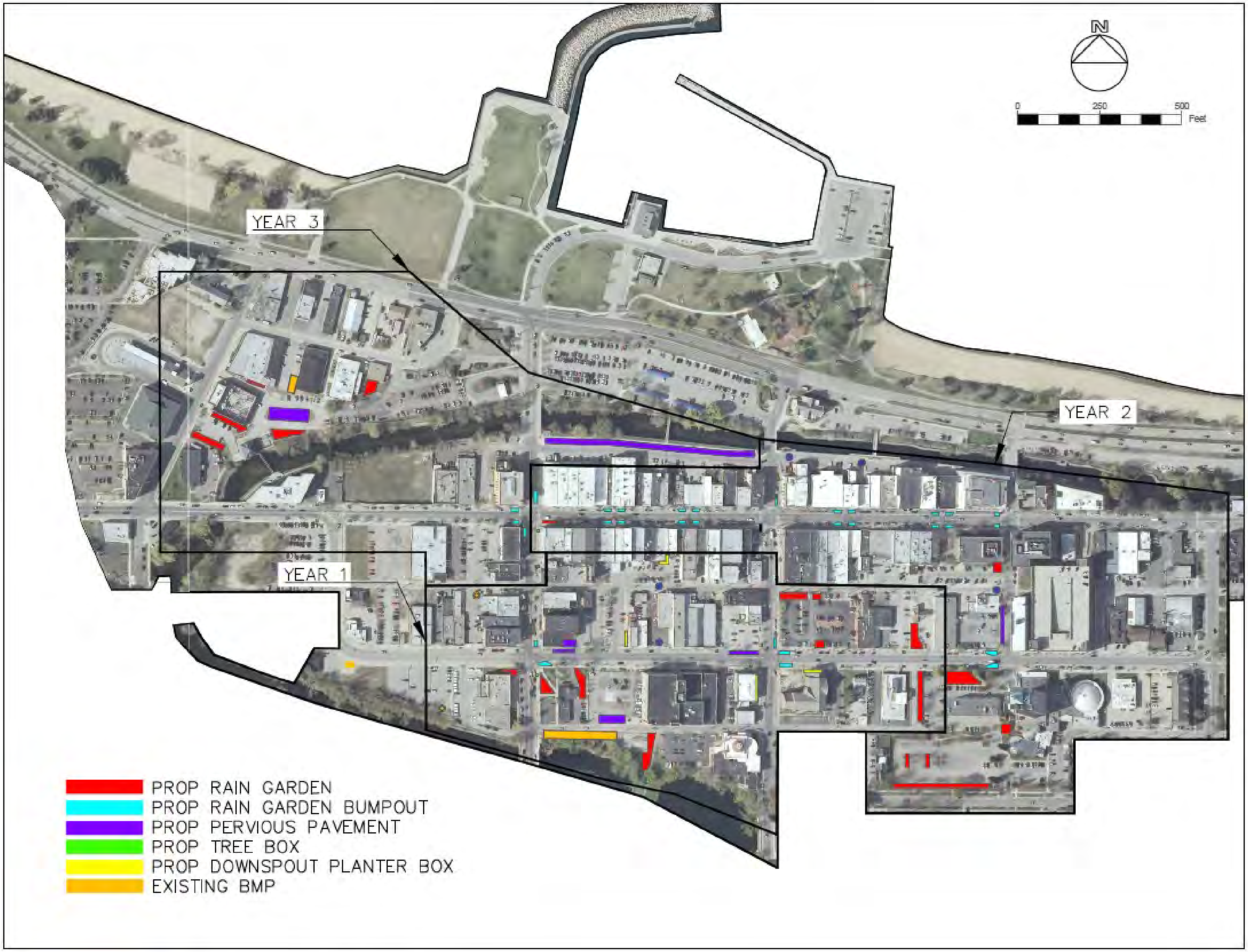


Figure 73. Three Year Capital Improvement Plan

The most relaxed CIP is presented next which has a ten year implementation period and an approximate stormwater budget of $200,000. **Table 14** shows the BMP and cost breakdown per year which **Figure 72** shows this installation spatially. A more detailed look at each sub-area is available in **Appendix D**.

Table 16. Ten-Year Capital Improvement Plan

	BMP Type	Area Treated (Acre)	Average Cost*	Avg. Cost per Impervious Acre Treated ($/acre)
Year 1 *Union St, State Street between Union and Cass* ***Subtotal = $291,260***	*1 Rain Gardens*	0.10	$6,400	**$64,000**
	9 Rain Garden Bumpouts	1.02	$51,860	**$50,843**
	9 Street Trees	0.74	$157,500	**$212,838**
	2 Downspout Planter Boxes	0.22	$11,000	**$50,000**
	3 Manufactured Treatment Devices	1.40	$64,500	**$46,071**
Year 2 *Union St, State St E of Union* ***Subtotal = $228,475***	*2 Rain Gardens*	0.52	$56,600	**$108,846**
	2 Rain Garden Bumpouts	0.22	$11,400	**$51,818**
	6 Street Trees	0.97	$105,000	**$108,247**
	3 Pervious Pavements	0.91	$55,475	**$60,962**
Year 3 *Intersection of Cass and State St* ***Subtotal = $179,525***	*2 Rain Gardens*	0.73	$46,000	**$63,014**
	3 Rain Garden Bumpouts	0.40	$18,400	**$46,000**
	5 Street Trees	0.78	$87,500	**$112,179**
	1 Pervious Pavement	0.08	$16,625	**$207,813**
	2 Downspout Planter Boxes	0.22	$11,000	**$50,000**
Year 4 *State St between Boardman Ave and Cass St* ***Subtotal = $215,288***	*2 Rain Gardens*	0.83	$78,900	**$95,060**
	4 Rain Garden Bumpouts	0.56	$34,100	**$60,893**
	4 Street Trees	0.47	$70,000	**$148,936**
	2 Pervious Pavements	0.63	$32,288	**$51,251**
Year 5 *Front St between Cass St and Boardman Ave* ***Subtotal = $211,620***	*1 Rain Gardens*	0.66	$40,000	**$60,606**
	7 Rain Garden Bumpouts	0.93	$41,120	**$44,215**
	5 Street Trees	0.47	$87,500	**$186,170**
	2 Manufactured Treatment Devices	0.94	$43,000	**$45,745**
Year 6 *Intersection of Boardman Ave and State St* ***Subtotal = $174,550***	*3 Rain Gardens*	0.31	$76,600	**$247,097**
	2 Rain Garden Bumpouts	0.38	$17,200	**$45,263**
	2 Pervious Pavements	0.19	$75,250	**$396,053**
	1 Downspout Planter Box	0.61	$5,500	**$9,016**
Year 7 *Park St Parking Lot* ***Subtotal = $203,480***	*6 Rain Gardens*	2.81	$203,480	**$72,413**
Year 8 *Parking lot between Cass St and Union St (N of Front)* ***Subtotal = $182,000***	*1 Pervious Pavement*	1.96	$182,000	**$92,857**
Year 9 *Warehouse District* ***Subtotal = $218,610***	*5 Rain Gardens*	0.86	$139,860	**$162,628**
	1 Permeable Pavement	0.46	$78,750	**$171,196**
Year 10 *Hall St, Front W of Cass* ***Subtotal = $214,202***	*1 Rain Garden*	0.17	$39,020	**$229,529**
	10 Street Trees	1.47	$175,000	**$119,048**

**Calculated by averaging the low and high cost for each BMP, and summing each BMP category*

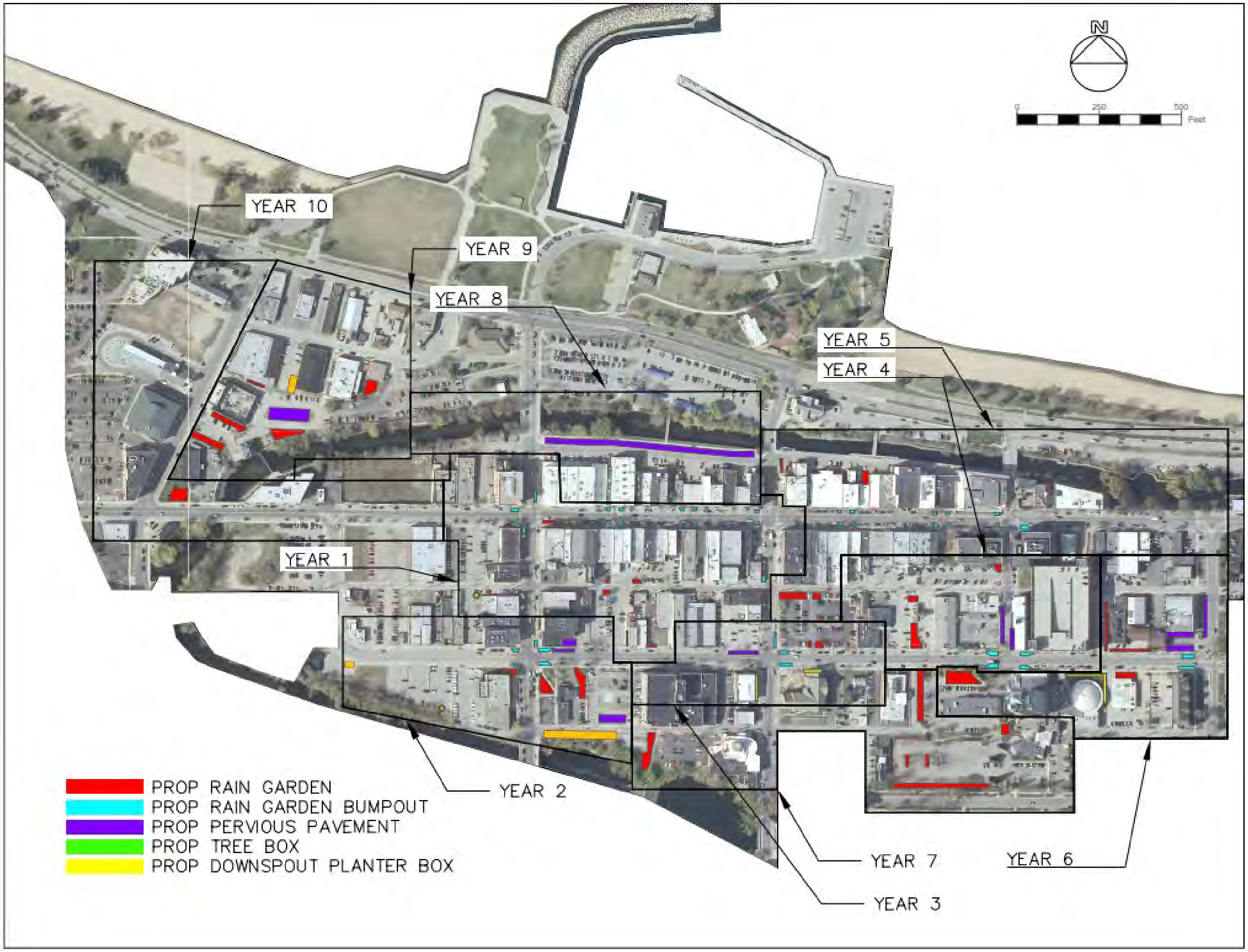


Figure 74. Ten Year Capital Improvement Plan

Appendix A – Site Contamination

Environmental Mapper

November 12, 2018

Restrictive Covenant	Notice of Approved Env. Remediation	Notice of Corrective Action
Notice of Corrective Action	Michigan Deptartment of Transportation	Notice of Aesthetic Impact
Ordinance	Restrictive Covenant	Ordinance

1:9,511

0 0.075 0.15 0.3 mi

0 0.125 0.25 0.5 km

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

Map by: State of Michigan - CSS

Environmental Mapper

November 12, 2018

Leaking Underground Storage Tanks (Part 213 Closed)

Closed

Leaking Underground Storage Tanks (Part 213 Open)

Open

Sites of Environmental Contamination (Part 201)

Underground Storage Tanks (Part 211 Active) LAST UPDATED NOVEMBER 21 2016

Active Tanks

1:9,511

0 0.075 0.15 0.3 mi

0 0.125 0.25 0.5 km

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

Map by: State of Michigan - CSS

Environmental Mapper

November 12, 2018

Brownfield Grant
Brownfield Loan
Assessments
TIF - Act 381
WRG
SFC

1:9,511

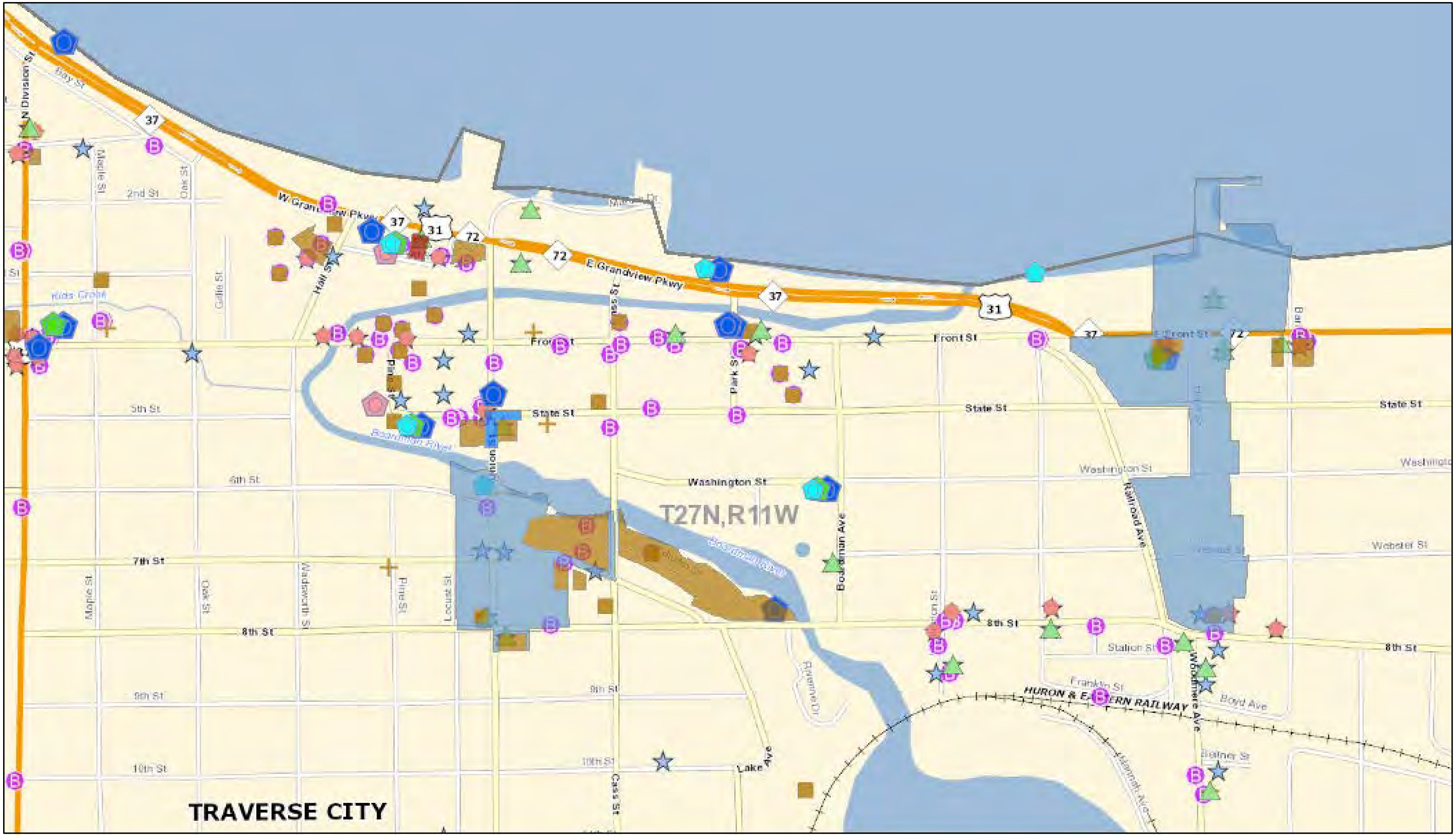
0 0.075 0.15 0.3 mi

0 0.125 0.25 0.5 km

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

Map by: State of Michigan - CSS

Environmental Mapper



November 12, 2018

Restrictive Covenant	Notice of Approved Env. Remediation	Notice of Corrective Action
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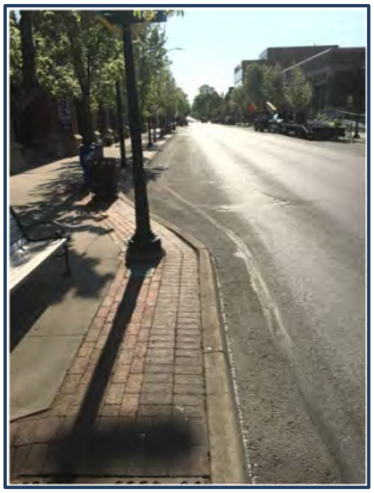
Map by: State of Michigan - CSS

Appendix B – BMP Tool Kits

Bumpout Rain Garden Opportunities — Public

Opportunity: Combine pedestrian bumpouts and rain gardens throughout the TIF 97 District for pedestrian safety and stormwater runoff control.



Bumpouts promote pedestrian safety by:

- Shortening road crossing distance
- Slowing vehicles
- Increasing pedestrian visibility
- Encouraging pedestrian use of crosswalk

Benefits of rain gardens in bumpouts:

- Infiltrate runoff from roads and sidewalks surrounding
- Landscaping adds visual appeal and urban green space
- High trafficked areas for education

Considerations:

- Public transit needs of a street
- Future applications of the road
- Reduces city parking to provide increased treatment

Location: In the TIF 97 District there are 19 locations of existing bumpouts, one of them pictured above, and at least 15 locations appropriate for the addition of bumpouts.

Stormwater Benefits

65% removal of total phosphorus (TP)
85% removal of sediment (TSS)
Reduces hydrologic impact of impervious cover

Example Outcome

In 2014, Suttons Bay, MI installed 18 rain gardens, many of which act as pedestrian bumpouts. One of these rain gardens is pictured below.

Estimated Costs

$8,000 to $15,000 depending on site constraints

Storm Trees – Global Opportunity | Public

Currently there are over 200 street trees lining the city streets in the TIF 97 District. Trees along State St at Boardman Ave are pictured below.

Example Outcome

Storm trees were recently installed along Medical Campus Drive in Traverse City, MI. Pictured below is one of these trees. It is a Japanese Lilac Tree which is a type of tree currently being used as a street tree in the TIF 97 District.

Opportunity

Street trees can be replaced with storm trees (also known as tree box infiltration). Retrofits of roads without street trees can also be designed to include storm trees.

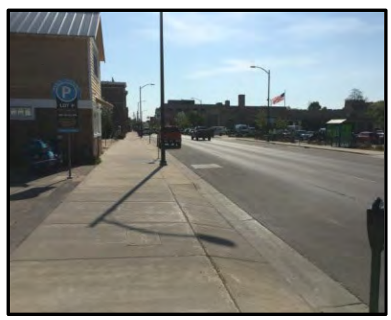
Benefits of storm trees

- Effective removal of suspended solids
- Fit in with existing infrastructure, replacing street trees
- Some storm tree options are currently being used as street trees
- Small footprint

Limitations of storm trees

- Designed to collect only the first flush of stormwater
- Fewer tree options
- More expensive to install than normal city trees

Locations where street trees need to be replaced can be opportunities to test storm trees.



There is sidewalk along roughly 20,000 ft of the existing city roads (with and without street trees) which could accommodate around 400 storm trees.

Stormwater Benefits

Storm trees can reduce runoff by approximately 15%.
Pollutant Removal Efficiencies:
Total Suspended Solids (TSS): 80-90+%
Nitrogen: 40-65%
Total Phosphorus: 50-80%

Estimated Costs

$20,000 per tree
200 Street Trees could be replaced with storm trees

Construction Site and Barren Land Sediment Control

Public/Private

Stormwater runoff from construction sites and barren land has the potential to contain high levels of sediment. Uncontrolled runoff from construction sites has been shown to have a TSS concentration ranging from 3,000 to 7,000 mg/l and annual loads of 3 tons per acre per year.

The TSS concentration from uncontrolled construction sites can be more than 150 times greater than that found in natural, undeveloped landscapes.

Typical TSS Loading from Runoff by Urban Land Use

Land Use	Commercial	Parking Lot	HDR	LDR	Freeway	Industrial	Park	Construction
TSS (lbs/acre-yr)	1000	400	420	10	880	860	3	6000

HRD: High Density Residential LDR: Low Density Residential

Source: Horner et al 1994

When proper BMP techniques are utilized, the TSS level can typically be reduced by at least an order of magnitude, if not more.

Vegetation:

One of the most effective methods of controlling sediment is to keep the soil covered with vegetation.
The vegetation is used to:

- protect from wind
- slow site runoff
- filter sediment

Watering:

Keeping bare soil moist by watering is a temporary measure for controlling wind soil erosion. This method requires an accessible water source and involves applying water to the site whenever moderate to high winds are anticipated.

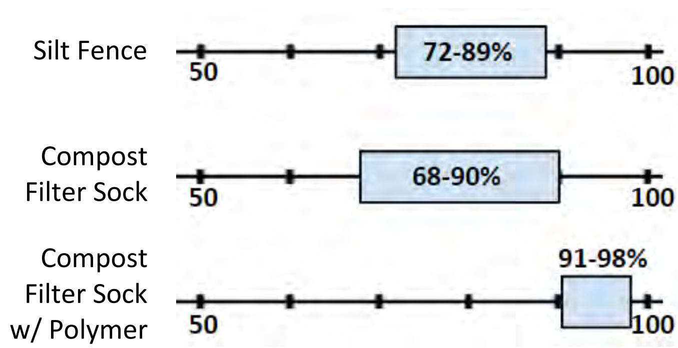
Sediment Control Barrier:

Installing sediment control barriers, such as silt fences, is one of the most commonly used BMPs to reduce sediment pollution. However, they must be installed properly or they will become inefficient. Compost filter socks are another type of sediment control barrier that is also a good option for site erosion control and are especially viable with the addition of polymers.

The sediment removal efficiencies of these technologies are listed to the right.

Sites undergoing new construction, like the one in the picture above currently in the TIF 97 district, can pollute runoff with high sediment levels, impairing receiving waters.

Sediment Removal Efficiencies



Rain Garden - 4,000 sq.ft Opportunity — PUBLIC

Location: Southeast corner of the intersection of Front and Railroad Streets

Picture from Google Maps.

Picture from Google Maps.

Picture taken May 25, 2018.

Pros

- Along the TART Trail – Opportunity for educational outreach
- Area is not a potential building location– will be able to have a longer lifetime
- Already has a catch basin
- Surrounding areas drain to it – regrading is not necessary
- Currently a sediment pollution source

Cons

- Looks like it may be a dumping zone for snow – salt pollutant source
- Just outside of TIF 97 District

Stormwater Benefits

4000 sqft Rain garden could potentially treat 0.5 acres of surrounding impervious area.

Pollutant Removal Efficiency:
Total Phosphorus (TP): 65%
Sediment (TSS): 85%

Estimated Cost

$15,000 to $25,000

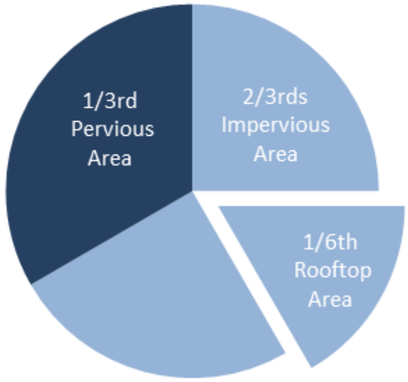
Example Outcome

Philadelphia's Germantown Section

https://e360.yale.edu/features/with-a-green-makeover-philadelphia-tackles-its-stormwater-problem

Green Roof Opportunities — Public/Private

TIF 97 Land Use



The majority of land in the TIF 97 District is impervious with nearly 24 acres, one sixth of the total area, being rooftop area.

~18.5 acres of this area could be useable to implement green roof technology.

~10 percent of this area is publicly owned.

Opportunity

Green roof technology can be used in these areas and in new development to reduce stormwater runoff

Pros

- Stormwater volume and rate control
- Increases lifespan of roof
- Boosts thermal performance of roof
- Reduce urban heat island effect
- Previously unused space
- Can be used for public open space

Cons

- Require structural analysis for existing infrastructure, increasing costs
- Potential roof retrofits may also increase costs
- Increased maintenance
- Increased wildlife can affect building

Retrofit Considerations

- Access to roof for maintenance
- Climate and microclimate
- Roof Slope
- Roof drain location and type
- Building code
- Building HVAC systems

New developments should be incorporating green roofs into design as this is the easiest and most cost effective way to use this technology.

Example Outcome

Pictured below is the 10,000 sqft intensive green roof built as part of the Uptown Condominium complex in 2017, located in the TIF 97 District.

Stormwater Benefits

Green roofs have the ability to retain 60-100% of stormwater received.
Can achieve 85% sediment (TSS) removal.

Expected Costs

Varies based on roof type, size, and plant selection.
Typical green roofs cost between $20-$25 per sq.ft.
Structural roof changes can add an additional $20-$25 per sq.ft.

Manufactured Treatment Devices | Public/Private

Manufactured treatments devices (MTDs) are structural BMPs designed to improve stormwater quality in systems directly discharging to waterbodies. They do not store water or reduce peak flow.

Types and Purposes

Separation Devices: standard stormwater MTDs

- Sediment deposition sump with chambers, baffles, or weirs
- Treats: sediments, traps trash, oil, grease, and other contaminants

Filtration Devices: MTDs for impaired water bodies or to meet TMDL requirements

- Sedimentation chamber a filtering chamber
- Treats: sediments and pollutants such as nitrogen, phosphorus, copper, lead, zinc, and bacteria

Catch Basin Inserts: MTDs for locations with limited space

- Can include filter media including porous polymers, treated cellulose, and activated carbon
- Treats: oil, grease, hydrocarbons, and heavy metals.

Opportunity

Install MTDs as pretreatment for other BMPs or to improve water quality in constrained locations

Pros

- Useful for pretreatment/removal of TSS
- Can be an excellent choice in ultra-urban or other constrained sites
- Useful for redevelopments and to improve local conditions
- Longevity can be high with proper maintenance

Cons

- Must be sized carefully to achieve design removal efficiencies
- Sediment size and loading rate may affect efficiency of device
- Regular maintenance required to achieve design removal efficiencies
- Not appropriate for terminal treatment for runoff from critically polluted areas

Applications

- Areas with physical constraints:
  - High groundwater levels
  - Poor soils
- Redeveloped areas
- Space constrained areas

Stormwater Benefits

Treatment levels will vary based on type.
Pollutant Removal Efficiencies:
Sediments (TSS): 80+%
Total Nitrogen (TN): 30+%
Total Phosphorus (TP): 20-50%

Cost Estimates

Costs will vary based on device type.
Can range from $3,000-$40,000+

Hydrodynamic separator located in the parking lot of Panache Boutique.

Permeable Pavers

Public/Private

Nearly 1/2 of TIF 97 District is impermeable roads, alleys, parking lots, and sidewalks.

Opportunity: Retrofit these areas with permeable pavement for stormwater control and treatment

Permeable Pavers	Permeable Concrete	Permeable Asphalt
		

Pavement Type	Permeable Pavers	Permeable Concrete	Permeable Asphalt	Traditional Concrete	Traditional Asphalt
Materials Cost (per square foot)	\$5-\$10	\$2-\$7	\$0.50-\$1	\$1-\$3	\$0.50-\$1.5
Longevity	20-30 years	20-30 years	15-20 years	25-50	15-30
Permeability	2 feet per day	10 feet per day	6 feet per day	-	-
Stormwater volume retention	34-100%	99-100%	25-100%	-	-

Advantages

- Retain stormwater runoff and improve water quality
- Allow adaquate rooting space for trees
- Minimal maintenance: periodic removal of debris

Disadvantages

- More expensive than traditional pavements
- Inappropriate for areas with heavy traffic or high weight requirements

Stormwater Benefits

Pollutant Removal Efficiencies:
TSS: 85-95% ; Total P: 65-85%
Total N: 80-85% ; Metals: 98%

Existing Location

3,500 sqft permeable parking area located by the Boardman River and S Union St. pictured below.

Opportunity Types and Locations

Opportunity in city parking lot.

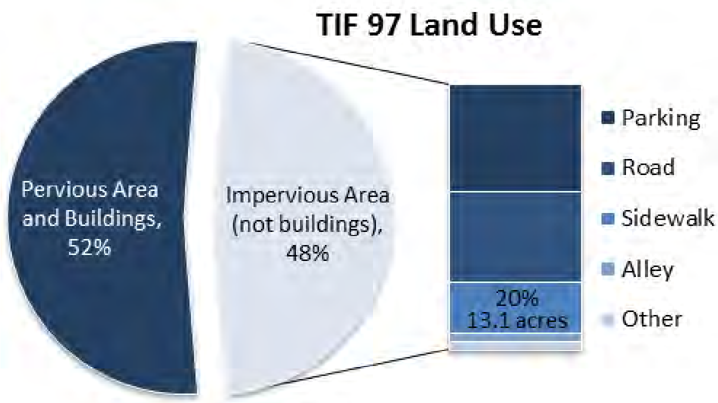
Opportunity in other area with brick paving.

Opportunity in low spot in driveway.

Opportunity in replaced part of driveway.

Permeable Pavers – 29,000 sqft Opportunity

Public - Specific



Nearly 1/2, 68 acres, of TIF 97 District is impermeable roads, alleys, parking lots, and sidewalks.

Roughly 20%, 13.1 acres, of this area is used for sidewalks.

5%, 0.65 acres, of the sidewalk area is paved with brick pavers.

In the TIF 97 District there are over 10,000 lineal feet of brick paving sections, pictured to the right, in the sidewalk area.

These sections equate to approximately 29,000 square feet, 5% of the sidewalk area.

Opportunity

Retrofit brick paving area, 29,000 square feet, with decorative pervious pavement which has similar cost, lifetime, and aesthetic function while also providing stormwater runoff and quality control.

Paver Comparison

Paver Type	Brick Pavers	Permeable Pavers
Cost (per sqft)	$3-$15	$4-$12
Lifetime	20+ years	15-25 years

Stormwater Benefits

Pollutant Removal Efficiencies:

TSS: 85-95%
Total P: 65-85%
Total N: 80-85%
Metals: 98%

Cost Estimate

Material Costs:
$116,000 - $350,000

Construction costs are similar for both brick and pervious pavers.

Example Outcome

Marquette Ave in downtown Minneapolis, 2009

In 2009, the sidewalks along Marquette Ave in Minneapolis, pictured to the right, were retrofitted to better manage stormwater and maintain and improve the region's aesthetic qualities.

The project included the implementation of 15,000 square feet of permeable pavers in tandem with a biofiltration system and 190 trees.

This system is design to reduce stormwater runoff from the surrounding 5.5 acres and store 21,600 cu. ft of stormwater from each rain event. It also is expected to achieve the following pollutant removal efficiencies:
80% P , 60% total N, >90% metals

Willowcreekpavingstones.com

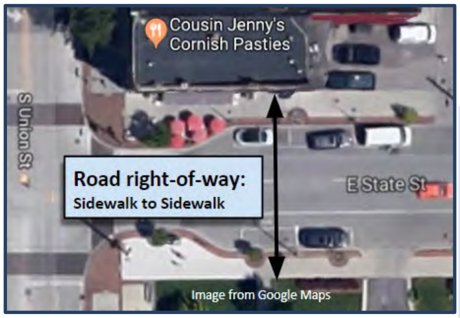


Image from Google Maps

Green streets are broad program initiatives aimed at mitigating significant sources of pollution, that are characteristic of roadways, through the use of combinations of BMPs.

Making up one third of the TIF 97 District and half of the region's impervious cover, urban road right-of-way (ROW) area, including public roads and sidewalks, totals 47 acres.

Annually this equates to 30 million gallons of runoff with more than 10 tons of sediment and 60 pounds of phosphorus.

Opportunity

ROW area in the TIF 97 district can be designed using combinations of stormwater BMPs to improve its function, protecting the region's water resources and enhancing community health and prosperity.

Stormwater Functions

- Provide source control of stormwater to limit the transport of pollutants to stormwater conveyance systems
- Restore predevelopment hydrology to possible extent
- Create roadways that help protect the environment and local water quality

Green Street Structure

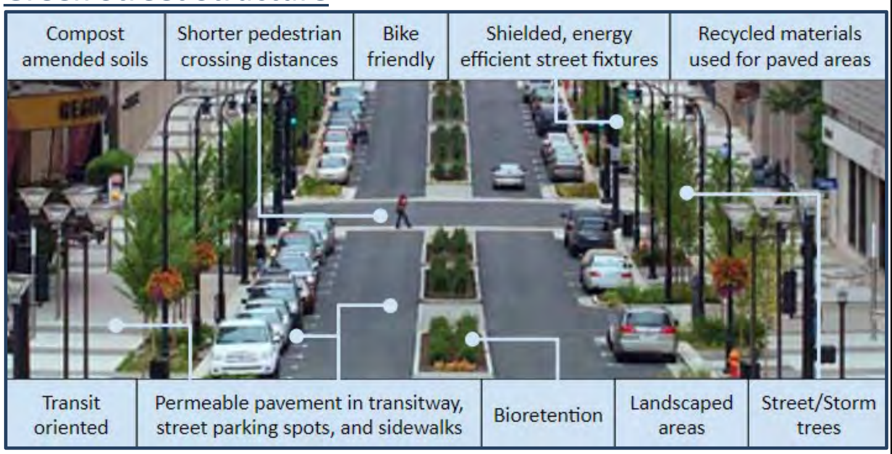


Image from Kaid Benfield Archive 2007-2014

Example Outcome

Retrofitted in 2012, Lake Street in Whitehall, MI was Michigan's first green street. Its 2,800 foot length incorporated BMP technologies including permeable brick pavers, pervious concrete intersections, bio-swales, bioretention, and wetlands. The project cost $1 million, with $381,000 of the costs paid for with federal grants, and took 4 months to complete. The picture below shows a pervious concrete intersection and bio-swale.


Image from https://www.youtube.com/watch?v=Qxf3T2oGqGM

Other Benefits

- Enhances aesthetics
- Improves local air quality
- Enhances economic development
- Improves pedestrian and bicycle safety and experience

Considerations

- Funding
- Integrate into road standards
- Limited space
- Extensive impervious surfaces
- Deicers

Stormwater Benefits

80-94% peak flow reduction
90% reduction of TSS, organic pollutants/oils, and heavy metals

Downspout Planter Boxes

Public/Private

Planter boxes receive runoff, usually from rooftops through downspouts. This stormwater runoff is retained and used to infiltrate the vegetation. They are designed to minimize stormwater runoff, improve water quality, and improve community aesthetics.

There are 24 acres of rooftops throughout the TIF 97 District, 10% owned by the city.

Opportunity

Design new buildings in TIF 97 District to control rooftop runoff with downspout planter boxes; retrofit existing planter boxes to accommodate stormwater; implement boxes near existing downspouts

Benefits

- Stormwater runoff reductions
- Water treatment capabilities
- Applicable for ultra-urban areas
- Enhance site aesthetics & habitat

Types:

Controlled (above ground): water is retained in box

Infiltration (below ground): water flows through system into the ground

Flow-through: water flows through system into stormwater system

Many buildings in the TIF 97 District are currently maintaining landscaping structures. The two pictures to the left, Blue Care Network, and right, Park Place, show existing planter boxes that could have been designed to accommodate stormwater.

Design Features

- Native vegetation
- May be designed to infiltrate or for pretreatment
- Flow bypass during winter
- Captured runoff drains out in 3-4 hours
- Contained and flow-through systems can treat hotspots

Stormwater Benefits

Pollutant Removal Efficiencies:

TSS – 80% ; Total N – 60% ; Total P – 40%

Maximum Impervious Drainage Area:

15000 square feet

Cost Estimate

Varies based on type, size, and plant selection.

Approximately:

Construction: $8-15 / sq.ft

Maintenance: $400-$500 / year / 500 sq.ft

Considerations

- Higher costs due to structural component variations
- Easier to implement during new construction
- Soil restrictions for infiltration systems

Example Outcome

The City of Los Angeles custom designed stormwater planter boxes for residential and business properties who applied to be a part of the program.

Each box was valued at $4,500. One is pictured below.

Image from: http://www.lastormwater.org/blog/2009/

Cisterns / Rainwater Harvesting — Public/Private

There are 24 acres of rooftops throughout the TIF 97 District, 10% owned by the city.

Cisterns are used to collect and store rooftop runoff for water reuse. Stormwater that is captured on a site can be reused for non-potable needs such as irrigation, toilet flushing, water supply for onsite fountains or ponds, and water supply for cooling systems.

Opportunity

Install cisterns on properties to collect water from roof and reuse for non-potable water needs

Benefits

- Reduces stormwater discharges
- Lessons stress on water sources
- Ultra-urban applications
- Reduce water fees for property owners

Limitations

- Only treat rooftop runoff
- Storage capacity must be monitored
- Regulations may limit reuse applications

Example Location in TIF 97

The rooftop area of Chemical Bank, pictured below, is around 4,000 sq.ft and collects, on average, over 10,000 cu.ft of rainwater per year.

The addition of a 4,000 gallon cistern, having a ~72 sq.ft footprint, on this site would provide a significant amount of the irrigation needs of the 7,000 sq.ft lawn.

In the month of July, the hottest month, reusing the stormwater entering the system could in a 58% reduction of irrigation needs and a $43 month water bill reduction.

Considerations

- Before installing a cistern, analyze if other BMPs would be better incorporated in the area.
- Cisterns are most effective when designed to meet a specific water need for reuse:
  - Perform a water budget analysis incorporating anticipated water inflow and usage.
- Underground cisterns have higher costs
- Incorporate design features to make inspecting and maintenance easier

Design Features

- 100 to 10,000 gallon capacity
- Overflow, pump, water distribution system
- Winterizing capabilities

Stormwater Benefits

Volume reduction and flow control of roof drainage varies depending on storage volume of design.

Cost Estimates

Costs vary, depending on material used, size, and pump characteristics. Material and installation costs can be $2,000-$20,000+.

Example Outcome

There are more than 140 rainwater harvesting systems in New York City community gardens, collecting over 1.5 million gallons of rainwater a year from nearby roofs or shade structures. This water is made convenient for the gardeners.

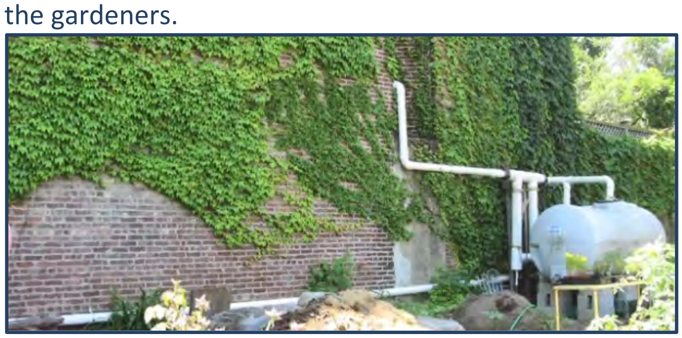


Image from: https://www.grownyc.org/openspace/rainwater-harvesting

Underground Storage | Public/Private

An underground detention facility consists of pipes or manufactured underground chambers used to temporarily store stormwater runoff following a storm event, discharging it at a controlled rate through a hydraulic outlet structure to a downstream conveyance system.

Opportunity

Construct underground storage facility under parks, parking lots, roads, or other land uses where surface-based BMPs are impracticable.

Benefits

- Capture and storage of stormwater runoff
- Longevity is high, with proper maintenance
- Low head requirement
- Insulation from freezing
- Applications for high density or urban areas

Limitations

- Discouraged unless other options unfeasible
- Not intended for water quality treatment
- Frequent maintenance is required
- High construction, materials, maintenance, and operation costs

Types of Underground Storage

Stone Storage	Storage Vaults	Pipe and Chamber Storage	Plastic Grid Storage
			

Inspections shall be made every six months and within 24 hours after every storm event greater than 1.0 inches to clean the oil and sediment accumulation.

Design Features

- Outlet structure
- Emergency spillway
- Maintenance access

Because underground detention in not intended for water quality treatment, it must be used in a treatment train approach with other structural BMPs that provide water treatment.

Maintenance Requirements

- Remove debris from inlet and outlet structures.
- Monitor sediment accumulation.
- Clean out sediment and floatable debris using catch basin cleaning equipment (vacuum pumps)

Stormwater Benefits

Maximum Drainage Area: 25 acres
Capacity: runoff from 100-year design storm

Cost Estimates

Pipe Storage: $5-$7 per CF
Chamber Storage: $5-$9 per CF
Pre-Cast Concrete Vault Storage: $10-$15 per CF

Example Outcome

In order to accommodate the runoff from a 100-year design storm and not reduce parking lot area, the Chrysler Jeep Dodge dealership in Lansing, MI was built with an underground pipe storage system with a 33,000 cu.ft capacity.

Image from: http://www.tritonsws.com

Street and Alley Sweeping — Public

Stormwater runoff from roads and alleys is one of the most significant sources of pollutants, including sediment and metals, to a city's surrounding waterbodies.

Paved road and alley area, 25 acres, accounts for 18% of the TIF 97 District. When including city parking lots, also sources of sediment and metals pollution, this number increases to 25%, 35 acres.

Street sweeping is a method for cities to remove sediment and other pollutants from roads, alleys, and parking lots to limit their entrance to the surrounding water bodies.

The Traverse City Streets Department is responsible for the upkeep of 100 miles of roads and 20 miles of alleys. 4 miles of these roads and 1 mile of alleys are located in the TIF 97 District.

Many Midwest utilities sweep streets twice a year, in spring to remove sand and salt and in the winter to remove leaves and debris. Others have programs that sweep streets as often as possible.

Types of Sweepers

Mechanical Broom: remove debris – used for gross pollutant pickup
Regenerative-air: remove smaller particles both and large materials on pavement with cracks and uneven sections
Vacuum: remove smaller particles on typical pavement

Sweeper Comparison

Type	Mechanical	Regenerative	Vacuum
Lifespan	5 years	10 years	8 years
Price	$100,000	$150,000+	$200,000+
O&M Cost	$50/curb-mi	<$25/curb-mi	$25/curb-mi
Particle Size	>100-125 um	<100 um	<100 um
Efficiency	41%	54-57%	54-57%

Stormwater Benefits

Pollutant Removal Efficiencies:
Sediment: 35-80%
Nutrients: 15-40%

Cost Estimates

Capital Investment: $100,000+
Twice per year: $500-$1,000
Four times per year: $1,000-$2,000

Opportunity

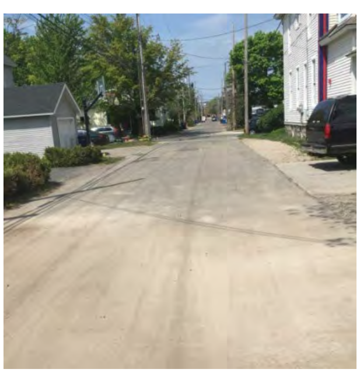
Increase sweeping efforts of TIF 97 District roads, alleys, and city parking lots identified to have critical sediment loads.

Advantages

- Clear out debris blocking stormwater infrastructure, reducing flooding
- Reduce sediment and debris, metal, and organic compound pollutants
- Aesthetic appeal of clean streets
- Can improve air quality, meeting PM-10 standards

Considerations

- 90% of sediments are within 2m of curb
- Minimize parking interference
- Select streets with more critical dust load
- Tandem sweeping operation – first use mechanical sweeper and then use regenerative air sweeper



Sweeping Importance in Alleys

Street sweeping can have the biggest impact in alleys where there tends to be more sediment, see picture to left.

Alleys are also the main locations of new catch basins not listed on city documents, see picture to right. Nearly 75% of the undocumented catch basins were located in alleyways.

Infiltration Basins

Public/Private

Infiltration basins are shallow, vegetated impoundments with the capacity to store and infiltrate stormwater providing runoff flow control and water quality benefits. Infiltration basins have limited applications in urban areas due to site constraints.

Opportunity

Where space allows, consider the use of infiltration basins to control and treat stormwater runoff.

Applications

- New development – where existing vegetation can be preserved
- Retrofitting existing lawns/open space

Design Considerations

- Soil capacity for infiltration
- Site slope
- Aesthetics
- Not intended for brownfield or hotspot sites
- Located away from buildings
- Groundwater separation >=3m
- Space requirements range from 1,000 sq.ft to up to an acre

Stormwater Benefits

Recommended Contributing Area: 50 acres or less

Pollutant Removal Efficiencies:

Sediment (TSS): 50-80%
Total Nitrogen (TN): 50-80%
Total Phosphorous (TP): 50-80%
Pathogens: 65-100%
Metals: 50-80%

Cost Estimate

Costs will vary based on site characteristics and basin size and design.
Expected to cost \$20-\$25 per sq.ft.

Existing Infiltration Basin Location

Currently in the TIF 97 District there is a roughly 800 sq.ft infiltration basin serving the parking lot next to NorthWoods Tattoo Parlour, pictured below. It has an estimated storage capacity of 600 cu.ft.

Potential Infiltration Basin Location

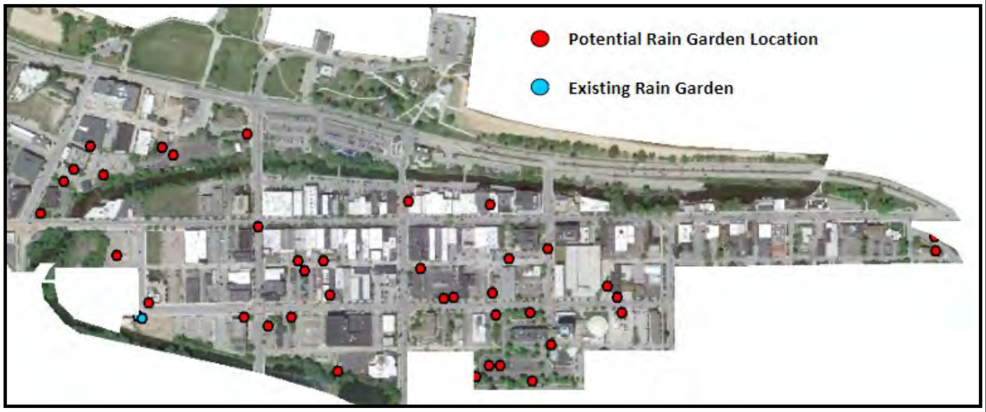
While there are not many locations in the TIF 97 District with enough open space to construct an infiltration basin, some sites have the potential. The green space beside Bay West Antiques, pictured below, is not currently serving an aesthetic purpose and would accommodate a 1,800 sq.ft infiltration basin with a roughly 3,300 capacity.

Rain Gardens | Public/Private

In order to improve water quality and reduce stormwater runoff volume, rain gardens (also called bioretention) are constructed by excavating a shallow surface depression and planting area with native vegetation.

Opportunity

Incorporate rain gardens into parking lots, along roads and sidewalks, and in larger open green spaces to capture, filtrate, and infiltrate the stormwater runoff from the surrounding regions.



Nearly 40 locations were identified in the TIF 97 District as being appropriate for potential rain garden implementation.

Benefits

- Volume control and groundwater recharge, filtration
- Moderate peak rate control
- Enhance site aesthetics, habitat
- Versatile

Limitations

- Higher maintenance until vegetation is established
- Limited impervious drainage area
- Requires careful selection and establishment of plants

Variations

- Subsurface storage/infiltration bed
- Use of underdrain
- Use of impervious liner

Design Considerations

- Native Plants
- Max draining area: 5:1
- Can be use with hotspots with pretreatment and/or impervious liner
- Soils types A and B preferred. Soil types C and D may require an underdrain.

Stormwater Benefits

Pollutant Removal Efficiency:
Total Phosphorus (TP): 65%
Sediment (TSS): 85%

Reduces hydrologic impact of impervious cover

Estimated Costs

Cost will vary based on site location, garden size, and plant type.

Approximately:
$10-$20 / sq.ft

Existing Rain Garden Location

Two rain gardens, pictured below, were recently constructed, in 2017, as part of the Uptown Development Condominium complex.