# Lewiston, Michigan
# Stormwater Assessment

Prepared for:

**Albert Township**

**Montmorency County Road Commission**


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The statements, findings, conclusions and recommendations in this report are those of Huron Pines and do not necessarily reflect the views of our funders or other partners.

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## Introduction

Lewiston, located in Montmorency County, Michigan, is a census designated place at the headwaters of the AuSable River. Approximately 996 people (US Census Bureau, 2020) reside in the census designated place of Lewiston, which encompasses 8.5 square miles (5467 acres). Established in 1892, Lewie's Town (later changed to Lewiston) began as a lumbering town where two mills processed lumber and shipped it to the city of Grayling. The lumber mills ran from 1892-1910, and the railroad until 1933. While the lumber industry was a big factor in the development of Lewiston, that is no longer the case and tourism is now a key part of the Lewiston economy. The summer months see an increase in residents and visitors coming from all over to enjoy the beauty of Northern Michigan and life on the lake. With an increase in development comes an increased strain on the natural resources in an area, especially in a town that relies heavily on its water resources in the summer months.

During snowmelt or rainfall events, stormwater picks up pollutants such as sediment, road salts, fertilizers, pet waste, oil and grease, detergents and other chemicals. In areas where runoff travels over impervious surfaces (e.g. roads, rooftops, sidewalks, and parking lots), the pollutants become more concentrated and are often transported directly into nearby bodies of water via overland flow (water running over the land that does not enter a storm sewer drain), ditches or storm sewer systems. Historically, as development occurred stormwater runoff was removed from roads and sidewalks as quickly as possible and directed to the nearest lake, river or wetland. As populations grow, the amount of polluted runoff decreases water quality and increases the likelihood of flooding and erosion in nearby areas. By thoughtfully managing stormwater runoff, communities can reduce the adverse effects of polluted stormwater runoff which include beach closures, waterborne illness, degraded fish and wildlife habitat and loss of natural aesthetics. Improving stormwater management practices can also help to minimize local flood-related issues.

The purpose of this stormwater assessment is to provide Albert Township and community of Lewiston a characterization of the current stormwater infrastructure, calculations of discharge and pollutant load estimates, and recommendations for improving stormwater management with a goal of protecting water quality. Water quality and its protection has important implications for human health, aquatic ecosystems, property values and the local economy. Identifying and quantifying stormwater concerns are the first steps in designing effective practice to prevent, reduce and treat/manage polluted stormwater runoff.

This stormwater assessment will focus on the urban area of Lewiston. To read studies regarding East and West Twin Lake and a storm pond that all of the Lewiston stormwater drains to, refer to Restorative Lake Sciences evaluations titled: “Evaluation of the Lewiston Storm Pond and Recommendations for Management of Nutrients Entering East Twin Lake” (RLS 2020), and “East and West Twin Lakes Limnological Evaluation and Lake and Watershed Management Plan Montmorency County, Michigan” (RLS 2018). The purpose of this assessment is to identify and address pollutants at the source, rather than areas of accumulation.

This stormwater assessment provides:

- A map of stormwater drainage zones and key overland flow areas in Lewiston
- Rainfall and runoff estimations for first flush (initial ½ inch of rainfall), 10 year, 25 year and 100 year rain events
- Determination of soil classifications and land use using remotely sensed satellite data to estimate the impervious surface in the city and calculate runoff flow rates
- Estimated pollutant loads from stormwater runoff
- Recommended BMPs suitable for Lewiston intended to reduce the amount and improve the quality of stormwater runoff entering surrounding water bodies

Specific stormwater management objectives include:

- Protect water quality by minimizing the amount of pollutants available for transport
- Minimize the portion of stormwater that flows rapidly overland or through storm sewer systems and maximize the portion of stormwater that naturally soaks into the ground. This will allow for better groundwater recharge, enhanced filtration and minimize potential flooding issues
- Educate community members about existing stormwater conditions and ways to protect clean water and natural resources through good stormwater management practices
- Focus on intercepting pollutants (front of pipe) before they enter the storm sewer system, avoid focus on ‘end of pipe’ solution

# Chapter 2. Stormwater Inventory

**Stormwater Infrastructure Mapping**

Huron Pines was provided with paper copies of the storm sewer system from Albert Township detailing the current known storm sewer system. Huron Pines digitized this information by georeferencing and ground-truthing stormwater inlets within the Village of Lewiston. **Figure 1** demonstrates the existing storm sewer infrastructure. Using the existing information on the location of stormwater inlets, gravity mains and outlets along with topographic data, soils data and land use information, 10 distinct stormwater drainage zones were delineated. These 10 zones either share an outlet, appear to be self-contained or were unique in the area's stormwater infiltration capacity. Aspect of the landscape (what direction the landscape is sloping) also was accounted for when zones were delineated, see **Figure 2**. The zones function as sub-watersheds in order to estimate runoff and pollutant estimates.

**While some stormwater may pass through between zones, the delineation between zones serves as a helpful tool for determining Best Management Practices (BMP), focal areas and estimations of effectiveness of BMPs. These zones also provide a means for estimating the volume of water that any given infrastructure be designed to accommodate.**

After the storm sewer was digitized, maps were sent to the Montmorency County Road Commission (MCRC) for review. Based on paper maps and comments received from the MCRC, the sewer system has been digitized to show the flow of stormwater as it makes its way through the storm sewer system. These can be found in **Figure 3**, and are accurate to the best of both Huron Pines' and Montmorency County Road Commission's knowledge based on paper maps and working knowledge of drainage issues in downtown Lewiston.

Items that were digitized include storm drains, crocks, and the storm sewer infrastructure underneath developed areas. Example photographs of storm drains crocks and the documents used

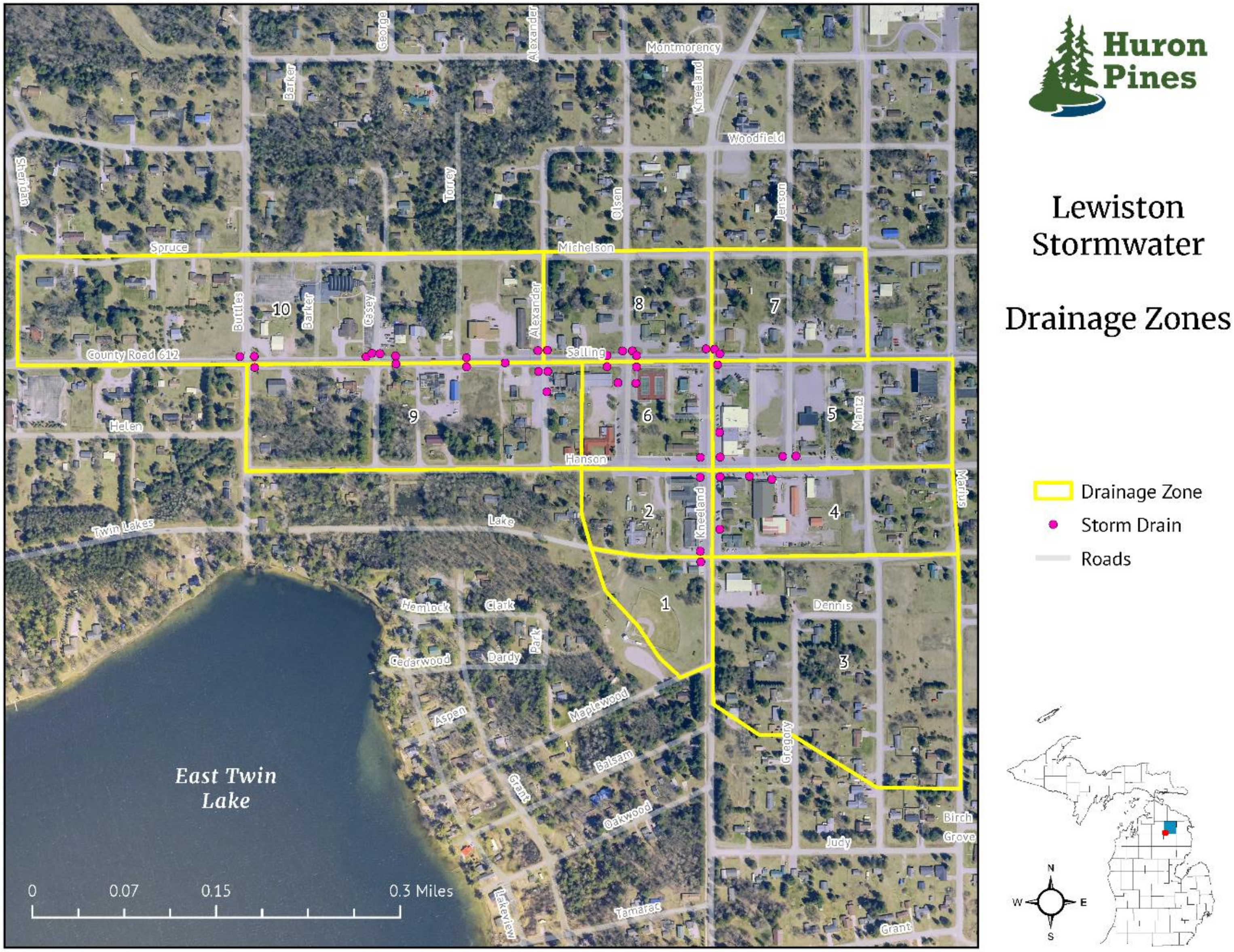


*Figure 1. Stormwater drainage zones for the area within the downtown area of the Village of Lewiston, MI.*

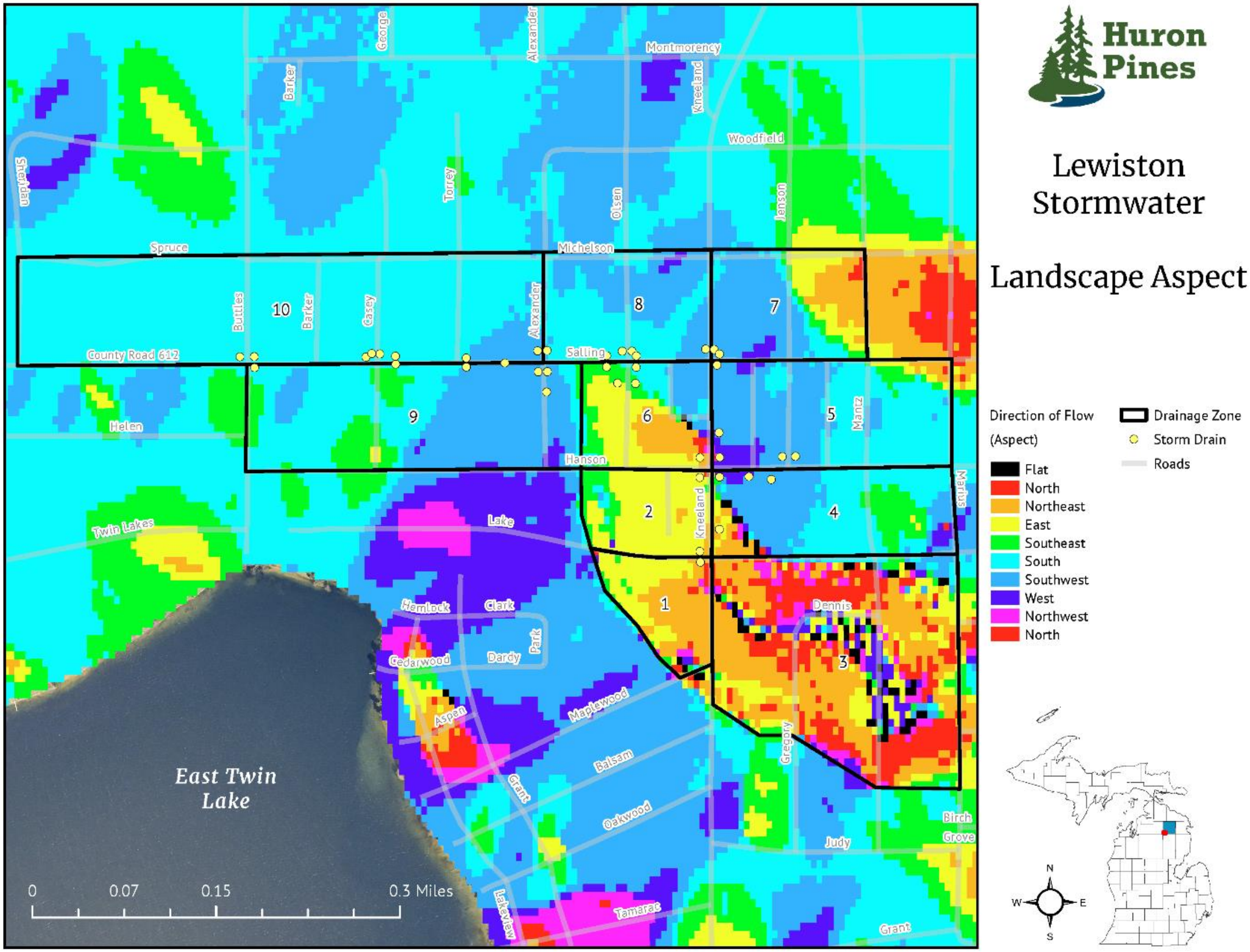


*Figure 2. Landscape aspect (direction that water flows off the land) used to delineate where runoff flows within each zone.*

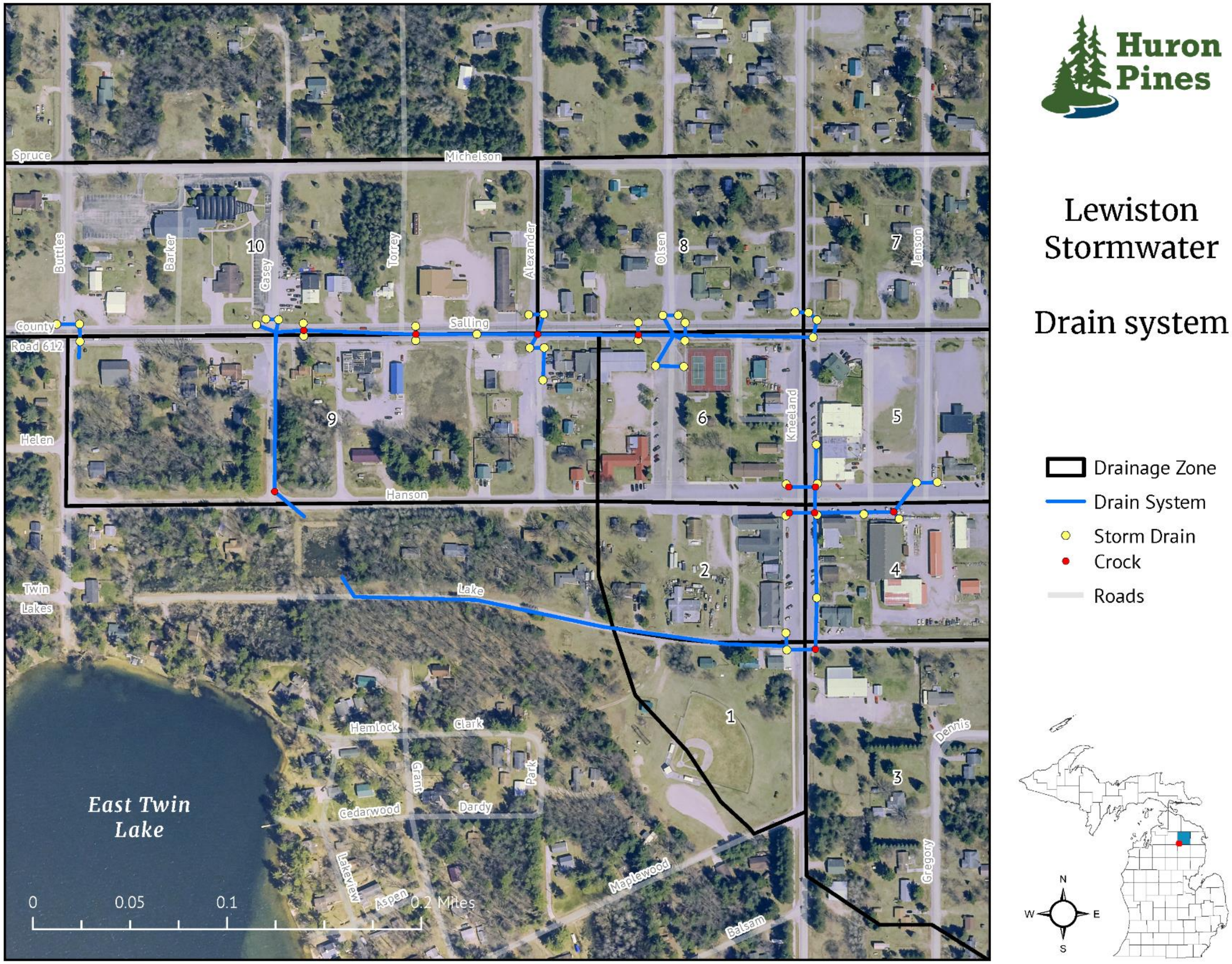


*Figure 3. Current underground stormsewer system in Lewiston, MI.*

## Estimated Stormwater Flows

Discharge and pollutant loadings for each zone were calculated in order to identify potential problem areas and suggest appropriate stormwater control BMPs. These values are listed in Table 1 and the method to estimate stormwater flows are below explained below. Stormwater runoff is listed as cubic feet per second and can give planners an idea of the volume of water that will occur during first flush (contributing to high pollutant runoff) and during extreme rain events leading to flooding concerns. Note that these values are estimated for a high water table. Therefore, areas with a high proportion of wetlands will have a high discharge rate since the wetlands are saturated under these conditions. However, wetlands are considered to provide excellent stormwater storage and filtering capacity and continue to allow for water filtration even when saturated.

Communities looking to improve stormwater management commonly elect to use a 10-year/24-hour storm scenario to size stormwater control BMPs. These BMPs will capture about 90% of rainfall events (most rainfall events are under 1 inch) and capture the "first flush" pollutants. Stormwater control practices can also be sized to treat design rainfall events such as 25-year/24-hour or 100-year/24-hour storms if flooding is the primary concern and funding is available to cover increased project costs of installing larger structures. In this assessment, estimated discharge values for each storm sewer drainage zone are calculated for first flush, 10-year/24-hour, 25-year/24-hour and 100-year/24-hour design storms.

A detailed description of the Hydrograph Method and the calculations used are provided in Appendix A.

***Table 1.*** *Stormwater calculations for different storm scenarios. Discharge estimates are listed in cubic feet per second (cfs)*

| Zone | Acres | Land Use Type | Hydrologic soil group | First Flush (cfs) | 10 year (cfs) | 25 year (cfs) | 100 year (cfs) |
|---|---|---|---|---|---|---|---|
| 1 | 4.197578 | Open Space 40%, Residential ½ acre 29%, Residential ¼ acre 17%, Residential 1/8 acre 1%, | A | 0.34 | 0.03 | 0.23 | 0.56 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Grasslands/Herbaceous 13% | | | | | |
| 2 | 4.692366 | Commercial 28%, Open Space 15%, Residential ½ acre 39%, Residential 1/4 18% | A | 0.12 | 0.54 | 1.28 | 2.16 |
| 3 | 21.4004 | Commercial 3%, Residential ½ acre 40%, Residential ¼ acre 32%, Residential 1/8 acre 18%, Woods 7% | A | 0.24 | 0.34 | 0.99 | 1.81 |
| 4 | 9.041663 | Commercial 0.2228, Residential 1/4 .078, residential 1/8 0.4179, Paved 0.2808 | A | 0.01 | 3.68 | 6.74 | 9.99 |
| 5 | 11.11984 | Commercial 43%, Paved 42%, Residential ½ acre 15% | A | 0.07 | 4.23 | 6.82 | 9.40 |
| 6 | 5.999996 | Commercial 39%, Paved 35%, Residential ½ acre 26% | A | 0.01 | 2.53 | 4.28 | 6.06 |
| 7 | 7.330129 | Open Space 3%, Residential ½ acre 37%, Residential ¼ acre 49%, Residential 1/8 acre 11% | A | 0.32 | 0.35 | 1.06 | 1.99 |
| 8 | 7.940636 | Open Space 6%, Residential ½ acre 36%, Residential ¼ acre 55%, Paved 3% | A | 0.49 | 0.63 | 1.86 | 3.43 |
| 9 | 15.22344 | Open space 15%, Residential ½ acre 33%, residential ¼ acre 46%, Paved 6% | A | 1.84 | 0.48 | 2.25 | 4.86 |
| 10 | 24.60044 | Open Space 28%, Residential ½ acre 28%, Residential ¼ acre 37%, Mixed forest 1%, Paved 6% | A/D | 1.59 | 1.26 | 4.16 | 8.02 |

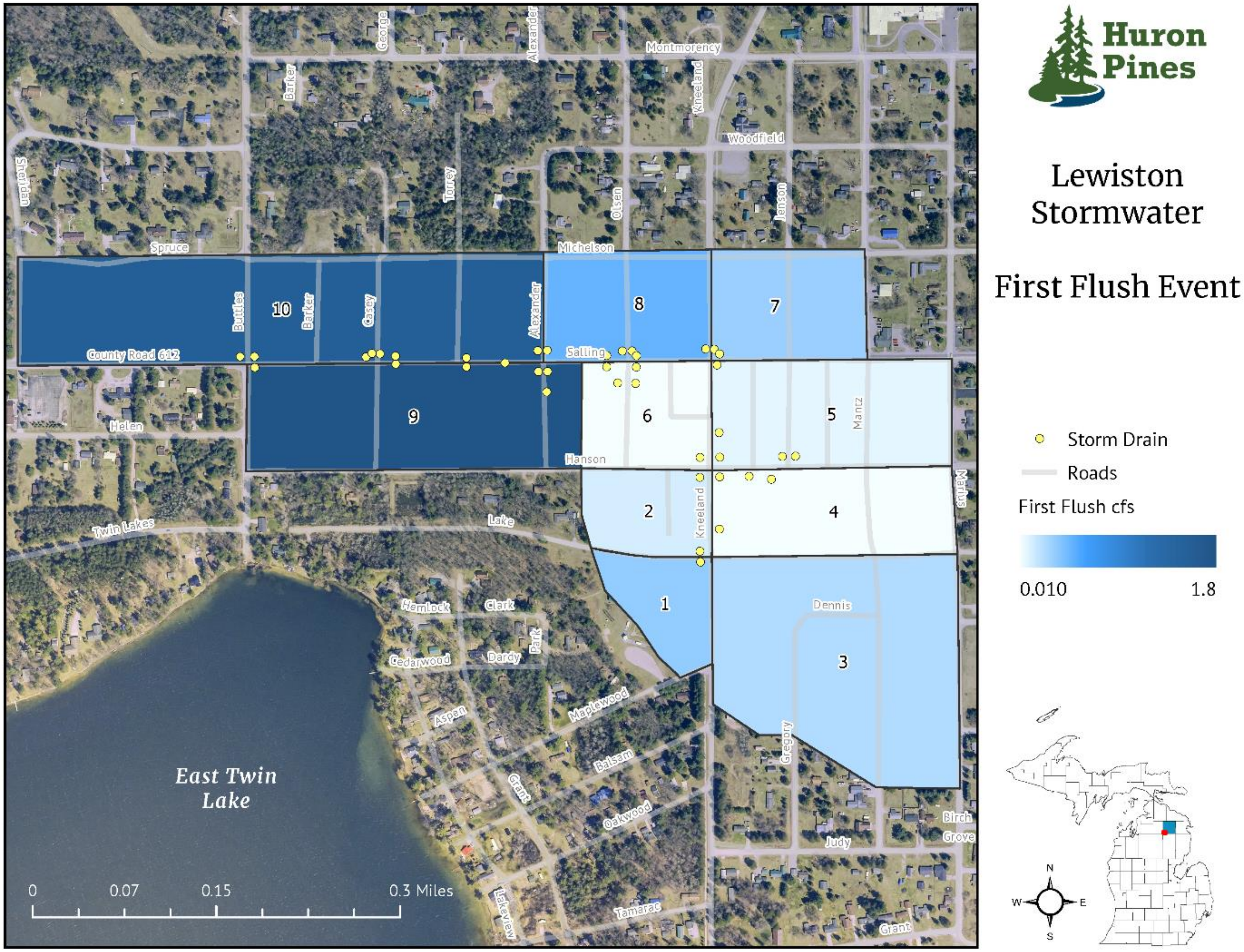


*Figure 4. The discharge of stormwater that travels overland during the first ½ inch of rainfall. The first ½ inch of rain picks up the majority of pollutants and is often targeted for capture when designing green infrastructure intended to improve water quality.*

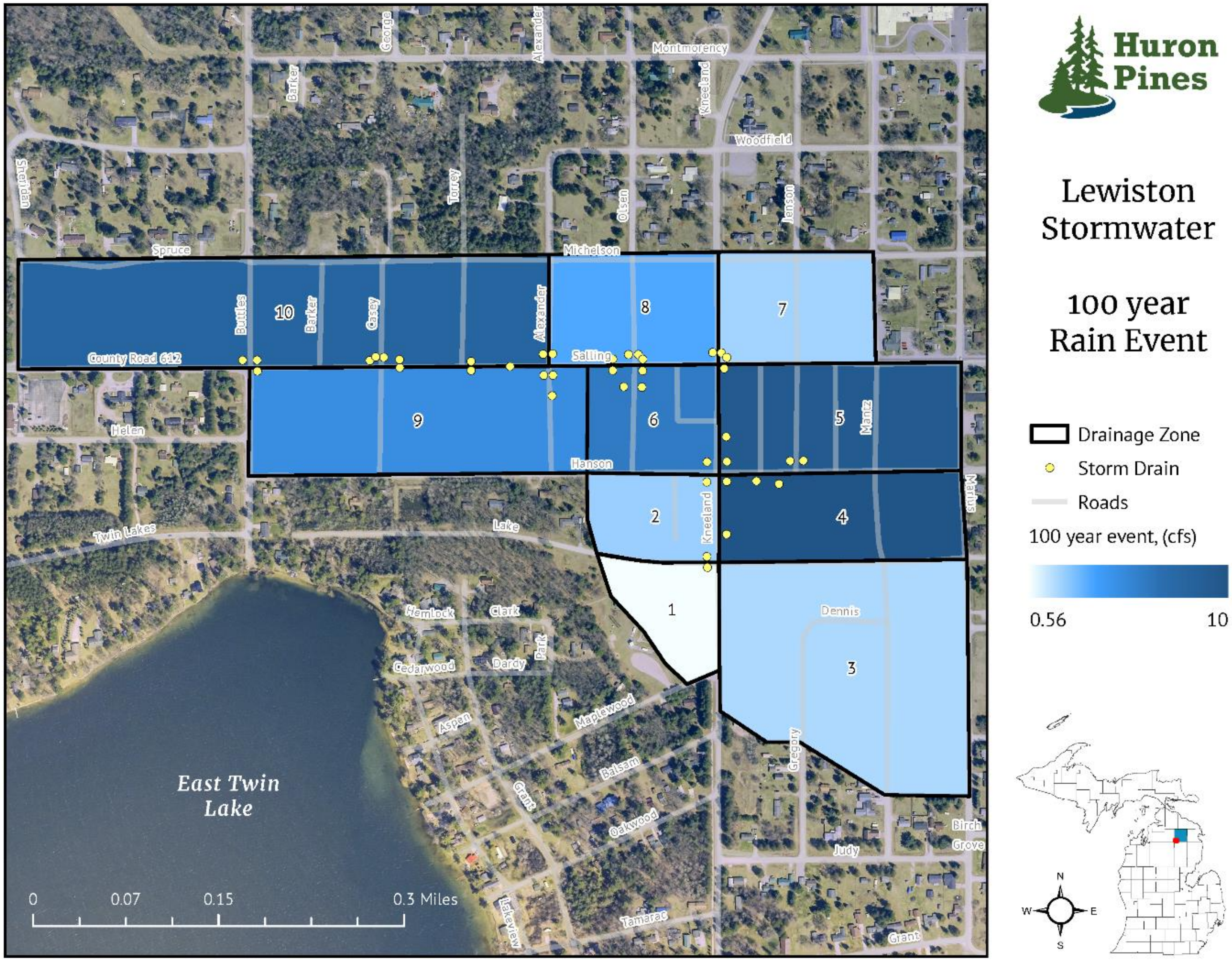


*Figure 5. The discharge of stormwater runoff that occurs within each drainage zone during a 100-year rain event. Volume is estimated in cubic feet per second (CFS).*

## Estimated Pollutant Loads

Stormwater runoff is a significant source of nonpoint source pollution in the Great Lakes basin. In undeveloped areas, a high proportion of stormwater soaks into the ground or is returned to the atmosphere through evapotranspiration. However, impervious surfaces in developed areas prevent precipitation from infiltrating the soil and water is forced to flow over the land surface. As stormwater flows over parking lots, roads, rooftops, construction sites and residential lawns it picks up sediment, oils and grease, road salt, bacteria, litter and other debris. Unlike wastewater, stormwater is not treated and these pollutants are transported directly into our rivers, streams and lakes through storm sewer drains, road ditches and via overland flow. Pollutant loading is often greater during first flush events, which are the first few minutes or hours of a storm. The reason pollutant loading is greater during these events is due to the deposition and accumulation of pollutants in the storm sewer system in between storms. These pollutants could be coming from sediments, organic buildup, or oil and grease that make their way into the storm drains during dry or frozen periods.

Polluted stormwater runoff leads to many detrimental effects on water resources. Excess sediment loading to streams covers up valuable gravel habitat used by spawning fish and aquatic invertebrates and chemical contaminants, excess nutrients and bacteria impair water quality for people and wildlife. When stormwater is forced to flow over land instead of filtering slowly through the soil, it enters our surface waters more quickly and often at an elevated temperature. This thermal pollution can harm trout and other aquatic organisms that rely on cold, clean water. Also, the rapid conveyance of water increases the frequency and severity of flood events, which can lead to increased streambank erosion, risk of property damage and damage to wildlife populations and habitat. Nutrient runoff contributes to harmful algae blooms in Lake Huron and transports bacteria that can lead to beach closures. When developed areas force stormwater to flow overland and through storm sewer systems less water is available for groundwater recharge. Consequently, the severity of drought also increases. Climate change is expected to cause an increase in both the frequency and intensity of storm events, which will increase the volume and velocity of runoff and risk for flashfloods.

Land cover type strongly influences the amount of pollutants transported by stormwater. For example, impervious commercial and industrial areas generally have the greatest pollutant loading potential due to limited ability of water to infiltrate into the ground. Vegetated areas have varying degrees of infiltration ranging from low infiltration (i.e. bare soil including fallow fields and row crops) to high infiltration (i.e. areas with deeply rooted plants including forests). Lawns typically contain shallow rooted grasses and can provide a small degree of infiltration. Soil type and slope are important factors for infiltration as well. Various studies have been conducted to estimate concentrations of certain pollutants in different land cover scenarios. Schueler (1987) has compiled average concentrations (mg/l) for total suspended solids, total phosphorus and total nitrogen in different land cover scenarios. Schueler (1987) also outlines a model, commonly referred to as Schueler's Simple Method, to estimate these annual loading of stormwater pollutants including total suspended solids, phosphorus and nitrogen.

This model is best explained and expanded upon in the Center for Water Protection's "The New York State Stormwater Management Design Manual – Appendix A: The Simple Method to Calculate Urban Stormwater Loads (2001)." The Simple Method estimates annual stormwater pollutant loads as the product of mean pollutant concentrations and runoff depths. Detailed calculations are included in Appendix D.

Estimated pollutant loading (total suspended solids, phosphorus and nitrogen) for each sewer drainage zone are summarized in Table 2. Appendix E contains calculations used to determine these values. Maps depicting these values are included (see figures 6–11).

In addition to the values calculated below, Huron Pines used the EPA's Pollutant Load Estimation Tool (PLET) to calculate nutrient loading in urban land uses. To learn more about this tool, visit this site. Huron Pines manually adjusted inputs in the PLET to reflect land use percentages and acreage existing in the focal area. According to the PLET, the total load is as follows for the defined focal area; N Load: 373.99 lbs/year, P Load: 53.61 lbs/year, TSS Load: 16,767.28 lbs/year. To see a comparison between Scheuler's Simple Method and the PLET tool, view the totals in Tables 2 and 3.

There are limitations to both the Scheuler's Simple Method and the PLET tool, which is why both calculations have been presented. The PLET tool is designed to be used at a much larger scale, typically used with data from a HUC12 watershed. These watersheds are around 10,000 to 40,000 acres, whereas the Schueler's Simple Method is designed to estimate pollutant loading for sites of a few acres or more. It is important to note that these are estimates based on best available data.

***Table 2.*** *Estimated annual pollutant loading based on Scheuler's Simple Method.*

| Zone | Area (acres) | Annual Runoff (inches) | Total Suspended Solids (lbs) | Suspended Solids per acre (lbs/acre) | Total Phosphorus (lbs) | Phosphorus per acre (lbs/acre) | Total Nitrogen (lbs) | Nitrogen per acre (lbs/acre) |
|---|---|---|---|---|---|---|---|---|
| 1 | 4.20 | 5.01 | 258.86 | 61.67 | 1.23 | 0.29 | 9.50 | 2.26 |
| 2 | 4.69 | 9.62 | 555.83 | 118.45 | 2.65 | 0.57 | 20.40 | 4.35 |
| 3 | 21.40 | 7.38 | 1,945.96 | 90.93 | 9.28 | 0.43 | 71.41 | 3.34 |
| 4 | 9.04 | 15.65 | 1,742.70 | 192.74 | 8.31 | 0.92 | 63.95 | 7.07 |
| 5 | 11.12 | 19.16 | 2,624.78 | 236.04 | 12.52 | 1.13 | 96.32 | 8.66 |
| 6 | 6.00 | 17.60 | 1,300.64 | 216.77 | 6.20 | 1.03 | 47.73 | 7.96 |
| 7 | 7.33 | 7.38 | 665.97 | 90.85 | 3.18 | 0.43 | 24.44 | 3.33 |
| 8 | 7.94 | 7.51 | 734.07 | 92.44 | 3.50 | 0.44 | 26.94 | 3.39 |
| 9 | 15.22 | 7.61 | 1,427.81 | 93.79 | 6.81 | 0.45 | 52.40 | 3.44 |
| 10 | 24.60 | 6.98 | 2,116.26 | 86.03 | 10.10 | 0.41 | 77.66 | 3.16 |
| Total | 111.55 | 103.90 | 13,372.88 | 119.89 | 63.80 | 0.57 | 490.75 | 4.40 |

***Table 3.*** *Estimated annual pollutant loading based on PLET*

| Zone | Area (acres) | Annual Runoff (inches) | Total Suspended Solids (lbs) | Suspended Solids per acre (lbs/acre) | Total Phosphorus (lbs) | Phosphorus per acre (lbs/acre) | Total Nitrogen (lbs) | Nitrogen per acre (lbs/acre) |
|---|---|---|---|---|---|---|---|---|
| Total | 111.55 | - | 18,474.74 | 165.18 | 53.61 | 0.48 | 373.99 | 3.35 |

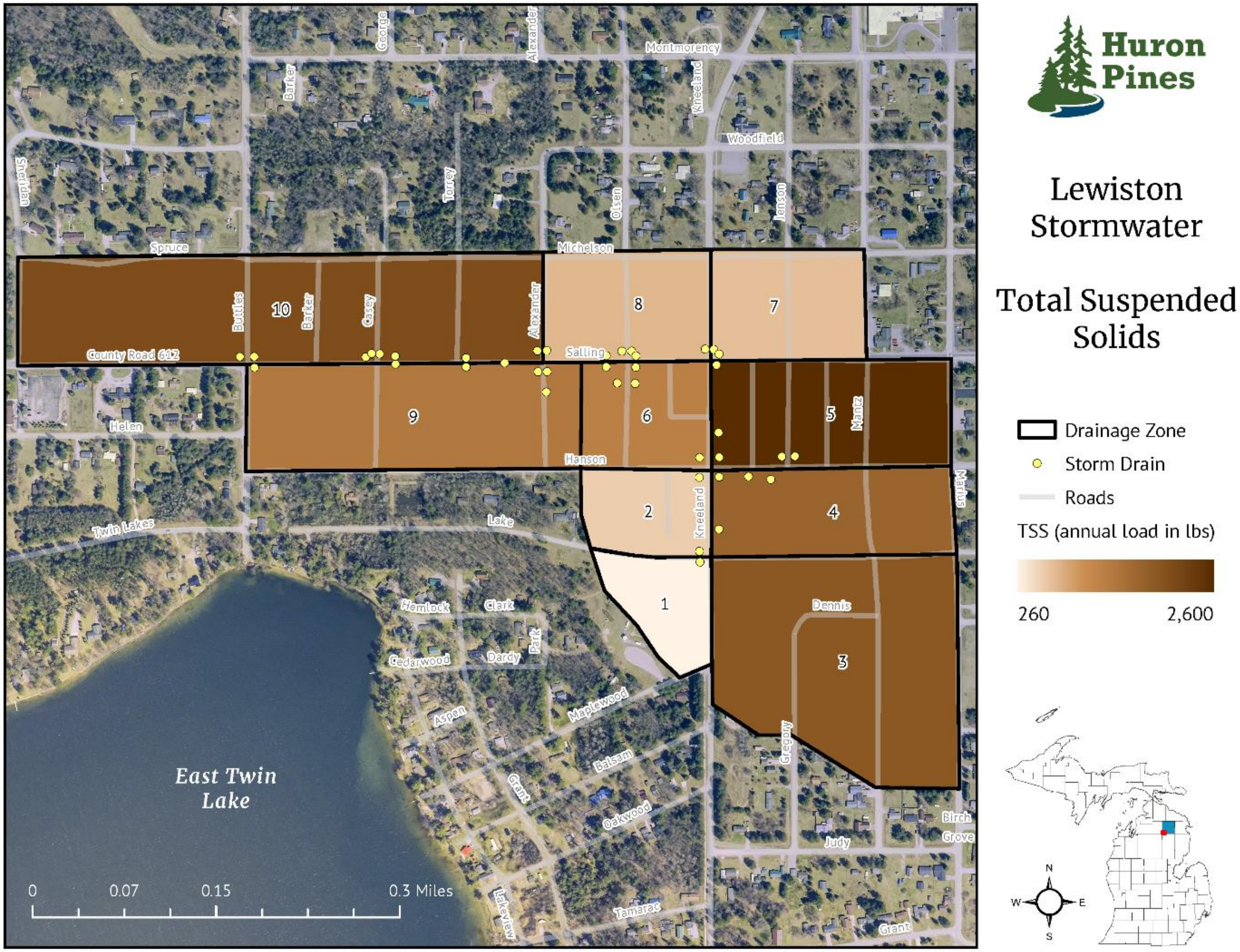


*Figure 6. The amount (lbs) of total suspended solids (TSS) picked and transported but stormwater annually in each zone. Note that the areas with the greatest impervious surfaces contribute the most TSS.*

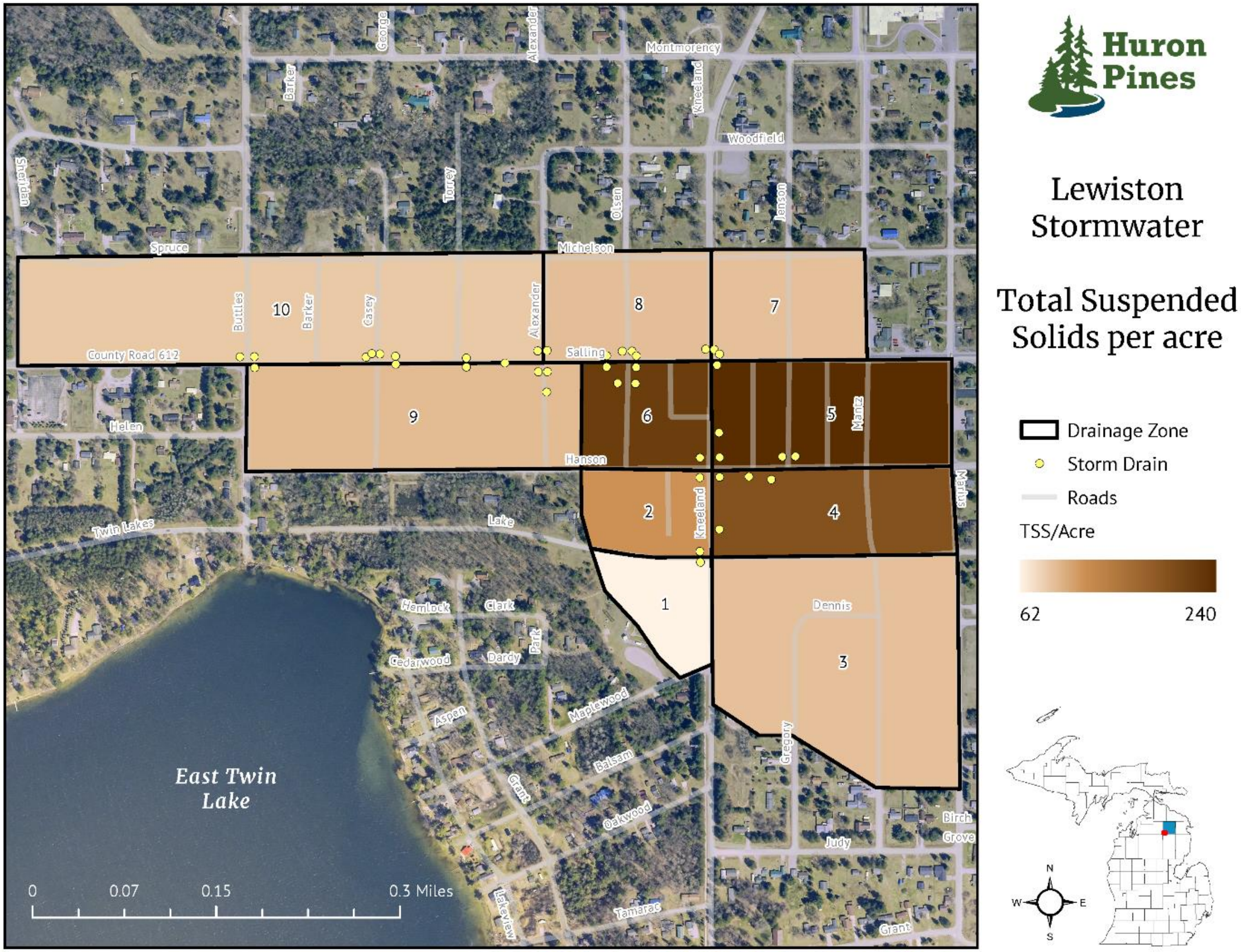


*Figure 7. The amount (lbs) of total suspended solids (TSS) picked and transported but stormwater annually per acre in each zone. This shows the concentration of contributing TSS.*

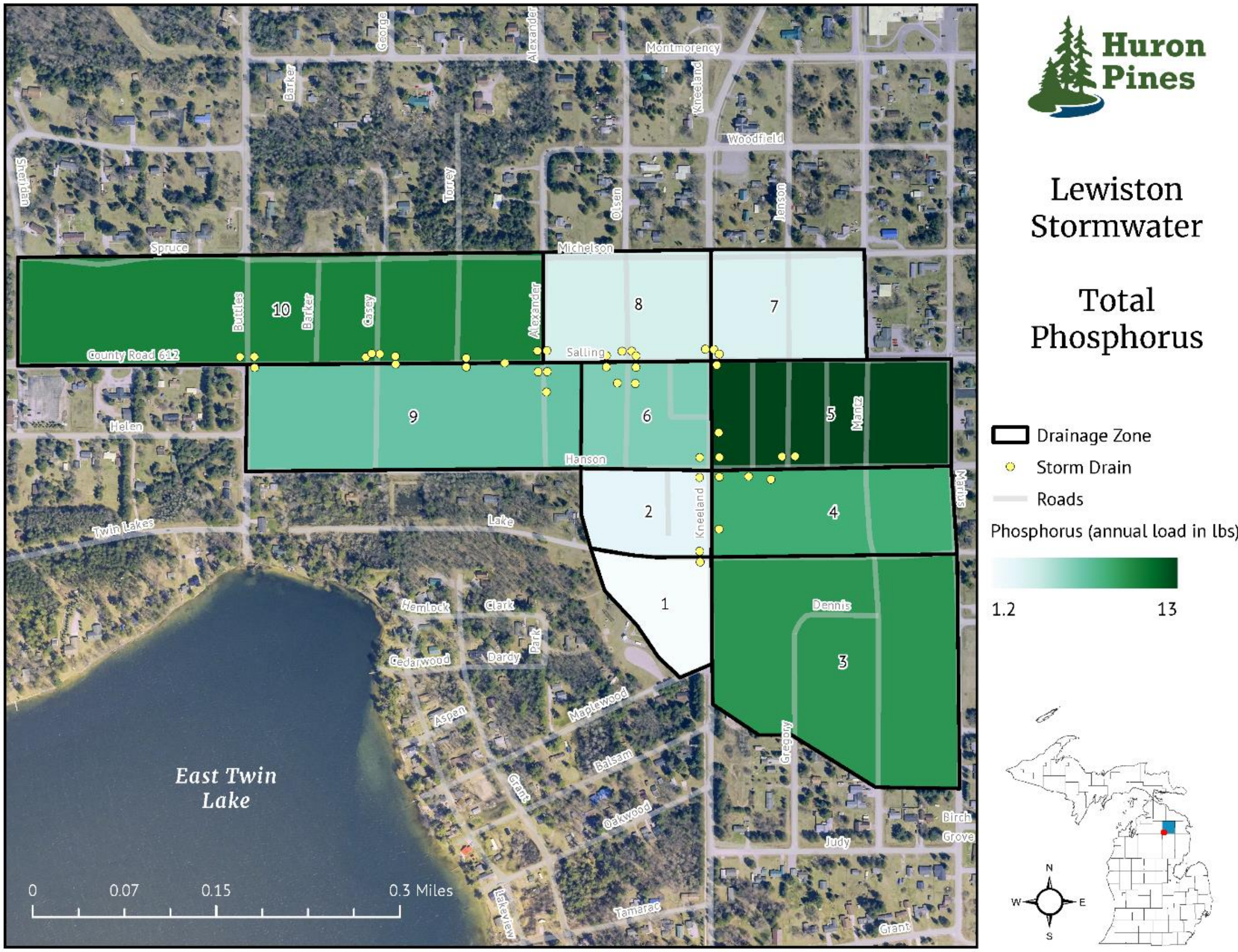


*Figure 8. The amount (lbs) of Total Phosphorus picked and transported but stormwater annually in each zone. Note that the areas with the greatest impervious surfaces contribute the most Phosphorus.*

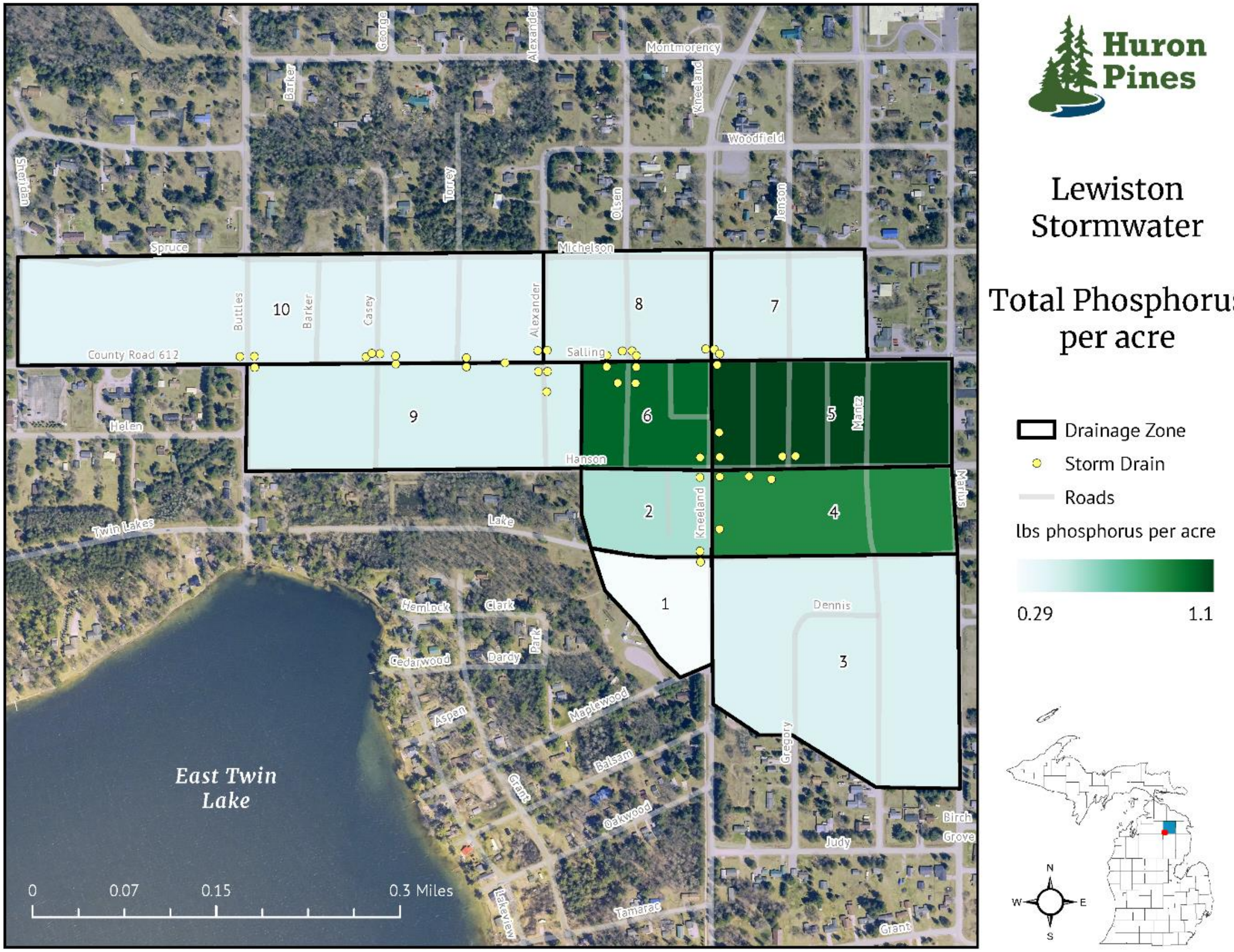


*Figure 9. The amount (lbs) of Phosphorus picked and transported but stormwater annually per acre in each zone. This shows the concentration of contributing Phosphorus.*

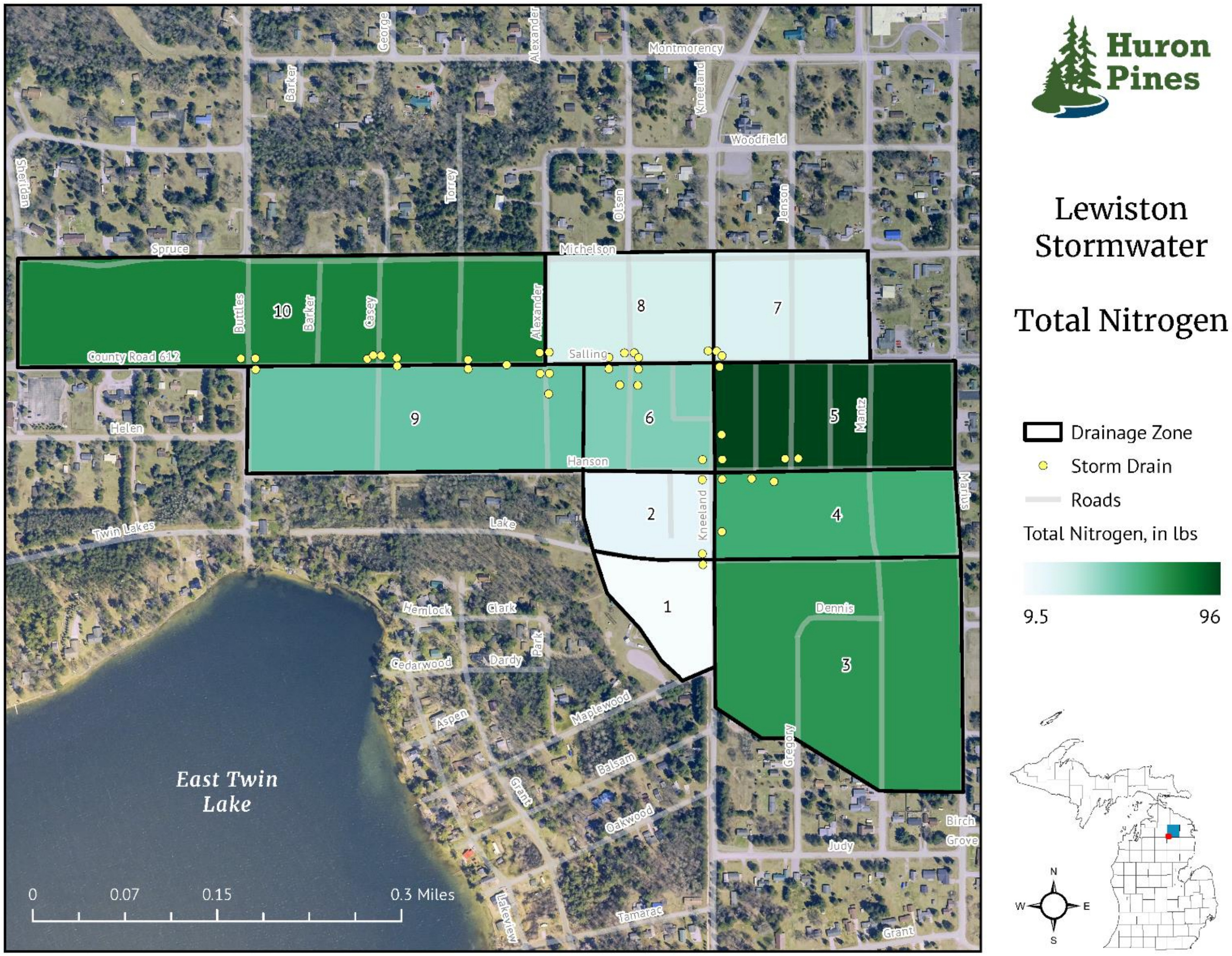


*Figure 10. The amount (lbs) of Total Nitrogen picked and transported but stormwater annually in each zone.*

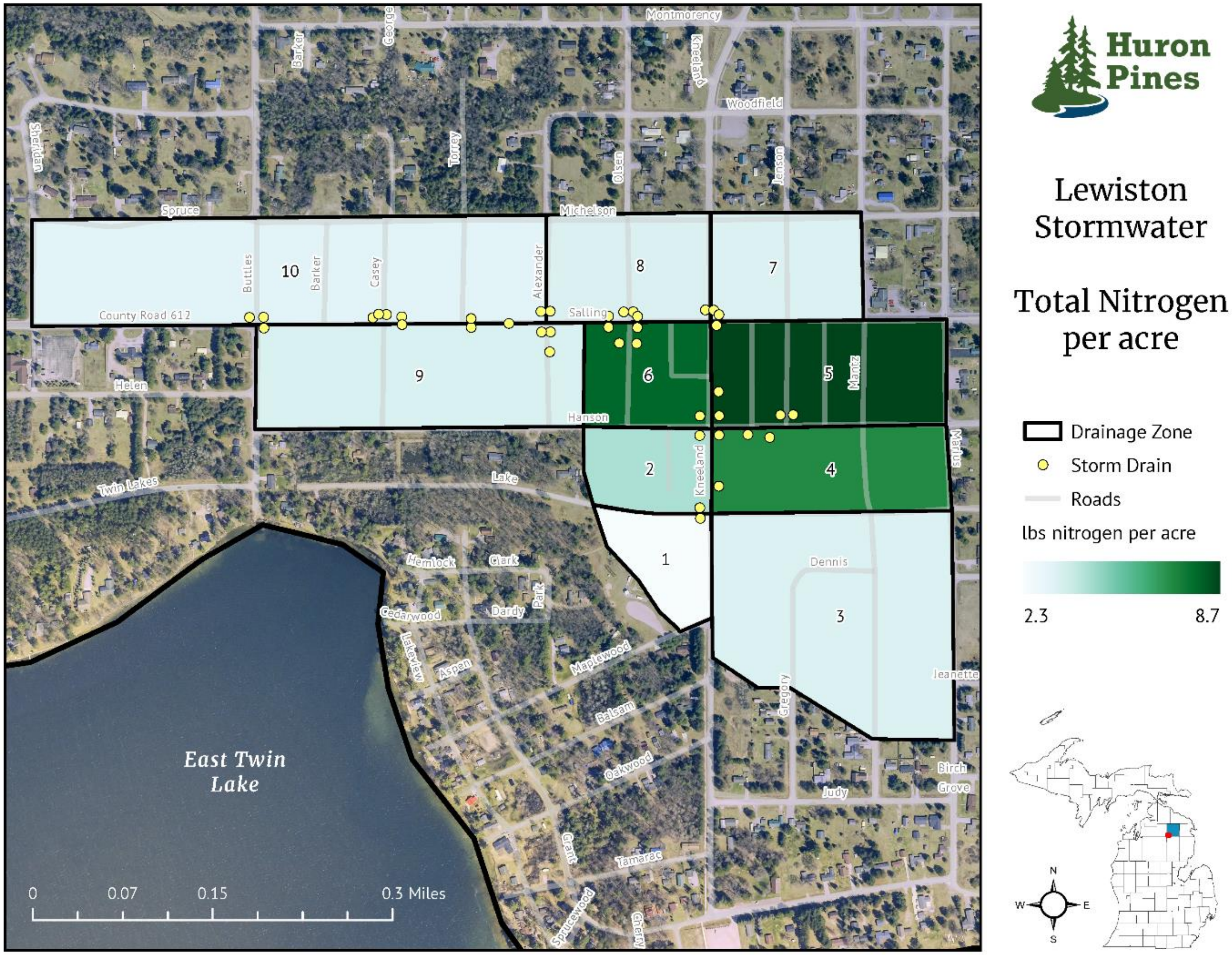


*Figure 11. The amount (lbs) of Nitrogen picked and transported but stormwater annually in each zone. This shows the concentration of contributing Nitrogen.*

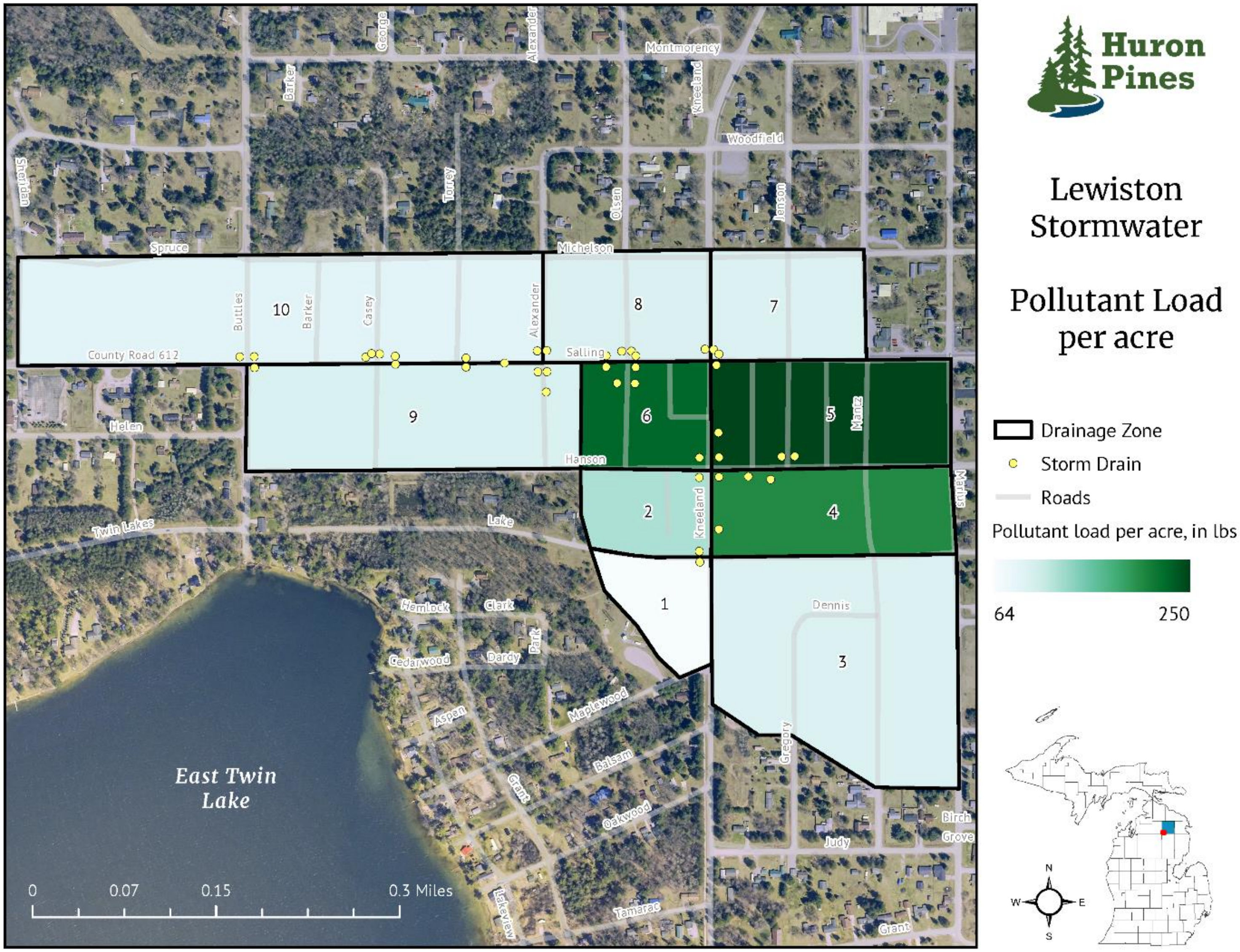


*Figure 12. Total Pollutant load (Nitrogen + Phosphorus) per acre.*

# Chapter 3. Stormwater Treatment Options

## Stormwater Treatment Options

The purpose of this stormwater assessment is to provide Lewiston a characterization of current stormwater infrastructure, including discharge and pollutant load estimates, along with recommendations for improving stormwater management to enhance and protect water and habitat quality. Water quality (e.g., clean water for drinking, swimming, and wildlife habitat) and quantity (e.g., runoff rates, flooding, and groundwater recharge) have important implications for human health and property, various aquatic wildlife and the local economy. Identifying and quantifying specific stormwater concerns are the first steps in designing effective practices to prevent, reduce and/or treat polluted stormwater runoff.

**BMPs can be structural or non-structural and can be classified as avoidance, minimization and mitigation measures.** Avoidance practices can be taken to limit the amount of pollutants that could potentially be transported by stormwater. Examples of avoidance BMPs include: educating people about where stormwater goes, providing convenient ways for hazardous substance disposal, strategically timing street sweeping, reducing the application of road sand and salt as well as decreasing the use of fertilizers and pesticides. Minimization practices focus on reducing amounts and rates of stormwater runoff, such as encouraging storm water to soak into the ground rather than enter storm sewers through the use of green infrastructure (e.g. rain gardens, vegetative swales, permeable pavers, and other Low Impact Development designs). Mitigation measures include retrofitting existing storm sewers with treatment units to filter sediments, oils, greases, litter and other pollutants after it enters the storm sewer system.

It is most effective to use a combination of BMPs to manage stormwater runoff. This chapter reviews some commonly used non-structural managerial and educational BMPs as well as structural/vegetative BMPs. Recommended BMPs specific to each of the eleven drainage zones in Lewiston are described by drainage zone and summarized in Table 4.

*Non-Structural Best Management Practices*

The following BMPs are generally considered to be necessary and beneficial to all urban and suburban areas.

One of the most important elements of a successful stormwater management strategy is educating the public. It is important that residents are aware that stormwater drains directly to waterways and does not undergo wastewater treatment. For example, nationwide efforts to label storm drains with “No Dumping - Drains to River” are effective campaigns to raise awareness of the connection between storm drains and water bodies and have been shown to decrease storm drain littering (EPA, 2010). Outreach efforts should also discourage the over-application and other misuses of pesticides and lawn fertilizers. Lewiston should ensure its residents have clear instructions on how to properly dispose of household hazardous waste, provide a convenient way for residents to comply, and have a mechanism for enforcing violations in place.

Municipal codes and ordinances should be reviewed and updated to include clear language that support stormwater goals. These ordinances could include creation and/or enforcement of laws prohibiting illicit discharges and littering, as well as ordinances that promote or incentivize green infrastructure designs to reduce the amount of future stormwater runoff. Existing ordinances should be reviewed to ensure they do not limit or restrict the use of green infrastructure. For example, some residential landscaping regulations require the use of turf grass or place restrictions on plant height, limiting the use of native plantings. Specific ordinances for development or site plans that clearly encourage or require the use of green infrastructure can be vital to their implementation, otherwise these solutions are not considered. There are many resources available to develop ordinance goals and languages. There are many resources available to develop ordinance goals and languages. One great place to start is Sea Grant’s publication “Tackling Barriers to Green Infrastructure: An Audit of Municipal Codes and Ordinances”, which can be found here.

Municipal BMPs include measures such as strategic timing and adequate frequency of street-sweeping (especially in the spring prior to major snowmelt events). The amount of total pollutants available for transport by stormwater runoff can be reduced up to 80% using a bimonthly or weekly sweeping schedule (Sutherland and Jelen, 1997). Proper maintenance of storm sewers and structural stormwater BMPs (cleaning out debris), proper storage and disposal of equipment and chemicals and reducing rates of road salt application in the winter are other municipal BMPs to consider. Educational and municipal BMPs should be used city-wide and comprehensively.

*Structural Best Management Practices*

Structural stormwater BMPs are physical structures, including the use of natural vegetation, which can be constructed or installed to reduce or treat stormwater runoff. In addition to implementing non-structural BMPs, it is important to manage stormwater in areas that have already been developed. Consequently, "retrofitting" existing storm sewer systems is often a necessary element of any comprehensive stormwater management plan. Selection for structural BMPs should be based on estimated pollutant loadings and the size of storm sewer drainage zones. Other important considerations include cost, space constraints, land ownership, soil types, existing structures and land features, and feasibility of installing a given BMP within the zone. Some common structural BMPs are discussed below.

*Mechanical removal*

Mechanical removal of debris can occur at multiple points throughout the stormwater system, as the methods for capture vary widely. Options on land may include interceptors, gutter bins, and household filters (River Network, 2020). Interceptors are an additional grate feature that captures debris before it enters the stormwater system. These are generally cost-effective and easy to install and maintain. Similarly, gutter bins direct incoming water through a catchment bag to trap debris. Household filters are also commercially available, and can be added to filter microplastics (tiny pieces of plastic less than 5 millimeters/0.2 inch) from wastewater (Figure 12).

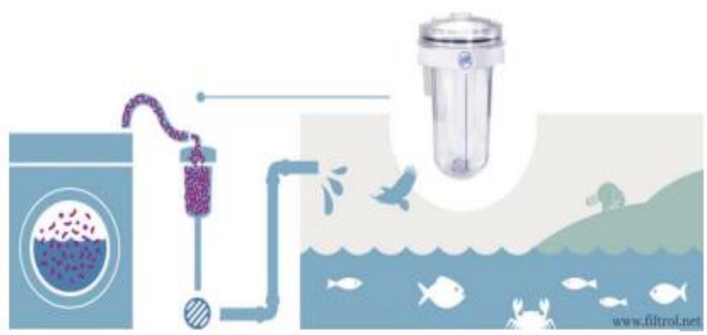


*Figure 13. Example of a household washing machine filter for microplastic capture (Filtrol www.filtrol.net)*

In stream and open water removal of debris methods include booms, litter traps, and immersive water pumps. Booms are used to corral floating debris in a waterway, and are easily installed and maintained. Litter traps combine booms with a gathering device downstream to capture debris. These structures are easily navigated by both humans and wildlife, and are considered low maintenance and cost effective. Immersive water pumps are ideal in areas of calm water such as harbors. They resemble a bucket, bringing water inside and pumping it out the bottom, with a filter to capture plastics down to 2mm in size.

Mechanical oil and grit separators are an increasingly popular stormwater treatment option. Various models are available but they tend to function in a similar manner (Figure 13). Mechanical oil and grit separators are flow-through units installed in-line with existing storm sewers. These units are installed near stormwater outfalls to provide treatment of all storm sewer water contributed by the drainage zone. Solids settle to the bottom of the unit and oils, greases and other floatables are trapped at the top of a separation chamber. These pollutants are then vacuum-pumped out through a manhole, usually once or twice per year.

Being hidden underground, these stormwater treatment units are unobtrusive and do not take up much space. Mechanical oil and grit separators are effective stormwater treatment methods in large storm sewer drainage zones because they treat all of the storm sewer water contributed from their drainage zones and require minimal maintenance.

*Figure 14. Oil/grit separators use various approaches to separating solids that settle at the bottom of the unit and oils and trash that float to the top. These pollutants can then be removed and disposed of properly. Water is allowed to pass through. Water soluble pollutants such as fertilizers and salt are not treated.*

Mechanical oil and grit separators also have shortcomings and should be used in conjunction with other stormwater management BMPs. Soluble pollutants such as pesticides and nutrients are not removed by mechanical oil and grit separators. Bacteria from pet waste, garbage and faulty septic systems are not treated by these stormwater treatment units. In smaller drainage zones, mechanical oil and grit separators may not be a cost-effective stormwater management technique as the initial cost of purchasing and installing these units can be significant.

**While these methods for mechanical debris removal are effective, end of pipe solutions should be evaluated only after preventative BMP's have been evaluated.** Capturing pollutants before they enter the storm sewer system is one of the best ways to deal with nutrient loading issues in bodies of water.

*Detention and Retention Basins*

Detention and retention basins are artificial ponds constructed in various sizes for the purpose of capturing and storing stormwater runoff from impervious areas. Pollutants settle out of stormwater held in these basins and water gradually discharges through an outlet (detention basin) or permeates the soil (retention basin) so that it reaches our surface waters much cleaner than when it entered the basin. Detention and retention effectively remove many pollutants but thermal pollution can be an issue due to extended solar exposure. Detention and retention basins take up a relatively large area and sufficient space in which to install a detention or retention pond may not always be available. Finally, these basins are sometimes considered eyesores or potential child safety hazards in residential areas and may need to be securely fenced in.

*Figure 15. This is an example of a wet detention basin in Lewiston. The pipe pictured carries stormwater to its final destination in a retention basin. (Photo sourced from RLS, 2020)*

A detention basin temporarily stores water before discharging into a surface-water body, used to reduce flood peaks (Menerey, 1999). These basins can look like dry detention basins, holding water during large rainstorms and snowmelts, or wet detention ponds that contain permanent pools and help remove nutrients and other pollutants.

A retention basin is a stormwater management practice that captures stormwater runoff and does not directly discharge into a surface waterbody (Menerey, 1999). Water in a retention basin either evaporates or infiltrates into the soil. It is important that the retention basin is sized correctly to retain runoff generated, and that the basin contains soils with high infiltration capacity i.e. sand, loam, or a mix of sandy loam.

*Vegetative Best Management Practices*

Natural vegetation can be used to help treat stormwater runoff before or after it enters the storm sewer system. Vegetative, or **Green Infrastructure**, BMPs have been shown to be efficient measures to mitigate runoff volumes and pollution and are cost effective compared to traditional gray infrastructure options (EPA, 2013). Vegetative BMPs include rain gardens, stormwater wetlands (a.k.a. constructed wetlands), vegetated buffer strips and grassed waterways or swales. All of these natural, vegetated options allow for increased infiltration and the slowing of runoff, reducing storm surges and reducing pollutant loading in stormwater. Green infrastructure solutions have the added benefit of being aesthetically pleasing and add valuable wildlife habitat to an area.

*Figure 16. Three examples of curbside stormwater solutions, referred to as rain gardens, bio swales and bio retention cells*

Increasing permanent vegetation on any scale is recommended. For example, installing rain gardens or tree boxes where impervious surface is can reduce polluted runoff from ever entering gray infrastructure. Supplementing lawns with native grasses, shrubs and trees is an effective BMP to reduce runoff. Turf grass commonly used in lawns have shallow roots (furthest left in figure 17) that limit water uptake and soil stabilization, whereas native plants often have much deeper and more complex root systems.

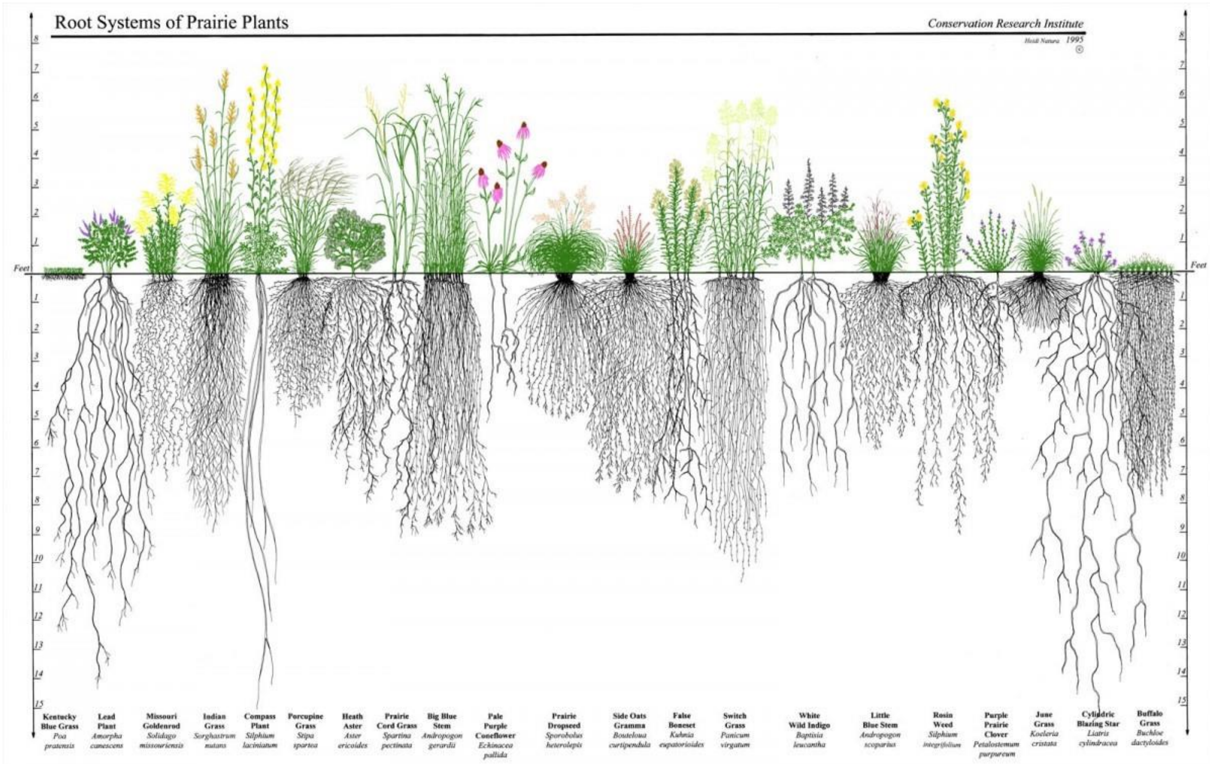


*Figure 17. Root systems of non-native grass (left) compared to native prairie species*

**Rain gardens** are strategically installed in natural depressions near impervious surfaces where they will intercept surface runoff before it can enter storm drains or flow over land to surface waters (Figure 15). Rain gardens may also be constructed by excavating a depression and replacing or amending the soil with a mix of sand, topsoil and organic matter. There are many native wildflowers, grasses and shrubs that are suitable for planting in a rain garden. As stormwater flows into a rain garden pollutants are trapped, plants uptake excess nutrients like phosphorus and nitrogen are, and water is filtered as it flows slowly through the soil before reaching surface waters. Rain gardens require occasional maintenance such as removing litter, keeping plants watered during drought conditions, weeding and supplementary planting.

**Tree Canopy** serves as another source of green infrastructure. Trees intercept rain on leaves, absorb stormwater through roots, release water into the air (evapotranspiration), absorb and capture nutrients and reduce erosion by stabilizing the soil. In areas with high impervious surfaces, additional engineering to hold stormwater may be necessary. Tree boxes and tree trenches add additional holding capacity and underdrains.

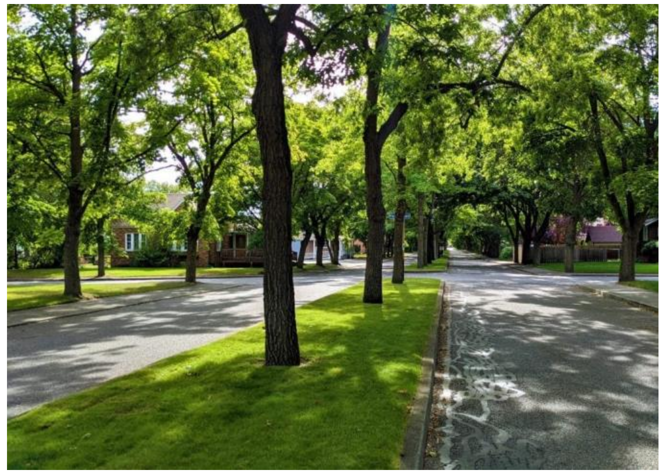

*Figure 18. Tree canopy benefits both environmental health and human wellbeing by cleaning runoff, improving air quality, providing shade and increasing property values.*

**Stormwater wetlands** are similar to rain gardens, but instead of catching runoff before it enters the storm sewer system this type of stormwater BMP treats stormwater coming out of the outfall. Stormwater wetlands tend to be larger than rain gardens and various designs can be used depending on site-specific constraints. Stormwater wetlands can be very effective at removing pollutants but their feasibility depends on land availability. If not sized appropriately, stormwater wetlands can also run the risk of drying out, if too large, or may not adequately filter pollution if too small. Stormwater wetlands are designed specifically for treating stormwater runoff, but any stormwater discharge into existing/natural wetland areas should first be treated with other stormwater control BMPs to avoid damaging natural ecosystems. Stormwater wetlands are considered end of pipe solutions whereas rain gardens, tree boxes and tree trenches focus on intercepting runoff before it can enter the storm sewer system. Existing, intact wetlands should not be used for these purposes to avoid damaging natural ecosystems.

**Tree Boxes**, or tree pits, are specially engineered spaces that allow for the interception and treatment of stormwater prior to it entering the stormwater system (NACTO, 2013). The boxes are made up of three components: the chamber, the substrate and the tree. Below sidewalk level, the chamber acts as a basin to catch and direct stormwater towards the substrate and the root system of the tree. The substrate, which is often soil, is a manufactured mix of organic and inorganic material that allows for rapid infiltration. The tree serves as another method of capture, taking water and pollutants (nitrogen and phosphorus) into its root systems/tissues and out of the captured stormwater. Additional tree cover also helps reduce heat island effects, making tree boxes a multipurpose solution to issues of impervious surface and development. While these tree boxes are effective on their own, connecting them with engineered underdrains to form a tree trench is even more effective at capturing stormwater (Figure 19). In tree trenches, runoff is better distributed between boxes which allows for maximum stormwater capture and additional root space for the trees.

Tree trenches are easily tailored to the stormwater management needs of a space. There are many substrate mixes and chamber design options to best fit the features of the land such as grade, geology, and climate. Tree trenches can also be designed proactively to adapt to the effects of climate change ([EPA, 2013]). By choosing the right tree species and sizing the drainage area appropriately, tree trenches can serve as an effective stormwater management strategy for years to come.

*Figure 19. Tree trenches can increase holding capacity and infiltration in developed areas. Above ground they look like typical city trees.*

Increasing native vegetation on any scale is recommended. For example, installing or expanding riparian buffers along shorelines can reduce polluted runoff into rivers, reduce erosion and moderate water temperatures. Also, supplementing lawns with native grasses, forbs, shrubs and trees is an effective BMP to reduce runoff. Turf grass, which makes up most lawns, is a poor substitute for native plants. Turf grass has shallow roots that limit water uptake and soil stabilization and lawns contain compacted soil that limits infiltration (see figure 17).

*Low Impact Development*

Low impact development (LID) is an approach to land development that aims to manage stormwater close to its source (US EPA: visit http://water.epa.gov/polwaste/green/ for more information on LID). Goals of LID include preserving existing natural features and implementing landscape designs that mimic natural functions. LID and green infrastructure are often used synonymously. Generally, LID refers to the planning and implementation of nature-based solutions at a specific site.

LID principles can be incorporated (e.g., through city ordinances or incentives programs) into future development and can also be used to retrofit existing developed areas. For example, vegetated strips can be installed to break up large paved parking areas in order to encourage infiltration of stormwater and reduce surface runoff. LID projects should be implemented whenever possible. LID projects can be minor and inexpensive but over time their cumulative impact on stormwater management ultimately improves the quality of freshwater resources.

## Funding Sources

Depending on established priorities and types of BMPs to put into action, several funding sources are available. **Table 4** contains a few funding options with a description of each and a link for further information. Some of these options are more complex than others in the eligibility requirements, match requirements and partner requirements. Huron Pines is committed to identifying and assisting in finding funding for natural resource protection. Please contact our office for additional and updated funding opportunities and mechanisms.

***Table 4.*** *Potential funding sources for water quality related projects in Northeast Michigan*

| Source | Summary | Further Information |
|---|---|---|
| Community Foundation for Northeast Michigan | Project must positively affect residents of Northeast Michigan Counties. Up to $5,000 per grant cycle is available. | CFNEM grants |
| EPA Green Infrastructure Grants and Loans | Multiple grant programs available; EPA Clean Water State Revolving Fund (CWSRF), EPA Drinking Water State Revolving Fund (DWSRF), EPA office of Sustainable Communities Greening America's Communities Program | EPA Green Infrastructure Grants |
| Midwest Glacial Lakes Partnership | Lake Conservation Grants available annually. Grants should benefit lake fish habitat | MGLP Website |
| Great Lakes Commission Green Infrastructure Champions Program | Pairs community with Green Infrastructure leaders to adopt green infrastructure across the Great Lakes region. | Green Infrastructure Champions |
| National Fish and Wildlife Foundation (NFWF) Sustain Our Great Lakes (SOGL) Program | Funding for aquatic and wetland restoration and stormwater green infrastructure projects. | SOGL |
| The Funders Network: Partners for Places | Competitive grant funding requiring 1:1 match from local community foundations for building community capacity and managing stormwater. | Partners for Places |
| Great Lakes Restoration Initiative (GLRI) | EPA and partner agencies funding for projects supporting GLRI Focus areas | GLRI Funding |

# Chapter 4. Recommendations

## Lewiston Stormwater Drainage Zones and Recommendations

Based on the stormwater information collected for this report and the experiences of Huron Pines working with other communities to improve stormwater management in Northeast Michigan (e.g., Rose City, West Branch, Grayling, Au Gres), the recommendations below are meant to provide a starting point for implementing controls as well as providing a frame of reference for the cost of such measures. A formal site inspection and detailed engineering designs would still be required for the installation of structural Best Management Practices.

The storm sewer drainage zone recommendations are based on analysis of the total acreage of each zone, soil type, amount of impervious cover, land use, and the amount of land available for installing stormwater control structures. Recommendations are summarized in **Table 5**.

***Table 5.*** *Best management practice recommendations for each drainage zone.*

| Drainage Zone | Acres | Land Use Types | Description | Suggested Best Management Practices |
|---|---|---|---|---|
| 1 | 4.2 | Open Space, Residential, Grasslands. | Runoff in this zone goes north and east towards Lake St. and Kneeland St. This zone contains a ballpark and a few residential buildings. Runoff is mitigated due to the land use and grass cover in this zone. | Street sweeping, outreach and education |
| 2 | 4.7 | Commercial, Open Space, Residential, Paved. | Runoff in this zone flows east towards Kneeland St. This zone encompasses a section of Lewiston's downtown strip, with large proportions of impervious surface. | Street sweeping, green infrastructure/LID, work with commercial property owners to reduce impervious surface |
| 3 | 21.4 | Commercial, Open Space, | Runoff in this zone goes Northwest towards the intersection of Lake and | Street sweeping, outreach and education |

| | | | | |
|---|---|---|---|---|
| | | Residential, Herbaceous | Kneeland St. There is relatively no slope to this zone, so many properties may experience ponding during rain events. | |
| 4 | 9.1 | Commercial, Open space, Paved, Residential | This zone is highly developed with large proportions of impervious surface. Due to this, the zone has high runoff values and high pollutant loading values | Strategic street sweeping, green infrastructure/LID, outreach and education, work with commercial property owners to reduce impervious surface |
| 5 | 11.1 | Commercial, Paved, Residential | This zone is highly developed and has the highest proportion of impervious surface in the study area. | Strategic street sweeping, green infrastructure/LID, outreach and education, work with commercial property owners to reduce impervious surface |
| 6 | 6.0 | Commercial, Paved, Open Space | This zone is developed, but contains open space where green infrastructure/LID may be beneficial. | Street sweeping, green infrastructure/LID, outreach and education |
| 7 | 7.3 | Open Space, Residential, Paved | This zone is primarily residential, with a few commercial properties and paved surfaces. | Street sweeping, work with commercial property owners to reduce impervious surface. |
| 8 | 7.9 | Open Space, Residential, Paved | This zone is primarily residential and open space. | Outreach and education |
| 9 | 15.2 | Commercial, Open Space, Residential, Paved | This zone is primarily residential, with a few commercial properties and paved areas. | Outreach and education, work with commercial property owners to reduce impervious surface. |

| | | | | |
|---|---|---|---|---|
| 10 | 24.6 | Open Space, Residential, Commercial, Herbaceous, Paved. | This zone is a mix of residential, open space and commercial areas. | Street sweeping, outreach and education, work with commercial property owners to reduce impervious surface. |

**Examples of areas where BMP action can be taken:**

*Figure 20 Example of a storm drain at the intersection of Salling and Kneeland that would benefit from strategic street sweeping.*

*Figure 21 This drain is an example of where street sweeping would capture sediment containing pollutants from entering the storm sewer system. Sand on both sides of the drain will be washed into the storm sewer system during rainfall events, mobilizing both suspended solids and nutrients.*

*Figure 22 Example of a storm drain on Olsen in need of clearing/maintenance*

*Figure 23 A severe example of a drain on Olson in need of maintenance or LID. Sediment is plugging the storm drain reducing effectiveness.*

*Figure 24 An example of a drain on Kneeland in need of sweeping/maintenance*

*Figure 25. Olsen Street drain and crock with debris.*

## Storm Sewer Drainage Zones Recommendations

The area of interest examined in this stormwater assessment contains many developed areas and impervious surfaces (see figures 27 and 28 in Appendix C). In the 111.5-acre focal area there is only 5.4% (about 6 acres) of forested/herbaceous cover, and 15.6% (about 17 acres) of developed open space. Developed open space can be areas with some constructed materials, less than 20% impervious surface, and are typically single family homes, lawns, parks etc. The remaining ~80% of the land cover in the focal area is comprised of impervious surface where rainfall has the ability to collect and transport pollutants. During rainfall events, stormwater flows over impervious parking lots, roads and rooftops picking up various things like sediment, oils, litter, road salt, and grease. This stormwater goes directly into storm drains, eventually making its way to a stormwater retention pond on Hanson street. It is recommended that Albert Township follow guidance set out in the 2022 update of the Master Plan. It is stated that "Improvements to the stormwater system may become necessary as the impervious surfaces increase with development. Sustainable, low impact stormwater management measures such as bioswales, should be considered to protect the surface and groundwater quality" (NEMCOG 2022). Addressing stormwater identified in this assessment with LID green infrastructure would **directly address Goal 3.2** of the Albert Township Master plan.

**Downtown Corridor** (Kneeland Street, Hanson Avenue)
It is recommended that the impervious surface in the downtown area is reduced using a combination of BMPs listed in the Stormwater Treatment Options section of this assessment. **The largest areas of concern are zones 4, 5, and 6**. These zones encompass Salling Avenue from Olsen Street to Maurius Street, Hanson Avenue from Olsen to Mantz St, and Kneeland Street from Salling Avenue to Lake Street. These zones cover around 26 acres of highly developed, commercial and residential areas. **These areas contain the highest amount of impervious surfaces in the study area** ranging from paved streets, parking lots, compacted soils, and residential/commercial roofs. Stormwater in this area does not have many chances to infiltrate into the ground and it travels straight into the storm sewer system as a result. Solutions to this issue would involve low impact development and green infrastructure to increase underground storage capacity and an increase in tree canopy. Rain gardens, bioswales, bioretention cells and tree boxes in the center of Kneeland Street and Hanson Avenue would allow for the slowdown and interception of runoff.

Working with private landowners, businesses, Albert Township and the Montmorency County Road Commission to install permeable pavement, rain barrels, green roofs, or bioretention areas in zones 4 through 6 is a priority as these zone contribute the most pollutants per acre due to their imperviousness.

***Action Steps:***

1. *Conduct public input sessions and surveys to engage the community with green infrastructure solutions.*
2. *Identify problem areas and prioritize LID in urban planning.*
3. *Work with conservation partners, township officials, engineers and local business owners to develop and implement green infrastructure solutions.*

**Tree Canopy**

There are few areas in downtown Lewiston that have adequate tree canopy to assist in infiltration and capturing of pollutants. The downtown corridor would benefit from increased tree cover and increased diversity of tree species. Adding a diversity of trees will help guard against future disease or pest and builds climate resilience. Diverse trees provide wildlife benefits, offering a variety of flower and seed sources throughout the year. In addition to stormwater and ecological benefits, tree canopy is an attractant to visitors adding aesthetic value and shade in the downtown area. A list of trees can be found on the Michigan.gov page titled: recommended trees for community planting.

***Action Steps:***

1. *Work with outside organizations to plant trees in the downtown area.*
2. *Plant trees in downtown area to increase urban canopy cover. A list of recommended trees can be found in Appendix F*
3. *Provide training to township maintenance staff on proper planting techniques, pruning regimes and other tree care practices*

**Street Sweeping, Road Salt Application, Winter Snow Plowing**

The application of road salts in Northeast Michigan is a critical aspect of keeping our winter roads safe. However, plants and animals in the region are not well adapted to increases in salinity. Road salt is detrimental to many native plant species and can drive the success of invasive plant species that have higher salt tolerance. In our freshwater systems, high levels of salt make it hard to regulate the osmotic pressure of cells and can lead to the death of zooplankton/phytoplankton all the way up to fish species. At lower water levels it can effect wildlife growth and reproduction. Thoughtful application of salt, as well as staying up to date with emerging technologies can protect our aquatic habitats in the long term.

Street sweeping is practiced in many urban areas as an aesthetic practice to remove sediment and large debris from curbs and gutters. Sweeping streets during spring snowmelt is a great way to reduce pollutant loads from road salt and sand/debris that accumulates throughout the colder months. It would be ideal to sweep streets multiple times throughout the year during the Spring runoff, during the summer months for aesthetic reasons, and then during the fall rainy season. It is understood that there is a high cost to operating a street sweeper, so strategically timing the street sweeping is key in managing pollutants and for aesthetic purposes. Capturing debris, sediment and pollutants during the spring snowmelt is of the utmost importance for ecosystem health.

Snow plowing is another critical aspect of keeping our winter roads safe. Snow that is plowed should not be stored on impervious surface such as paved roads or parking lots when possible. It is best to store snow on permeable soils, or areas where snowmelt can infiltrate slowly as it melts. Removing snow piles from roads and other impervious surfaces reduces the amount of debris, litter and pollutants (accumulated road salts, oils and grease) that flush directly into the storm sewer system.

***Action Steps***

1. *Determine best practices for the timing and frequency of street sweeping in the downtown corridor of Lewiston.*
2. *Determine best practices for snow removal/management in the downtown corridor of Lewiston.*

**Gray Infrastructure**

Gray, end of pipe stormwater infrastructure improvements such as oil/grit separators could be considered where space is available.

Oil/Grit separator units are installed inline at the downstream end of the storm sewer system. A rough cost estimate on a mechanical oil/grit separator unit (based on past projects Huron Pines has managed) is $60,000-$100,000, making them costly for a smaller rural town such as Lewiston. These units trap 70-90% of sediments, oils, greases and litter entering the storm sewer system. Pollutants including bacteria, road salts and chemicals are *not* removed by these units, so reducing their availability with Green Infrastructure before stormwater can carry them into the storm sewer system should be emphasized. These units require occasional maintenance, typically vacuum-pumping the contents out and transporting polluted water to a wastewater treatment facility or other appropriate disposal site.

Storm sewer system maintenance is necessary to ensure the system works as it is intended and designed. Annual inspections of storm drains, crocks and storm sewer infrastructure may reveal deficiencies or problem sites where action can be taken. Crocks should be cleaned and inspected annually to ensure there are no sewer line clogs.

The most cost effective approach to limit the amount of pollutants entering the stormwater sewer system is through educational and managerial BMPs. In general, Green infrastructure is just as effective at removing pollutants, reducing peak flows, and reducing sedimentation as gray infrastructure, but on average costs 5-30% less to construct and are 25% less costly to maintain over the life cycle of the project. (EPA, 2015)

***Action Steps***

1. *Consider the use of an of oil/grit separator at or before the final destination of the stormwater.*
2. *Conduct annual maintenance to ensure proper performance of the storm sewer system*

**Opportunity Areas:**

Downtown Lewiston has a few areas where rain gardens, pavers, bioswales and curb cutouts may be placed to decrease the impervious surface and improve stormwater runoff. An example of this area can be found south of Hanson Avenue, in a township owned labeled "Albert Township – Parking Lot" in Figure 26. This area would be a great spot to install green infrastructure, with options for different desired uses. If the township were to decide to keep this area as a parking lot, it would be a great location for permeable pavement to reduce impervious surface. If the township were to decide to turn the parking lot into a bioswale or a rain garden, it would reduce impervious surface and increase the stormwater storage capacity in the downtown area.  This location is adjacent to Kneeland street where many business are, opening the opportunity to capture runoff from impervious surfaces (from business roofs) and divert that runoff into an engineered retention basin like a rain garden or a bioswale.

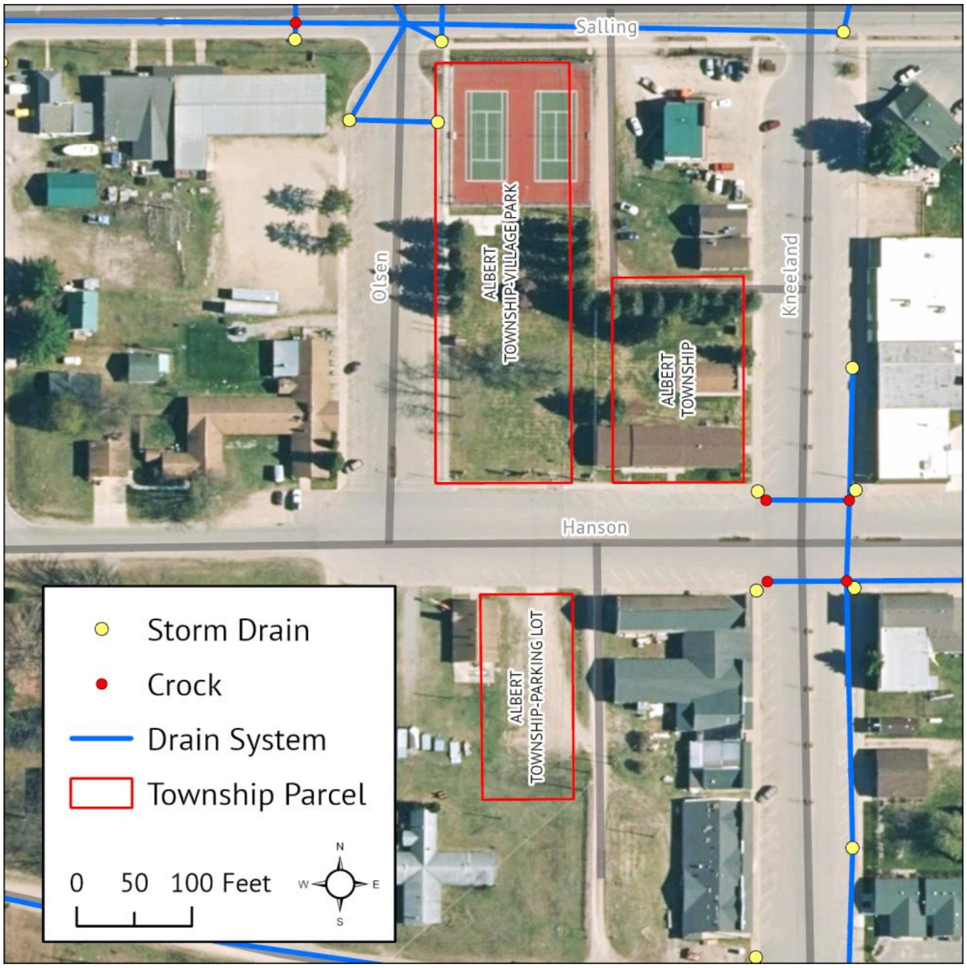


*Figure 26. Albert Township owned parcels*

Another opportunity exists north of Hanson street next to the Albert Township Hall building. This area would be a great opportunity for an example rain garden to demonstrate what a rain garden can look like in an urban area.

Roads play an important role in runoff transport and the downtown corridor along Kneeland and Hanson street would be great areas for rain gardens with curb cut outs. Designing rain gardens to increase water storage in areas where impervious surface is currently in place would greatly decrease the volume of runoff and associated pollutants from entering the storm sewer system.

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## APPENDIX A. Unit Hydrograph Method

Huron Pines received images from the Montmorency County Road Commission detailing the known storm sewer system within Downtown Lewiston and surrounding area. Huron Pines digitized this information using Geographic Information Systems (GIS). Documents were uploaded into a program (ArcGIS Pro) and georeferenced. This involves matching up known features such as road intersections or natural features on a map to the image in order to spatially organize data. By georeferencing the documents Huron Pines has the ability to check the accuracy of paper plans and model runoff and pollutant loading accurately.

Specifically, image files of the stormwater infrastructure from the Montmorency County Road Commission were converted to a format usable for GIS and then added to the existing map. In order to ensure locations for the sewer lines were accurate, the new files were georeferenced using a 1 foot resolution imagery layer of Montmorency County provided to Huron Pines by the Michigan Department of Great Lakes and Energy. To map the infrastructure features (sewer lines, crocks (manholes), and sewer), feature classes were created. Line feature classes were used for the sewer lines. Outlets and crocks were mapped in a point feature class.

Maps were then created and loaded into mapping software called Avenza to enable ground truthing of mapped features. This ground truthing was completed in May of 2022 to ensure the accuracy of the digitized features. A follow up meeting was held with Todd Behring, Managing Director of the Montmorency County Road Commission, to gain additional understanding of the storm sewer system.

Description of runoff calculations:
To estimate stormwater flows for each of the 10 storm sewer drainage zones the following information was collected from government agency data and relevant scientific literature:

- Annual rainfall probabilities (U.S. Climate Data 2019)
- Area of each drainage zone (calculated in ArcGIS)
- Soil types (USDA, Web Soil Survey)
- Land use types (USGS National Land Cover Database, 2021 and Homer et al., 2015)
- Elevation and slope (USGS national map viewer)

Design rainfall events, or “design storms” (mathematical representations of rainfall events used to size stormwater infrastructure), are commonly used in stormwater assessment studies to simulate stormwater runoff intensities in small watersheds. A first step in determining the type, size and location of a stormwater BMP is to choose the design storm intensity that the structure will be designed to effectively handle. At a minimum, the

Michigan Department of Environmental Quality recommends that stormwater BMPs should be sized to account for "first flush," which, in developed areas, is the first ½ inch of rainfall per storm event (MDEQ, 2017). The majority of pollutants that have accumulated between rain events are picked up and transported in that initial ½ inch of stormwater runoff during a storm event, with subsequent runoff carrying proportionately fewer pollutants as the storm continues.

The Unit Hydrograph Method of estimating peak stormwater (cubic feet per second) is used in this stormwater study. The Unit Hydrograph methods are described in the following paragraphs and are detailed in Sorrell 2010. This method is appropriate for use in small (less than 10 square miles) ungauged watersheds such as the stormwater drainage zones identified in Lewiston. A major advantage of this method is that the required parameters (drainage area, soil types, annual rainfall and land use) are relatively easy to determine (USGS National Hydrography Dataset). Drainage area was determined by delineating and mapping drainage zones based on field inventory results and analysis of topographic maps, then calculating drainage areas using GIS. Soil types were determined using Web Soil Survey maps available at www.websoilsurvey.usda.nrcs.gov. Soils were classified into four main hydrological drainage categories ranging from sandy soils with high infiltration rates (type A) to those with very low permeability, such as clay soils (type D) using a list of Michigan soil types found in Sorrell (2010). In Montmorency County, most of the soils are well drained (A) or a combination (A/D). Combination soils are soils that have good filtration capacity when well-drained but are located in areas with high water tables and tend to be saturated during high water events (i.e. spring runoff). Maps of soil types and soil drainage types for the focal area can be found in Appendix B.

Land cover types for each storm sewer drainage zone were determined based on the National Land Cover Database (NLCD, 2021). NLCD land cover categories were reclassified into the most similar land cover categories listed in Sorrell's paper, which are used as input variables in calculating pollutant loads weighted by Sorrell land cover type. Land cover types are used for storm water calculations because they can be indicators of the percentage of imperviousness of different surfaces and can be indicators of the amount of water absorbed by vegetation. Information about these land cover categories can be found in Appendix B.

The rainfall probabilities were gathered from the NOAA atlas of rainfall frequencies for Lewiston, MI (WorldClimate.com).

These parameters were used to calculate Runoff Curve Numbers (RCNs), which are index values representing the runoff potential of areas with certain soil and land cover characteristics. Drainage zones with multiple land categories and hydrological areas required calculating a proportional, weighted Runoff Curve Numbers value for each Sorrell land cover type in the drainage zone. The Runoff Curve Numbers were used to calculate

Surface Runoff Values (SRO) (calculations shown in Appendix D). The Surface Runoff Values were calculated separately for the first flush, 10-year storm, and 25-year storm. Slope values were calculated using a digital elevation model in ArcGIS, using LiDAR data collected and provided by the USGS. Within each drainage zone boundary, we assumed that runoff drains overland as sheet flow for an average of 200 feet before entering the system via storm drains, where it then flows as small channels to the outfall location. An approximation of the slope of the actual sewer pipes was estimated based on field inventory observations and confirmed using GIS tools.

The next step was to calculate the Time of Concentration (Tc), which represents the time it takes for stormwater runoff entering the most distant upstream point in the watershed to travel to the outfall/discharge point (this is therefore the conservative, estimated maximum, because stormwater entering the sewer system at points closer to the outfall would be expected to spend less time in the sewer system). The Time of Concentration value is used to calculate the peak discharge (Q) in cubic feet per second (CFS). This is the critical value for selecting the desired capacity (i.e., size) of a structural stormwater BMP such as an oil/grit separating unit. Refer to Sorrell 2010 for the Unit Hydrograph Method details and formulas.

While the Unit Hydrograph Method is widely used to calculate stormwater discharge for city stormwater assessments such as in this report, it should be noted that the model has some limitations. Being simplifications of reality, all models contain some level of error. However, the potential for error is greatly reduced when the Unit Hydrograph Method is applied to very small watersheds like the storm sewer drainages of Lewiston. Limitations and assumptions of the Unit Hydrograph Method are that:

- The model is only valid for estimating discharge generated by a 24-hour rainfall event
- Rain falls at a constant intensity for the duration of the 24-hour rainfall event
- Rainfall is distributed uniformly throughout the drainage zone
- Hydrographs are directly proportional (i.e., if a hydrograph represents 1 inch of excess rainfall, a hydrograph representing 2 inches of excess rainfall can be obtained simply by multiplying the first times two)
- The model fails to produce accurate results in drainage zones that have well-drained soils and very little impervious cover

## APPENDIX B. Soils

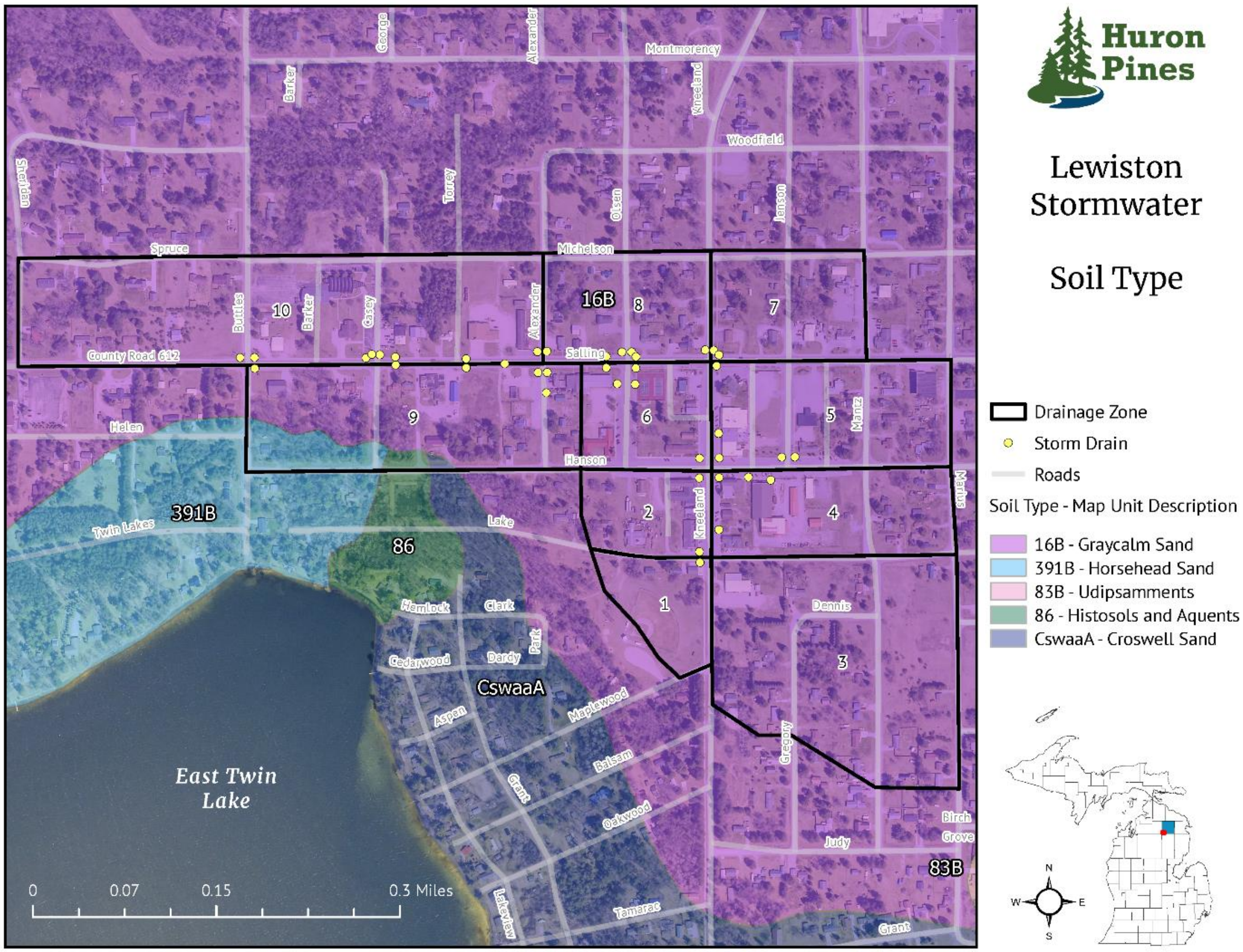


*Figure 27 Soil type*

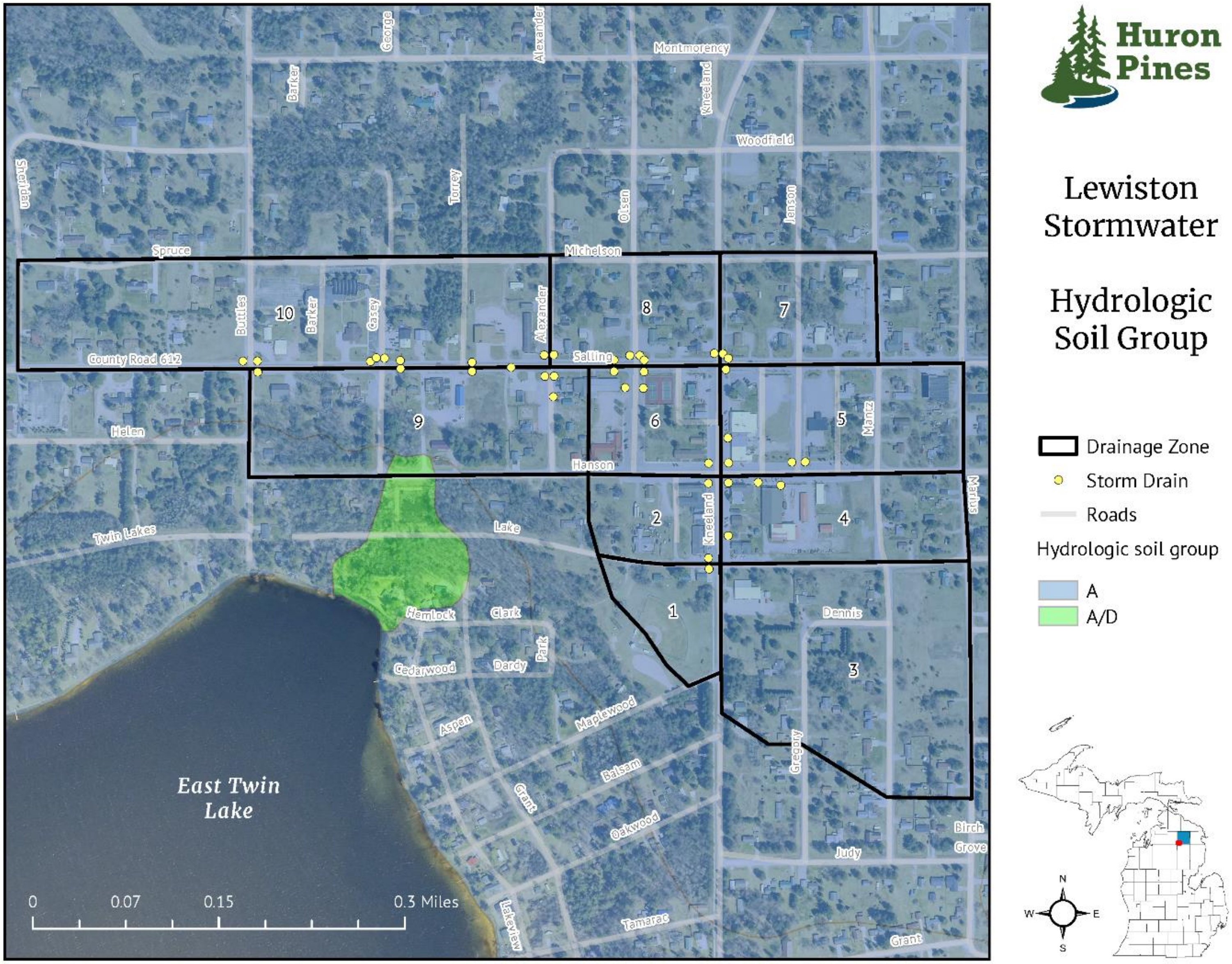


*Figure 28 Soil Drainage Class*

**Table A1.** USDA Soil Types in Lewiston, MI

| Soil label | Soil Name | Hydrologic Soil Group* | Acres | Percent of total Area |
|---|---|---|---|---|
| 16 B | Graycalm Sand, 0 to 6 percent slopes | A | 108.8 | 97.5 |
| 86 | Histosols and Aquents, Ponded | A/D | 0.4 | 0.3 |
| CswaaA | Croswell sand, 0 to 6 percent slopes | A | 0.2 | 3.00% |
| Totals for Area of Interest | | | 111.6 | 100.00% |

*Excerpt from Web Soil Survey (USDA):
*Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.*

*The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:*

*Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.*

*Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.*

*Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or* *soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.*

*Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.*

*If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes*.

# APPENDIX C. Lewiston and Cover Information

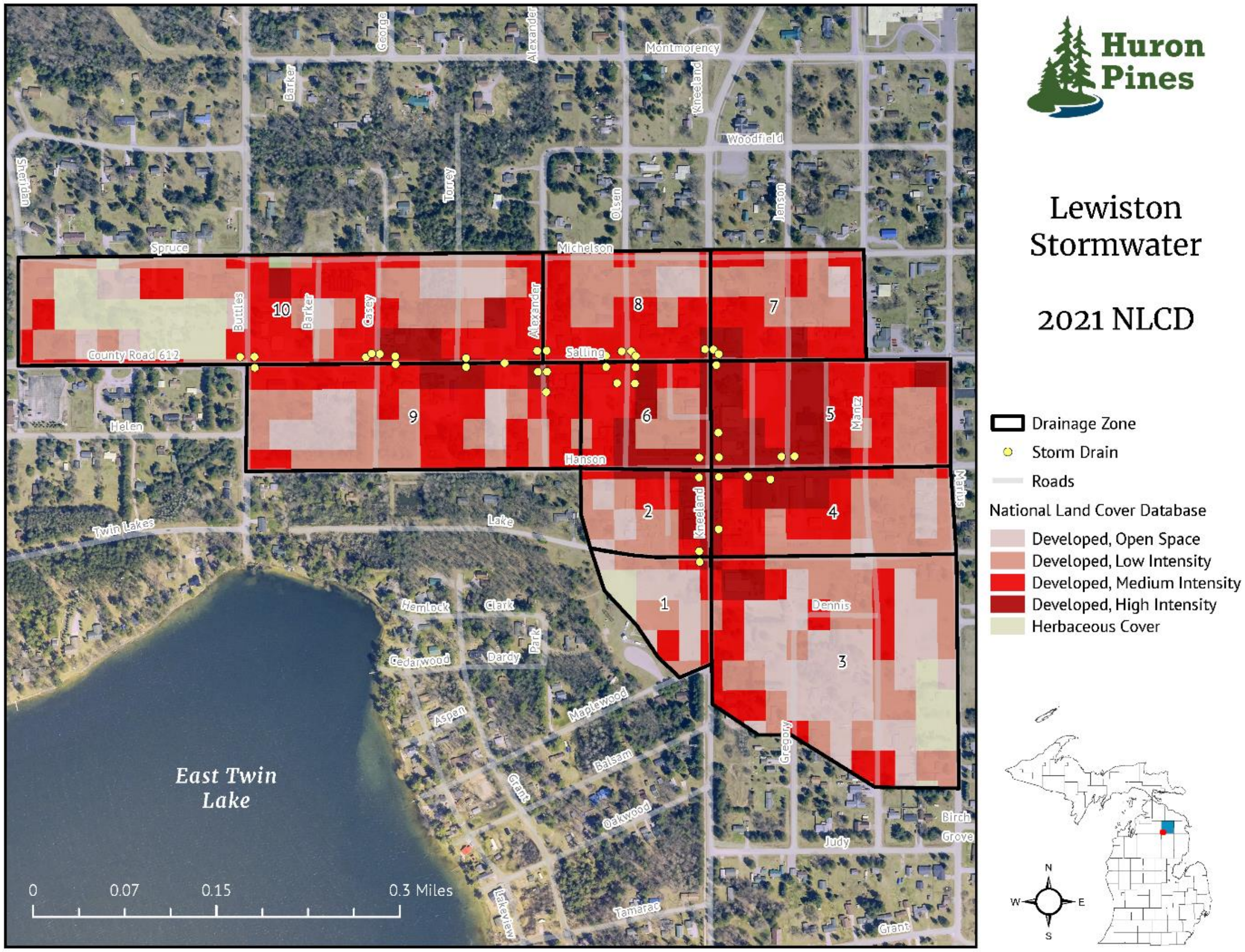


*Figure 29 National Land Cover Database descriptions (UJSGS National Map Viewer*

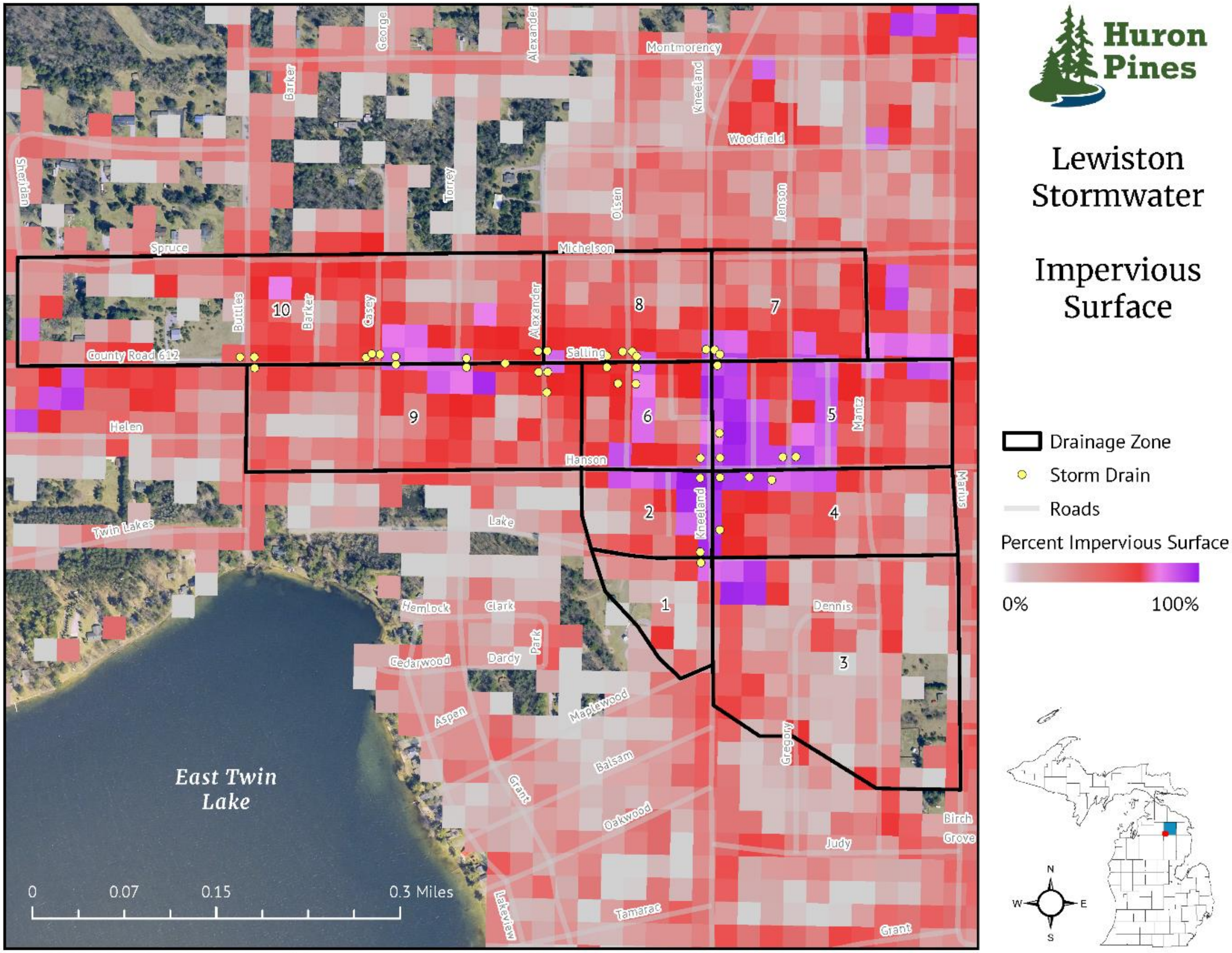


*Figure 30 Impervious surface (USGS National Map Viewer)*

# APPENDIX D. Lewiston Elevation Information

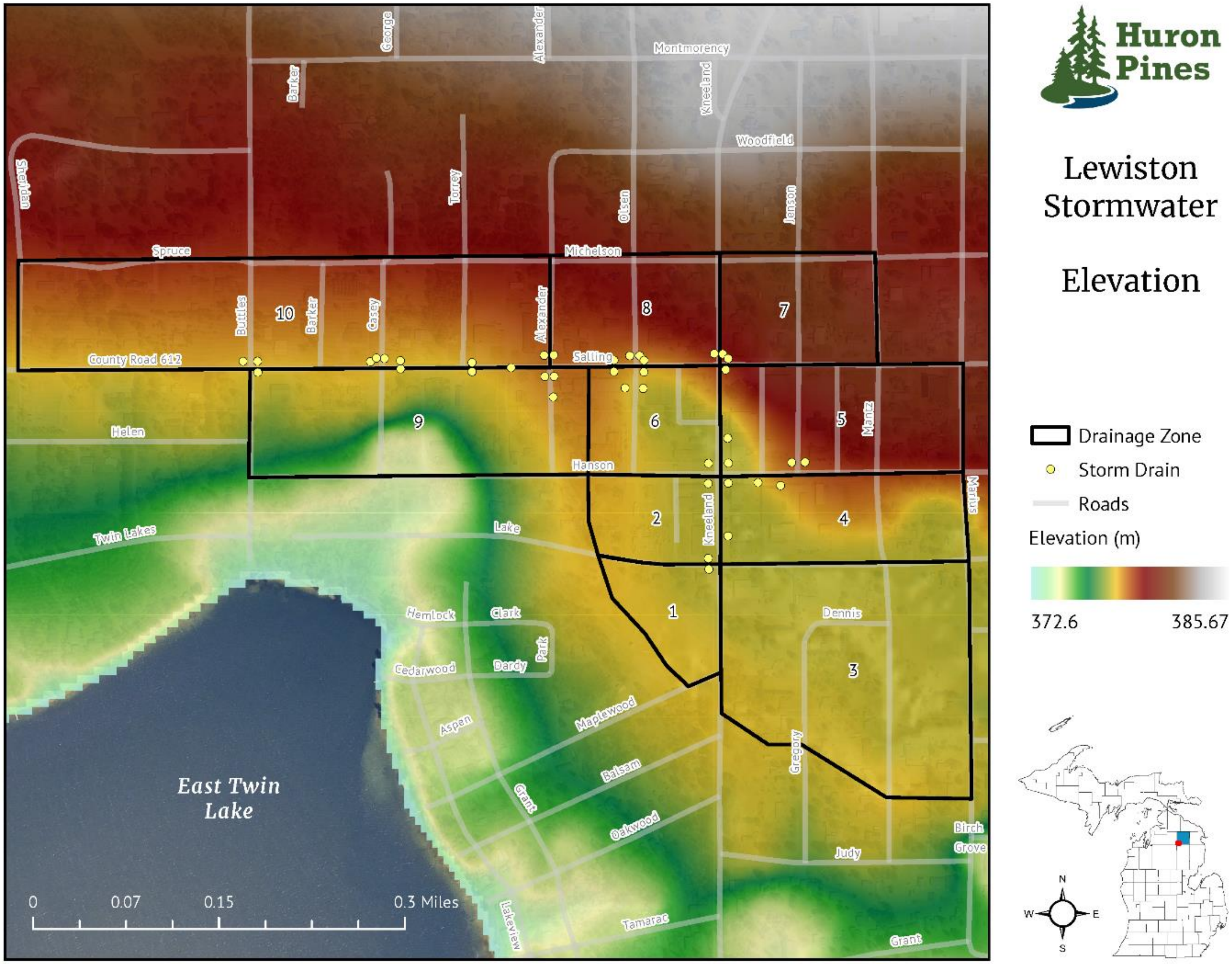


*Figure 31 Elevation Map (USGS National Map Viewer)*

## APPENDIX E. Detailed Calculations

### Discharge Calculations

| Zone ID | Drainage Area (Acres) | Hydrologic Soil Group | *Weighted Runoff Curve Number (RCN) | Surface Runoff (first flush) | Surface Runoff (10 Year) | Surface Runoff (25 year) | Hydrologic Peak | First Flush (cfs) | 10 year (cfs) | 25 year (cfs) | 100 year (cfs) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.198 | A | 48.88 | 0.286 | 0.025 | 0.190 | 183.895 | 0.067 | 4.225 | 6.821 | 9.403 |
| 2 | 4.692 | A | 64.31 | 0.075 | 0.323 | 0.771 | 226.211 | 0.009 | 2.533 | 4.283 | 6.061 |
| 3 | 21.400 | A | 59.03 | 0.130 | 0.186 | 0.535 | 55.199 | 0.315 | 0.350 | 1.063 | 1.989 |
| 4 | 9.042 | A | 77.31 | 0.003 | 0.832 | 1.526 | 312.745 | 0.487 | 0.633 | 1.859 | 3.431 |
| 5 | 11.120 | A | 86.75 | 0.022 | 1.394 | 2.251 | 174.436 | 1.842 | 0.483 | 2.255 | 4.864 |
| 6 | 6.000 | A | 83.13 | 0.004 | 1.155 | 1.953 | 233.880 | 1.591 | 1.260 | 4.158 | 8.021 |
| 7 | 7.330 | A | 57.86 | 0.145 | 0.160 | 0.488 | 190.361 | 0.067 | 4.225 | 6.821 | 9.403 |
| 8 | 7.941 | A | 58.60 | 0.135 | 0.176 | 0.517 | 289.757 | 0.009 | 2.533 | 4.283 | 6.061 |
| 9 | 15.223 | A/D | 52.02 | 0.229 | 0.060 | 0.281 | 337.572 | 0.315 | 0.350 | 1.063 | 1.989 |
| 10 | 24.600 | A | 56.35 | 0.164 | 0.130 | 0.429 | 251.902 | 0.487 | 0.633 | 1.859 | 3.431 |

*Weighted RCN Values were calculated using Land Use multiplied by the percentage of drainage area, then added together.

**Time of Concentration Calculations**

| Zone | Slope | Average slope | Small waterway velocity (ft/s) | Total Travel Time |
|---|---|---|---|---|
| 1 | 0.005 | 0.0115312945 | 0.084 | 1.374 |
| 2 | 0.006 | 0.0115312945 | 0.091 | 1.067 |
| 3 | 0.001 | 0.0115312945 | 0.041 | 5.961 |
| 4 | 0.014 | 0.0115312945 | 0.141 | 0.719 |
| 5 | 0.014 | 0.0115312945 | 0.144 | 1.465 |
| 6 | 0.011 | 0.0115312945 | 0.125 | 1.025 |
| 7 | 0.009 | 0.0115312945 | 0.115 | 1.317 |
| 8 | 0.018 | 0.0115312945 | 0.159 | 0.789 |
| 9 | 0.026 | 0.0115312945 | 0.194 | 0.655 |
| 10 | 0.012 | 0.0115312945 | 0.129 | 0.936 |

**Calculations for Pollutant Loads**

| | | | | | | Pollutant concentrations | | | Annual Pollutant loads | | | Total Annual Pollutant |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zone | Area (acres) | Annual Rainfall (inches) | Weighted % Imperviousness | Runoff coefficient | Annual runoff (inches) | TSS (mg/L) | P (mg/l) | N (mg/l) | TSS | P (lbs) | N (lbs) | (lbs/acre) |
| 1 | 4.20 | 29.88 | 15.13 | 0.19 | 5.01 | 54.50 | 0.26 | 2 | 258.86 | 1.23 | 9.50 | 64.23 |
| 2 | 4.69 | 29.88 | 34.18 | 0.36 | 9.62 | 54.50 | 0.26 | 2 | 555.83 | 2.65 | 20.40 | 123.37 |
| 3 | 21.40 | 29.88 | 24.95 | 0.27 | 7.38 | 54.50 | 0.26 | 2 | 1945.96 | 9.28 | 71.41 | 94.70 |
| 4 | 9.04 | 29.88 | 59.10 | 0.58 | 15.65 | 54.50 | 0.26 | 2 | 1742.70 | 8.31 | 63.95 | 200.73 |
| 5 | 11.12 | 29.88 | 73.63 | 0.71 | 19.16 | 54.50 | 0.26 | 2 | 2624.78 | 12.52 | 96.32 | 245.83 |
| 6 | 6.00 | 29.88 | 67.16 | 0.65 | 17.60 | 54.50 | 0.26 | 2 | 1300.64 | 6.20 | 47.73 | 225.76 |
| 7 | 7.33 | 29.88 | 24.92 | 0.27 | 7.38 | 54.50 | 0.26 | 2 | 665.97 | 3.18 | 24.44 | 94.62 |
| 8 | 7.94 | 29.88 | 25.46 | 0.28 | 7.51 | 54.50 | 0.26 | 2 | 734.07 | 3.50 | 26.94 | 96.28 |
| 9 | 15.22 | 29.88 | 25.91 | 0.28 | 7.61 | 54.50 | 0.26 | 2 | 1427.81 | 6.81 | 52.40 | 97.68 |
| 10 | 24.60 | 29.88 | 23.30 | 0.26 | 6.98 | 54.50 | 0.26 | 2 | 2116.26 | 10.10 | 77.66 | 89.59 |

## APPENDIX F: Recommended Trees for Community Planting

| Common Name | Scientific Name | Deciduous or Evergreen | Size Class | Climate Adaptable | Native | Street Tree | Riparian Tree | Park/Open Lawn |
|---|---|---|---|---|---|---|---|---|
| Alaskan Cypress/Alaska Cedar | Chamaecyparis nootkatensis | Evergreen | Large | No | No | No | No | Yes |
| American Beech | Fagus grandifolia | Deciduous | Large | No | Yes | No | Yes | Yes |
| American Elm (DED Resistant Cultivars) | Ulmus americana x Hybrids | Deciduous | Large | Yes | Yes | Yes | Yes | Yes |
| American Holly | Ilex opaca | Evergreen | Medium | No | No | No | No | No |
| American Linden/Basswood | Tilia americana | Deciduous | Medium/Large cultivar dependent | Yes | Yes | Yes | No | Yes |
| American Plum | Prunus americana | Deciduous | Small/Medium | No | Yes | No | No | Yes |
| American Smoketree | Cotinus obovatus | Deciduous | Small | No | No | No | No | No |
| American Tamarack | Larix laricina | Deciduous | Medium | No | Yes | Yes | No | No |
| Bald cypress | Taxodium distichum | Deciduous | Large | Yes | No | No | Yes | Yes |
| Balsam Fir | Abies balsamea | Evergreen | Medium | No | Yes | No | No | No |
| Bitternut Hickory | Carya cordiformis | Deciduous | Large | No | Yes | No | Yes | Yes |
| Black Cherry | Prunus serotina | Deciduous | Large | No | Yes | No | No | Yes |
| Black Gum/Black Tupelo | Nyssa sylvatica | Deciduous | Medium | Yes | Yes | Yes | No | Yes |
| Black Spruce | Picea mariana | Evergreen | Medium | No | Yes | No | Yes | No |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Black Walnut | Juglans nigra | Deciduous | Large | No | Yes | No | Yes | Yes |
| Black Willow | Salix nigra | Deciduous | Large | No | Yes | No | Yes | No |
| Bristlecone Pine | Pinus aristata | Evergreen | Small | No | No | No | No | No |
| Bur Oak | Quercus macrocarpa | Deciduous | Large | Yes | Yes | Yes | No | Yes |
| Butternut/White Walnut | Juglans cinerea | Deciduous | Large | No | Yes | No | No | Yes |
| Canadian Plum | Prunus nigra | Deciduous | Small/Medium | No | Yes | No | No | Yes |
| Canadian Yew | Taxus canadensis | Evergreen | Small | No | No | No | No | No |
| Catalpa | Catalpa spp. | Deciduous | Large | No | No | No | No | Yes |
| Chinkapin Oak | Quercus muehlenbergii | Deciduous | Large | Yes | Yes | Yes | No | Yes |
| Common Larch | Larix decidua | Deciduous | Medium | No | No | No | Yes | No |
| Common Persimmon | Diospyros virginiana | Deciduous | Medium/Large | Yes | No | Yes | No | Yes |
| Corneliancherry Dogwood | Cornus mas | Deciduous | Small | No | No | No | No | Yes |
| Crabapple | Malus spp. | Deciduous | Small | No | No | No | No | Yes |
| Cucumber tree Magnolia | Magnolia acuminata | Deciduous | Large | No | No | No | No | Yes |
| Dawn Redwood | Metasequoia glyptostroboides | Deciduous | Large | No | No | No | No | Yes |
| Douglas Fir | Pseudotsuga menziesii | Evergreen | Medium | No | No | No | No | No |
| Eastern Hemlock | Tsuga canadensis | Evergreen | Medium | No | Yes | No | Yes | Yes |
| Eastern Redbud | Cercis canadensis | Deciduous | Small | No | Yes | No | Yes | Yes |
| Eastern Red cedar | Juniperus virginiana | Evergreen | Medium | Yes | Yes | No | No | No |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Eastern White Pine | Pinus strobus | Evergreen | Large | No | Yes | No | No | Yes |
| European Beech | Fagus sylvatica | Deciduous | Large | No | No | No | No | Yes |
| European Hornbeam | Carpinus betulus | Deciduous | Small/Medium | No | No | Yes | No | Yes |
| Flowering Dogwood | Cornus florida | Deciduous | Small | No | Yes | No | No | Yes |
| Freeman Maple | Acer rubrum x saccharinum 'Freemani' | Deciduous | Medium/Large | No | No | No | No | Yes |
| Ginkgo (Male only) | Ginko Biloba | Deciduous | Medium/Large | Yes | No | Yes | No | Yes |
| Hackberry | Celtis occidentalis | Deciduous | Medium/Large | Yes | Yes | Yes | Yes | Yes |
| Hawthorn (Thornless) | Crataegus spp. var. inermis | Deciduous | Small | No | No | No | No | Yes |
| Hinoki Falsecypress | Chamaecyparis obtusa | Evergreen | (Cultivar Dependent) | No | No | No | No | Yes |
| Hop-Hornbeam/Ironwood | Ostrya virginiana | Deciduous | Small/Medium | Yes | Yes | Yes | Yes | Yes |
| Hornbeam/Musclewood/Blue Beech | Carpinus caroliniana | Deciduous | Small/Medium | Yes | Yes | Yes | No | Yes |
| Jack Pine | Pinus banksiana | Evergreen | Small/Medium | No | Yes | No | No | No |
| Katsura | Cercidiphyllum japonicum | Deciduous | Medium/Large | Yes | No | Yes | No | Yes |
| Kentucky Coffeetree | Gymnocladus dioicus | Deciduous | Large | Yes | Yes | Yes | No | Yes |
| Kousa Dogwood | Cornus kousa | Deciduous | Small | No | No | Yes | No | Yes |
| Littleleaf Linden | Tilia cordata | Deciduous | Medium/Large cultivar dependent | Yes | No | Yes | No | Yes |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| London Planetree | Platanus x acerifolia | Deciduous | Large | Yes | No | Yes | No | Yes |
| Mugo Pine/ Swiss Mountain Pine | Pinus mugo | Evergreen | Small | No | No | No | No | No |
| Nannyberry | Viburnum lentago | Deciduous | Small | No | Yes | No | No | Yes |
| Northern Red Oak | Quercus rubra | Deciduous | Large | Yes | Yes | Yes | No | Yes |
| Norway Spruce | Picea abies | Evergreen | Medium/Large | No | No | No | No | No |
| Ohio Buckeye | Aesculus glabra | Deciduous | Large | No | Yes | No | No | Yes |
| Ornamental Cherries | Prunus spp. | Deciduous | Cultivar Dependent | No | No | No | No | Yes |
| Osage Orange (Thornless) | Maclura pomifera var. inermis | Deciduous | Medium/Large | Yes | No | No | No | Yes |
| Pagoda Dogwood/Alternate-leafed Dogwood | Cornus alternifolia | Deciduous | Small | No | Yes | No | Yes | Yes |
| Paper Birch | Betula papyrifera | Deciduous | Medium | No | Yes | No | Yes | Yes |
| Pawpaw | Asimina triloba | Deciduous | Small/Medium | No | Yes | No | No | Yes |
| Persian Parrotia | Parrotia persica | Deciduous | Medium | Yes | No | Yes | No | Yes |
| Pignut Hickory | Carya glabra | Deciduous | Large | No | Yes | No | No | Yes |
| Pin Oak | Quercus palustris | Deciduous | Large | Yes | Yes | Yes | No | Yes |
| Red Horsechestnut | Aesculus X Carnea | Deciduous | Medium | No | No | No | No | Yes |
| Red Maple | Acer rubrum | Deciduous | Medium/Large | No | Yes | Yes | Yes | Yes |
| Red Pine | Pinus resinosa | Evergreen | Large | No | Yes | No | No | No |
| River Birch | Betula nigra | Deciduous | Medium | No | Yes | No | Yes | Yes |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sargent Cherry | Prunus sargentii | Deciduous | Medium | No | No | No | No | Yes |
| Sassafras | Sassafras albidum | Deciduous | Medium/Large | No | Yes | No | No | Yes |
| Saucer Magnolia | Magnolia x soulangiana | Deciduous | Medium | No | No | No | No | Yes |
| Serviceberry/Juneberry/ Sugar Plum | Amelanchier spp. | Deciduous | Small | No | Yes | No | Yes | Yes |
| Shagbark Hickory | Carya ovata | Deciduous | Large | No | Yes | No | No | Yes |
| Shingle Oak | Quercus imbricaria | Deciduous | Large | Yes | No | Yes | No | Yes |
| Shumard Oak/Swamp Red Oak | Quercus shumardii | Deciduous | Large | Yes | Yes | Yes | No | Yes |
| Siberian Spruce | Picea omorika | Evergreen | Medium | No | No | No | No | No |
| Silver Linden | Tilia tomentosa | Deciduous | Large | Yes | No | Yes | No | Yes |
| Sourwood | Oxydendrum arboreum | Deciduous | Medium | Yes | No | Yes | No | Yes |
| Star Magnolia | Magnolia stellata | Deciduous | Small/Medium | No | No | No | No | Yes |
| Sugar Maple | Acer saccharum | Deciduous | Large | No | Yes | No | No | Yes |
| Swamp White Oak | Quercus bicolor | Deciduous | Large | Yes | Yes | Yes | Yes | Yes |
| Sweetgum | Liquidambar styraciflua | Deciduous | Medium | Yes | No | Yes | No | Yes |
| Sycamore | Platanus occidentalis | Deciduous | Large | Yes | Yes | Yes | No | Yes |
| Thornless Honeylocust | Gleditsia triacanthos var. Inermis | Deciduous | Medium/Large | Yes | No | Yes | No | Yes |
| Tulip Tree | Liriodendron tulipifera | Deciduous | Large | Yes | Yes | Yes | No | Yes |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Turkish Filbert/Turkish Hazel | Corylus colurna | Deciduous | Medium | Yes | No | Yes | No | No |
| White Cedar/Arborvitae | Thuja occidentalis | Evergreen | (Cultivar Dependent) | No | Yes | No | Yes | No |
| White Fir | Abies concolor | Evergreen | Medium | No | No | No | No | No |
| White Oak | Quercus alba | Deciduous | Large | Yes | Yes | Yes | No | Yes |
| White Spruce | Picea glauca | Evergreen | Medium | No | Yes | No | No | No |
| White Willow | Salix alba | Deciduous | Large | No | No | No | Yes | No |
| Yellowwood | Cladrastis kentukea | Deciduous | Medium | Yes | Yes | Yes | No | Yes |
| Zelkova | Zelkova serrata | Deciduous | Medium | Yes | No | Yes | No | No |