Rose City Stormwater Assessment

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Conserving the Forests, Lakes and Streams of Northeast Michigan

Table of Contents

List of Figures

List of Tables

Appendices

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Chapter 1

Introduction

Introduction

The bountiful natural resources surrounding Rose City, the second largest city in Ogemaw County after West Branch, have always been important to the people inhabiting this area. Members of the Chippewa Tribe first hunted and fished the forests and streams that later attracted the logging industry in the 1800's. Rose City became a city in 1905 and since then agriculture and tourism have become its dominant economic activities. Today, outdoor recreationists continue to explore the forests, lakes and streams of the Rose City area. The entrance to the 4,449-acre Rifle River State Recreation Area is just 3 miles east of Rose City and offers year-round recreation opportunities including paddling, hiking, hunting, fishing, skiing, biking, camping, swimming and wildlife viewing. In town, the beautiful Rose City Park borders the cool and clear Houghton Creek, a high-quality tributary of the Rifle River. Children and adults alike visit the park to fish for trout or to cool off by swimming on hot summer days.

The City of Rose City, in keeping with its historical love of the land and respect for nature, acknowledges the social, economic and ecological advantages of protecting its freshwater resources and is collaborating with Huron Pines to improve stormwater runoff management in the city. The results of this effort will reduce the amount of excess sediment and other pollutants that enter Houghton Creek and the Rifle River. Additionally, improving stormwater management practices can help protect streambanks and reduce damage to downstream ecosystems and property by reducing the severity of future flood events. The purpose of this stormwater assessment, which is Phase I of the project, is to provide Rose City with recommendations for improving stormwater management through the use of structural, managerial and educational Best Management Practices (BMPs). The Phase I findings will be useful for selecting projects and securing funding for Phase II, which will entail the implementation and maintenance of BMPs selected to protect Houghton Creek and the Rifle River Watershed overall.

Stormwater runoff is generated when precipitation from rain or melting snow flows over impervious surfaces including roads, driveways, parking lots, rooftops and sidewalks. Along the way runoff picks up sediment, road salt, oils and greases, bacteria, fertilizers and other chemicals, often carrying these pollutants directly into nearby streams or wetlands via storm sewer systems and ditches unless appropriate management practices are put in place.

Huron Pines, with the support of the City of Rose City, conducted this stormwater assessment addressing these specific components:

- Complete an inventory of storm sewer drains and outfalls
- Produce a map delineating each storm sewer drainage zone and overland stormwater flow area within Rose City limits
- Determine soil classifications and current land use information to estimate the amount of impervious surface in the city and calculate runoff flow rates
- Estimate pollutant loading from stormwater runoff to Houghton Creek and nearby tributaries
- Recommend BMPs (Best Management Practices, which are control measures taken to mitigate changes to both quantity and quality of urban runoff caused through changes to land use) suitable for the City of Rose City in order to reduce the amount of polluted runoff entering Houghton Creek and surrounding tributaries
- Provide cost estimates for recommended BMPs
- Present findings to the Rose City Council in a public format
- Provide the community with a final report to assist with stormwater management and serve as the basis for pursuing funding to implement BMPs

Ultimately, the goal of this Phase I stormwater assessment and the implementation of stormwater BMPs in Phase II of this project is to protect our freshwater resources in Houghton Creek and the Rifle River Watershed. Some specific objectives that align with this goal include:

- Protecting water quality by minimizing the quantity of stormwater runoff generated as well as the amount of pollutants available for transport
- Allowing adequate groundwater recharge to occur by encouraging infiltration of water into the soil wherever possible
- Preventing excessive streambank erosion due to rapid and abundant stormwater runoff
- Minimizing future flood risk by reducing the quantity and runoff rate of urban stormwater

Chapter 2

Stormwater Inventory

Storm Drain Mapping

The Rose City stormwater sewer system was installed *circa* 1951. Because no maps of the current stormwater system exist, Huron Pines and the Rose City Department of Public Works collaborated to visually identify and map the location of each stormwater sewer drain and outfall in Rose City. Field data was collected on June 19, 2013 and used to determine the direction of stormwater flow overland and through the storm sewer system. Drain and outfall locations were recorded using a Global Positioning System (GPS) unit and analyzed along with topographic maps and visual assessment in the field to delineate storm sewer drainage zones. Each stormwater sewer outfall structure was photographed and measured and notes about the general condition of each outfall were recorded.

Twelve individual stormwater areas were identified within the city limits of Rose City (Figure 1, Table 1 and Table 2). Four storm sewer drainage zones exist in Rose City, although much of the city is drained by one storm sewer drainage zone. Google Earth software was used to calculate the approximate area of each storm sewer drainage zone. Drainage zones, sometimes referred to as watersheds, indicate the total land area over which precipitation drains to a common outlet. Therefore, every land location is part of one drainage zone or another. While the movement of water through undeveloped watersheds generally adheres to topographical boundaries on the land surface, drainage zones in developed areas are often largely determined by subterranean storm drain systems. Understanding the size, location, and attributes of each storm sewer drainage zone is critical to designing, funding and implementing effective BMPs.

Eight additional overland flow areas were identified. These overland flow areas do not necessarily reflect true hydrological drainage zones but are simply sections of Rose City that were subjectively identified in order to provide a convenient basis for discussing stormwater BMP recommendations in those areas. Although these overland flow areas fall outside the boundaries of the four storm sewer drainage zones they all potentially contribute stormwater pollutants to Houghton Creek and so it is still important to implement BMPs in these zones.

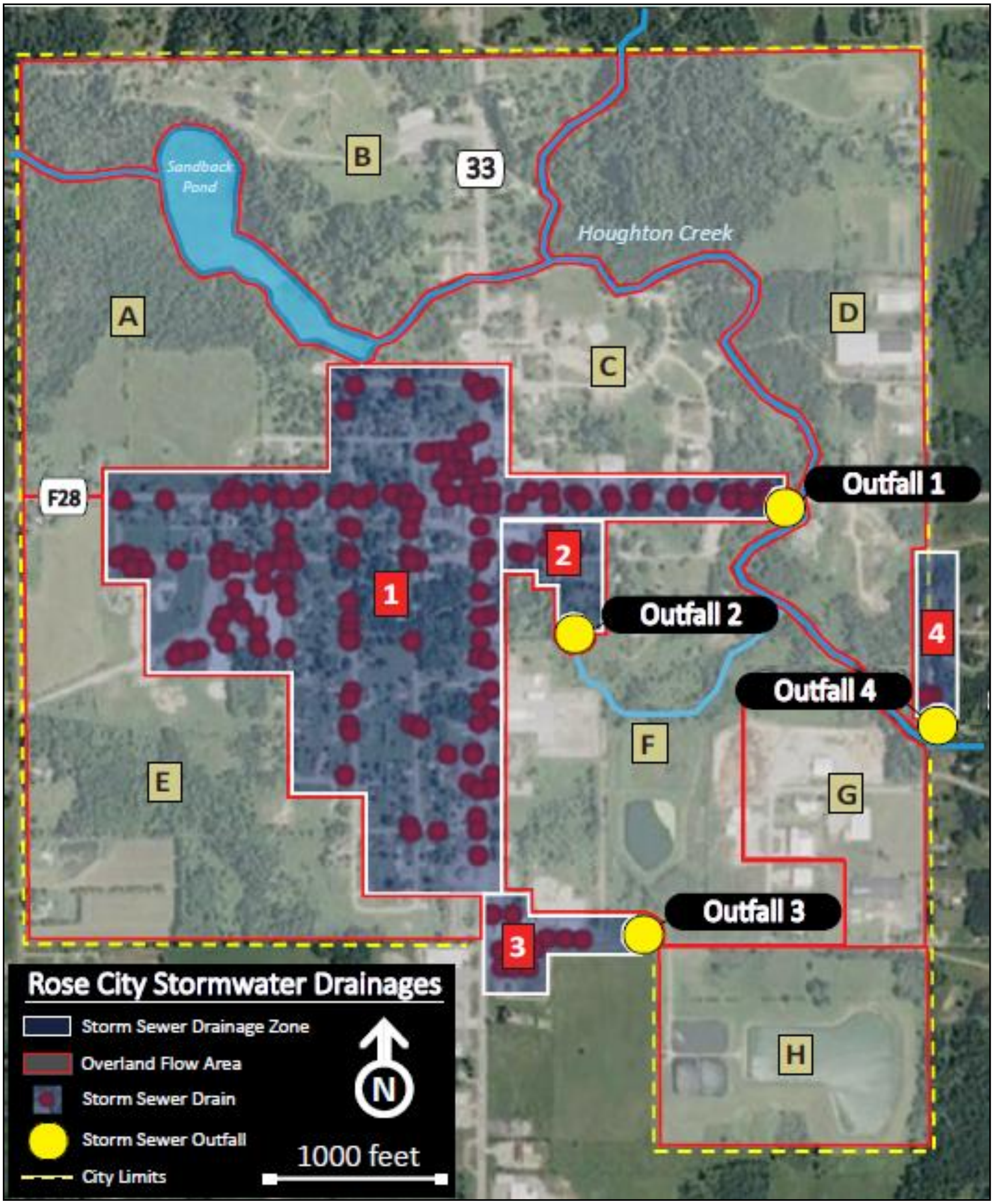


Figure 1: Map of Rose City stormwater sewer drainage zones (numbered 1-4) and overland flow areas (lettered A-H). Characteristics of each drainage zone and overland flow area are given in Table 1 and Table 2, respectively. Note the storm sewer zones represent hydrological watersheds, whereas the overland flow areas were subjectively identified to provide a basis for discussing stormwater BMPs in these different sections of Rose City.

Table 1 Stormwater Sewer Drainage Zones			
Zone	**Discharge Size**	**Location**	**Notes**
1 106.5 acres	49” high, 79” wide concrete pipe	South of County Highway F28, west of Houghton Creek 44.42148°N -84.20947°W	Drains over riprap near bridge footing, about 2’ from Houghton Creek
2 5.5 acres	24” plastic pipe	Located along ORV trail about 100 yards north of Water St 44.41931°N -84.11415°W	Drains to sluggish, vegetated channel that flows about 600 yards to Houghton Creek
3 6.6 acres	Unable to locate	Casemaster St east of M-33, likely in marsh north of Casemaster Dr	Unable to locate outfall – in marsh north of Casemaster Dr
4 2.9 acres	20” plastic pipe	East side of Beachwood Rd, north side of Houghton Creek 44.41790°N -84.10607°W	Drains into riprap near bridge footing, about 4’ from Houghton Creek

Table 2 Stormwater Overland Flow Areas	
Zone*	**Comments**
A 65.5 acres	Stormwater drainage is north to Sandback Pond through mostly forested landscape; outlet creek from Sandback Pond flows east into Houghton Creek.
B 76.3 acres	Stormwater drainage west of M-33 is south to Sandback Pond through forested landscape and private yards; outlet creek from Sandback Pond flows east into Houghton Creek. East of M-33, stormwater drains east directly to Houghton Creek.
C 44.2 acres	Stormwater drainage is to the north or northeast through Rose City Park over lawn grass to Houghton Creek. Eastern portion of Zone C drains east to Houghton Creek.
D 85.7 acres	Stormwater drainage is west or south through primarily forested landscape to Houghton Creek.
E 84.5 acres	Stormwater drainage is to the south or southwest through a mixture of agricultural and forested landscape, eventually reaching Wilkins Creek, which flows into Houghton Creek approximately one half mile southeast of Rose City.
F 71.8 acres	Stormwater in southern half of Zone F flows north through marsh to drainage canal that flows into Houghton Creek. In the northern part of Zone F, drainage is south to drainage canal or east directly to Houghton Creek. Some water is retained in an artificial pond.
G 28.1 acres	Stormwater drainage in this industrial zone flows over impervious surfaces and lawns north directly into Houghton Creek, or east into ditch along Beachwood Road and then north to Houghton Creek.
H 44.1 acres	Stormwater drainage in Zone H is primarily to a closed artificial pond (for wastewater treatment). A small portion of stormwater drains north to ditch along Casemaster Drive before passing through a culvert into Zone F, which eventually drains to Houghton Creek.

*Acreage of overland flow areas includes only area within Rose City limits.

Estimated Stormwater Flows

Characteristics of each of the eight overland flow areas within Rose City limits are described in this report, along with recommendations for managing stormwater in these areas. Generally, the Rose City overland flow areas are in well-vegetated areas which allow water to infiltrate into the soil thus limiting surface runoff. Where surface runoff does occur within these overland flow areas it tends to flow diffusely. However, it is still important to proactively address stormwater runoff in these overland flow areas through educational and managerial stormwater BMPs.

In contrast to the overland flow areas, the four storm sewer drainage zones capture stormwater runoff from commercial and residential areas of Rose City and drain to discrete outfalls, making them high priority targets for implementing stormwater control BMPs, including structural ones. Discharge and pollutant loadings for each zone were estimated in order to identify problem areas and suggest appropriate stormwater control BMPs. To estimate stormwater flows for each of the four storm sewer drainage zones in Rose City the following information was collected:

- Annual rainfall amounts
- Approximate area of each drainage zone
- Soil types
- Land use types (percentage of impervious surface in each drainage zone)

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 control BMP is to choose the design storm intensity that the structure will be designed to effectively handle. At a minimum, stormwater control BMPs should be sized to account for “first flush” which in developed areas is generally considered to be the first ½” of rainfall per storm event. A majority of pollutants that have accumulated between rain events are picked up and transported in the initial stormwater runoff of a storm event, with subsequent runoff carrying proportionately fewer pollutants.

Communities looking to improve stormwater management commonly elect to use a 10-year/24-hour design storm to size stormwater control BMPs. Stormwater control BMPs can also be sized to treat more conservative design rainfall events such as 25-year/24-hour or 100-year/24-hour storms if funding is available to cover increased project costs of installing larger structures. In this Rose City stormwater assessment, discharge values for each storm sewer drainage zone are calculated for first flush, 10-year/24-hour and 25-year/24-hour design storms. The recommendations and cost estimates provided in Table 5 of this report are based on values calculated for a 10-year/24-hour design storm event, which is a moderately conservative estimate.

The Unit Hydrograph Method to estimate peak stormwater, which is detailed in Sorrell 2010, is followed in this stormwater study. This method is appropriate for use in small (less than 10 square miles) ungaged watersheds such as the stormwater drainage zones identified in Rose City. 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. 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 the Google Earth software area calculation tool. Soil types were determined using Web Soil Survey maps available at www.websoilsurvey.usda.nrcs.gov (Appendix A). Soils are 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). Analysis of soil types in Rose City indicated that soils in storm sewer drainage zones 1, 2 and 3 are primarily type C soils, which have relatively poor infiltration rates. Rose City storm sewer drainage zone 4 is located over sandier soil of hydrological soil type A. Land cover types for each storm sewer drainage zone were determined through field inventory and the use of Google Earth software.

Design rainfall amount atlases have been compiled by various government agencies based on decades of climate data. Design rainfall event values used in this report are from Sorrell's 2010 "Computing Flood Discharges for Small Ungaged Watersheds," which are based on a study by Huff and Angel 1992 of the Midwestern Climate Center and the Illinois State Water Survey entitled "Rainfall Frequency Atlas of the Midwest" (more commonly known as "Bulletin 71"). Based on this data, the 24-hour rainfall amounts used in this report for first flush, 10-year design storm, and 25-year design storm were 0.5 inches, 3.04 inches and 3.60 inches, respectively.

These parameters were used to calculate runoff curve numbers (RCNs), which are index values representing the runoff potential of areas with certain soil and landcover characteristics. For Rose City storm sewer drainage zones 1 and 2 weighted RCN values were calculated to reflect the multiple landcover types within these drainage zones. The RCN values were then used to determine surface runoff (SRO) values. After calculating SRO for each storm sewer drainage zone and design storm frequency the next step was to calculate time of concentration (T_C), which is the time it takes for runoff to travel to the discharge point from the most hydraulically distant point in the watershed. T_C values were obtained by calculating runoff travel paths and average slope using Google Earth and USGS topographic maps. It was assumed that runoff drains as sheet flow for an average of 200 feet, then flows as small waterways (e.g., through the storm sewer system) for the remainder of the distance to each storm sewer drainage zone outfall (see Appendix B for step-by-step calculations). The T_C value were then plugged into the equation $q_p' = 238.6 * T_C^{-0.82}$ to calculate the unit hydrograph peak (q_p). Multiplying peak discharge, surface runoff and drainage area together yields discharge (*Q*) of the watershed in cubic feet per second (CFS) for a given design storm event. These discharge values should be used to help guide the selection of stormwater control BMPs, including the type, size and location of stormwater management structures. Contributing drainage area, land use type and hydrological soil group for each Rose City storm sewer drainage zone are shown in Table 3, with estimated discharge values for first flush, 10-year storm and 25-year storm events.

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 Rose City, which collectively cover less than 125 acres. 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” of excess rainfall, a hydrograph representing 2” 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 (which is why discharge calculations were not estimated for Zone 4)

Table 3
Stormwater Discharge Calculations

Zone	Acres	Land Use Type	Hydrological Soil Group	Estimated Stormwater Discharge		
				First Flush (CFS)	10-year (CFS)	25-year (CFS)
1	106.5	25% Commercial 75% Residential ½ acre	C	0.5	147.6	193.3
2	5.5	30% Commercial 70% Woods (fair)	C	< 0.1	15.4	20.8
3	6.6	Commercial	C	2.3	39.7	48.8
4*	2.9	Woods (good)	A	-	-	-
Total	**121.5**					

*Note: Calculations are not given for Zone 4 because the Unit Hydrograph method is not valid for calculating discharge in well-drained watersheds such as this. However, due to the size and drainage conditions of Zone 4, stormwater discharge would be relatively minimal in this zone.

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.

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 alike. When stormwater is forced to flow over land instead of filtering slowly through the soil as groundwater 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 to streams increases the frequency and severity of flood events, which can be lead to increased streambank erosion, risk of property damage and damage to wildlife populations and habitat. 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.

Landcover 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. Various studies have been conducted to estimate concentrations of certain pollutants in different landcover scenarios. Schueler 1987 has compiled average concentrations (mg/l) for total suspended solids, total phosphorous and total nitrogen in different landcover 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, phosphorous and nitrogen.

The Simple Method estimates annual stormwater pollutant loads as the product of mean pollutant concentrations and runoff depths:

$$L = 0.226 \times R \times C \times A$$

Where: L = Annual load (lbs)

R = Annual runoff (inches)

C = Pollutant concentration (mg/l; taken from averages derived in Schueler 1987)

A = Area (acres)

0.226 = unit conversion factor

Annual runoff (R) is calculated using the following equation:

$$R = P \times Pj \times Rv$$

Where: R = Annual runoff (inches)

P = Annual rainfall (inches)

Pj = Fraction of annual rainfall events that produce runoff (0.9 was used here)

Rv = Runoff coefficient

According to WorldClimate.com, the Rose City area receives approximately 29.5 inches of rainfall annually. Runoff coefficients for each storm sewer drainage zone were selected from values given in Schueler 1987, based on the landcover characteristics determined for each zone. Pollutant concentration is taken from the Pollutant Concentrations by Land Use tables also included in Schueler 1987.

A summary of estimated pollutant loadings for each storm sewer drainage zone are given in Table 4. Zone 1 is by far the largest storm sewer drainage zone in Rose City and not surprisingly it contributes the highest amount of total pollutants to the Houghton Creek Watershed.

Table 4
Estimated Annual Pollutant Loading based on Schueler's Simple Method

Zone	Acres	Annual Runoff* (inches)	Annual Pollutant Loads			Total annual pollutant load per acre
			TSS (lbs)	Nutrients		
				Total P (lbs)	Total N (lbs)	
1	106.5	11.95	26,965	101.7	618.4	259.9
2	5.5	8.76	1,034	3.7	23.3	193.0
3	6.6	21.24	2,376	6.3	63.4	370.6
4	2.9	3.72	244	1.0	5.4	86.3
Total	**121.5**	**-**	**30,619**	**112.7**	**710.5**	**-**

*Annual runoff based on average annual rainfall data (29.5 inches) for Lupton, MI station (1961-1990 average), taken from www.worldclimate.com, and runoff coefficients given in Schueler's 1987 Simple Method for estimating stormwater pollutant loadings from different landcover types.

Chapter 3

Stormwater Treatment Options

Stormwater Control Techniques

The goal of this stormwater assessment is to provide Rose City with a basis for planning stormwater management improvement efforts to enhance and protect water and habitat quality in Houghton Creek and the overall Rifle River Watershed. Water quality and water quantity have important implications for human health and property, diverse wildlife and the local economy, which relies heavily on the various outdoor recreational activities available in the Rifle River Watershed. Identifying and quantifying problem areas are first steps in designing effective BMPs to control, reduce and/or treat polluted stormwater runoff. According to the US EPA, a BMP is a "technique, measure, or structural control that is used for a given set of conditions to manage the quantity and improve the quality of stormwater runoff in the most cost-effective manner." The information contained in this stormwater report should guide the selection of appropriate types, locations and sizes of BMPs.

BMPs can be structural or non-structural and can be classified as avoidance, minimization and mitigation measures. Actions can be taken to limit the amount of pollutants that could potentially be transported by stormwater, minimize the amount of stormwater runoff and/or mitigate the impact of existing stormwater runoff through use of various treatment options. In many cases it will be necessary to use a combination of BMPs to effectively manage stormwater runoff. This chapter reviews some commonly used non-structural managerial and educational BMPs as well as structural/vegetative BMPs. Finally, recommended BMPs for each Rose City stormwater drainage zone are described and summarized in Table 5. Table 5 also includes cost estimates for recommended stormwater BMPs.

Non-Structural Best Management Practices

Unlike wastewater, stormwater runoff entering storm sewer systems in many communities, including Rose City is not treated and drains directly to our surface waters. One of the most important elements of a successful stormwater management strategy is educating the public. In particular, residents must be aware that stormwater drains directly to waterways. Outreach efforts should be made to discourage over-application and other misuses of pesticides and lawn fertilizers. Rose City should ensure that residents have clear instructions on how to properly dispose of household hazardous waste and must provide a convenient way for residents to comply. Rose City may want to develop stormwater ordinances to serve as a legal framework to help minimize stormwater pollution. These ordinances could include creation and enforcement of laws prohibiting illicit discharges and littering, as well as ordinances that promote low impact development construction designs to reduce the amount of future stormwater runoff.

Municipal BMPs are another type of non-structural stormwater best management practice. Municipal BMPs include measures such as increased street-sweeping (especially when implemented in a strategic way such as in the spring prior to major snowmelt events), which can reduce the amount of total pollutants available for transport by stormwater runoff by 50%-90%. Maintenance of storm sewers and structural stormwater BMPs, proper storage and disposal of equipment and chemicals and reducing rates of road salt application in the winter are other municipal BMPs to consider. Again, multiple BMPs can and should be used in concert if effective levels of stormwater pollution control are to be achieved.

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. In this report recommendations for structural BMPs will be based largely 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 oil and grit separators are an increasingly popular stormwater treatment option. Various models are available but they tend to function in a similar manner. Mechanical oil and grit separators are flow-through units installed in-line with existing storm sewers. These units are generally 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. Mechanical oil and grit separators are very effective at isolating solids and oils and greases. 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 among the most 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.

Mechanical oil and grit separators also have shortcomings and should be used in conjunction with other stormwater management BMPs. Soluble pollutants such as certain pesticides and nutrients are not removed by mechanical oil and grit separators. Bacteria from pet wastes and thermal pollution are also 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.

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.

Vegetative BMPs

Natural vegetation can be used to help treat stormwater runoff before or after it enters the storm sewer system. Vegetative BMPs include rain gardens, stormwater wetlands (a.k.a. constructed wetlands), vegetated buffer strips and grassed waterways or swales. These methods are generally aesthetically pleasing because they look more natural than other structural stormwater BMPs and tend to attract butterflies, bees, birds and other wildlife.

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. Rain gardens are 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 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 and occasional weeding when necessary.

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. Therefore stormwater wetlands are positioned between stormwater outfalls and surface waters. Stormwater wetlands are also generally much larger than rain gardens and various designs can be used depending on site characteristics. Stormwater wetlands can be very effective at removing pollutants but their feasibility depends on land availability. If not sized appropriately stormwater wetlands run the risk of drying out. Stormwater wetlands are designed specifically for treating stormwater runoff. Any stormwater discharge into existing wetland areas should first be treated with other stormwater control BMPs to avoid damaging these natural ecosystems.

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. Examples include limiting the amount of impervious surfaces through use of rain gardens, permeable pavement and vegetated rooftops.

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 our freshwater resources.

Zone Specific BMPs

Based on the stormwater information collected for this report and the experiences of Huron Pines in applying BMPs, the recommendations below are to provide a starting point for implementing controls as well as providing a frame of reference for the cost of such measures. A site inspection and detailed engineering designs will still be required for each zone prior to the installation of structural BMPs.

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. Appropriate BMPs for overland flow areas in general, and for overland flow areas C and G in particular, are also discussed below.

In addition to recommended structural BMPs, street sweeping, stormwater outreach and education, and promotion of LID techniques should be implemented throughout all of Rose City. All efforts should be made to protect existing vegetation as well. Recommendations and cost estimates are summarized in Table 5. The estimated costs include both the materials and installation for the BMPs.

Zone 1

Drainage Zone 1 is the largest stormwater drainage zone in Rose City. Zone 1 drains 106.5 acres of Rose City, including most of the downtown area and almost all of the residential area west of M-33. Zone 1 drains to a single outfall located under the County Highway F-28 (East Main Street) bridge as shown in the photograph at right.
About 25% of the land area within Zone 1 is classified as “commercial” with the remainder being “residential.” Most of Zone 1 is located over class C soils, which are generally high in clay and relatively poorly drained. Because of the landcover and soil characteristics of Zone 1, a large proportion of its stormwater drains as surface runoff that enters the storm sewer system and eventually drains directly to Houghton Creek. Stormwater discharge calculations estimated that for a 10-year/24-hour storm event the discharge at this outfall would be approximately 147.6 cubic feet per second (CFS). For a 25-year/24-hour storm the discharge was estimated to be 193.3 CFS. Annual pollution loading estimates for Zone 1 were 26,965 lbs for total suspended solids, 101.7 lbs of phosphorous, and approximately 618.4 lbs of nitrogen. Because of the size and location of storm sewer Zone 1, both discharge and pollutant loadings are significantly higher than in the other storm sewer zones, which each cover areas of less than 10 acres. A very high proportion of Rose City’s total stormwater runoff and associated pollutants are contributed by Zone 1. Therefore, Zone 1 should be considered a high-priority for implementing stormwater control BMPs.

Huron Pines recommends installing a mechanical grit and oil separator just above the outfall of storm sewer drainage Zone 1. A mechanical grit and oil separator would be feasible to install at this location and would provide cost-effective treatment of the majority of stormwater runoff contributed by the developed areas of Rose City. A site inspection and detailed engineering designs will be required before structural stormwater BMPs can be implemented. In addition to any structural BMPs, non-structural BMPs such as stormwater education and outreach, street sweeping and promoting incorporation of LID into new and existing development should also be implemented in Zone 1 and throughout Rose City.

<u>Zone 2</u>

Storm sewer drainage Zone 2 covers an area of approximately 5.5 acres, including part of the downtown area immediately south of County Highway F-28 (East Main Street) and immediately east of M-33. Approximately 30% of this drainage zone is in a commercial area, while 70% is relatively well vegetated.

Estimated annual pollutant loadings for storm sewer drainage Zone 2 are 1,034 lbs of total suspended solids, 3.7 lbs of phosphorous, and 23.3 lbs of nitrogen. For a 10-year/24-hour rainfall event the estimated discharge from Zone 2 is 15.4 CFS and for a 25-year/24-hour rainfall event it is 20.8 CFS.

The outfall of drainage Zone 2 drains into a shallow channel that flows sluggishly for about 600 yards before its confluence with Houghton Creek. Visual inspection revealed that this low-gradient ditch hosts abundant aquatic vegetation in the summer months, helping to slow water velocity and serving to filter out at least some stormwater pollutants before the water reaches Houghton Creek. It appears likely that this channel acts as a stormwater wetland and consequently investing in a major structural stormwater BMP for drainage Zone 2 might not be a cost-effective measure. However, rain gardens may be worth considering in Zone 2, particularly in the commercial portion of the zone where gardens could intercept pollutants before they can enter storm drains. Non-structural stormwater BMPs such as street-sweeping, stormwater education and outreach, and incorporating LID whenever possible are advisable in Zone 2 and throughout all of Rose City.

<u>Zone 3</u>

Storm sewer drainage Zone 3 covers approximately 6.6 acres, draining a highly developed (100% “commercial” landcover) area near the intersection of M-33 and Casemaster Drive. Zone 3 drains the parking lots of McDonald’s, a BP gas station, and other commercial properties as well as Casemaster Drive itself. Field investigation of the storm drains allowed the drainage zone boundaries to be approximately delineated but the outfall of Zone 3 was not located. The Zone 3 outfall is assumed to empty into the heavily vegetated marsh north of Casemaster Drive, which is fenced in and was inaccessible for investigation during the field inventory.

Estimated discharge from Zone 3 for a 10-year/24-hour storm event was 39.7 CFS and for a 25-year/24-hour storm event it was estimated at 48.8 CFS. Estimated annual pollution loadings for Zone 3 were 2,376 lbs of total suspended solids, 6.3 lbs of phosphorous and 63.4 lbs of nitrogen.

Zone 3 covers a relatively small area but occupies a commercial area with significant expanses of impervious surfaces. Non-structural BMPs such as street-sweeping, stormwater education and outreach, and stormwater ordinances should be implemented in drainage Zone 3 and throughout Rose City. Because a majority of Zone 3 is covered in impervious pavement this would be a great area to promote LID techniques and vegetative BMPs to encourage infiltration of stormwater into the ground rather than the storm sewer system. Due to its small size and drainage into a marsh that eventually empties to either a closed pond or into the vegetated channel draining Zone 2, structural stormwater BMPs such as a mechanical grit and oil separator would probably not be cost effective measures in Zone 3.

Zone 4

Storm sewer drainage Zone 4 drains 2.9 acres along Beachwood Road. Except for Beachwood Road itself Zone 4 is heavily vegetated and overlies fairly well-drained, sandy soils. The Zone 4 outfall is located under the Beachwood Road bridge over Houghton Creek and it essentially drains direct road runoff and ditch runoff contributed by Beachwood Road.

Because of the small drainage area and well-vegetated ditches, this stormwater outfall does not seem to be particularly necessary. It is worth considering eliminating this discharge point altogether and simply directing the small amount of stormwater runoff from Beachwood Road into the well-vegetated ditches and/or adjacent forest before it can reach Houghton Creek. Because the Unit Hydrograph Method is not valid for use in very well-drained watersheds, estimates of discharge were not calculated but are assumed to be minimal. Estimated annual pollutant loadings for Zone 4 are 244 lbs of total suspended solids, 1 lb of phosphorous, and 5.4 lbs of nitrogen. In summary, Zone 4 is not a priority area for structural stormwater BMPs but again it is important to implement a suite of non-structural stormwater BMPs throughout Rose City, including street-sweeping along Beachwood Road and educating residents on proper use and disposal of chemicals.

Recommended BMPs for Overland Flow Areas

In this Rose City stormwater assessment report overland flow areas were identified to provide a basis for talking about stormwater BMPs in different parts of Rose City that fall outside of the four storm sewer drainage zones. Note that these overland flow areas do not necessarily reflect hydrological drainage zone boundaries. In all of the overland flow areas and throughout all of Rose City efforts should be made to provide stormwater education and outreach to the public. Additionally, implementing a city-wide street sweeping program (especially each spring before the first major snowmelt events) is an important way to reduce the amount of pollutants that can be picked up and transported by stormwater runoff. LID techniques should also be promoted wherever possible to help manage stormwater as close to its source as possible. Two of the overland flow areas (C and G) are worth discussing in more detail as additional stormwater BMPs may be appropriate.

Overland Flow Area C

Overland flow area C is located in the area east of M-33, north of County Highway F-28 (East Main Street) and south of Houghton Creek. Rose City Park is located within overland flow area C, which experiences overland runoff flowing primarily from south to north (from the north edge of the commercial downtown area through the park to Houghton Creek). Rose City Park would be an excellent location to install rain gardens due to the amount of overland stormwater flow this area receives and the fact that this is a well-visited and public space. Rain gardens at Rose City Park would provide functional stormwater control while also serving as an educational tool to raise awareness of stormwater management. Rain gardens also attract wildlife, are aesthetically pleasing and are a relatively inexpensive stormwater treatment option.

Overland Flow Area G

Overland flow area G is located in the industrial zone in the southeast corner of Rose City, north of Casemaster Drive and west of Beachwood Road. Visual inspection revealed a significant amount of gravel and bare soil in this overland flow area, which is a source of sediment pollution to Houghton Creek. Overland flow area G would be a good focus area for promoting LID measures and providing stormwater education and outreach material to local businesses. This could also be a good opportunity to partner with local businesses to install a rain garden or other vegetative stormwater BMP to help reduce stormwater pollution in this overland flow area. Drainage in overland flow area G is primarily north towards Houghton Creek, either as sheet flow overland or via the road ditch along Beachwood Road.

Table 5
Recommended Stormwater Control BMPs and Cost Estimates

Zone/Area	Acres	Land Use Type	Recommended BMPs	Costs
1	106.5	Residential, Commercial	Oil/grit separator Rain gardens Street sweeping, education, LID	$70,000 $1,500/garden Minimal
2	5.5	Woods, Commercial	Street sweeping, education, LID Vegetative BMPs	Minimal
3	6.6	Commercial	Street sweeping, education, LID Rain gardens	Minimal $1,500/garden
4	2.9	Woods	Eliminate outfall point Street sweeping, education, LID	$10,500 Minimal
Overland Areas A, B, D, E, F, H	Variable	Variable	Street sweeping, education, LID	Minimal
Overland Area C	44.2	Commercial, Public Park	Install rain gardens at Rose City Park	$1,500/garden
Overland Area G	28.1	Industrial	Street sweeping, education, LID Rain gardens	Minimal $1,500/garden

Costs for an oil/grit separator and rain gardens reflect materials and installation costs. Costs for eliminating the outfall for drainage zone 4 include excavation, mobilization and site restoration costs. Recommendations are based on drainage zone area, soil type, land use and amount of impervious cover, and land availability for installing structures. Non-structural BMPs such as maintenance, education and outreach, and promotion of low impact development (LID) should be implemented throughout the City of Rose City.

Appendices

Appendix A

Rose City Soils Information

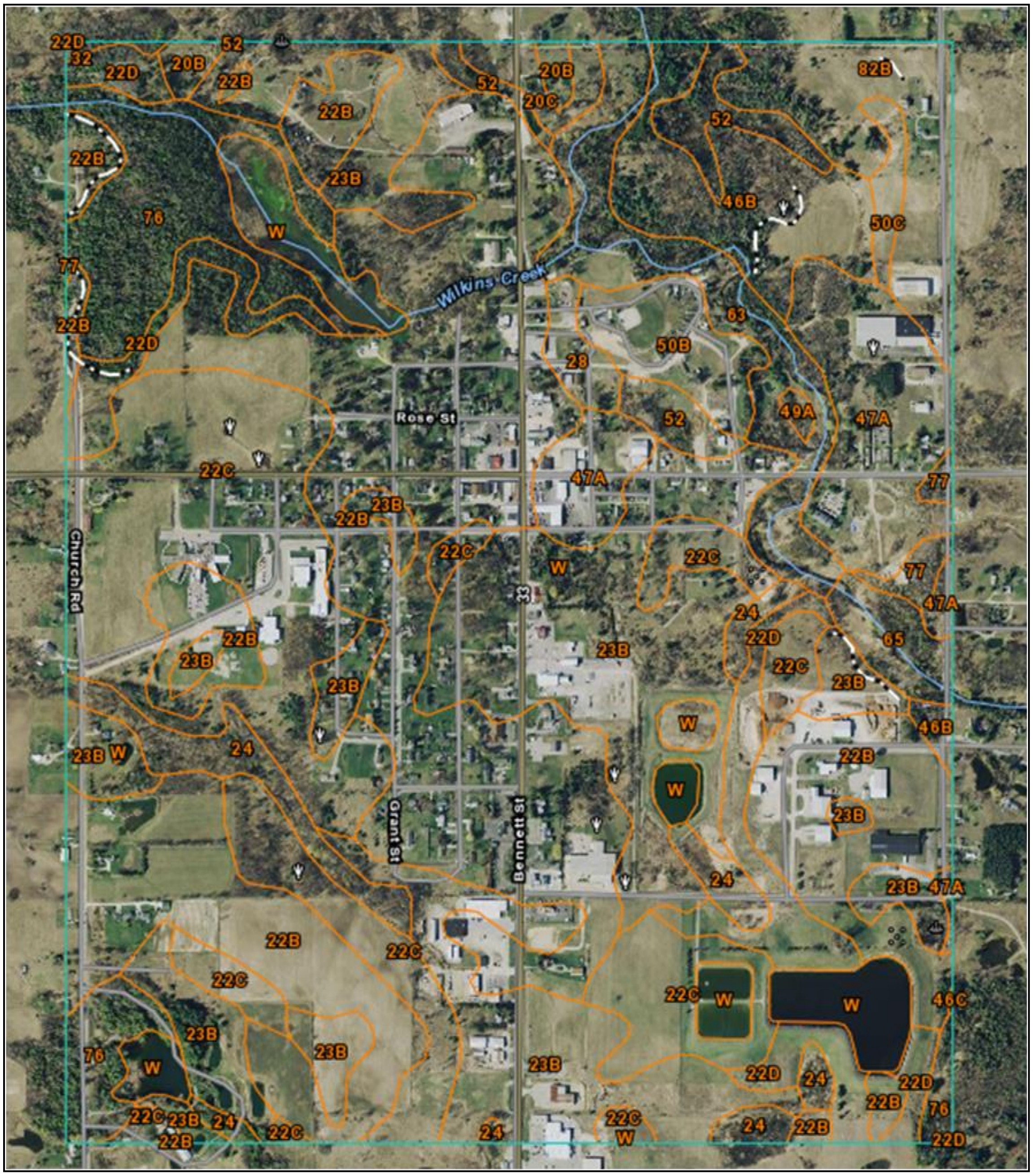


Figure A.1: Map of soil types within Rose City, MI. Map and data are from the Web Soil Survey available at http:// www.websoilsurvey.usda.nrcs.gov. Soil type names and hydrological groups of soil types shown on this map are listed in Table A.2.

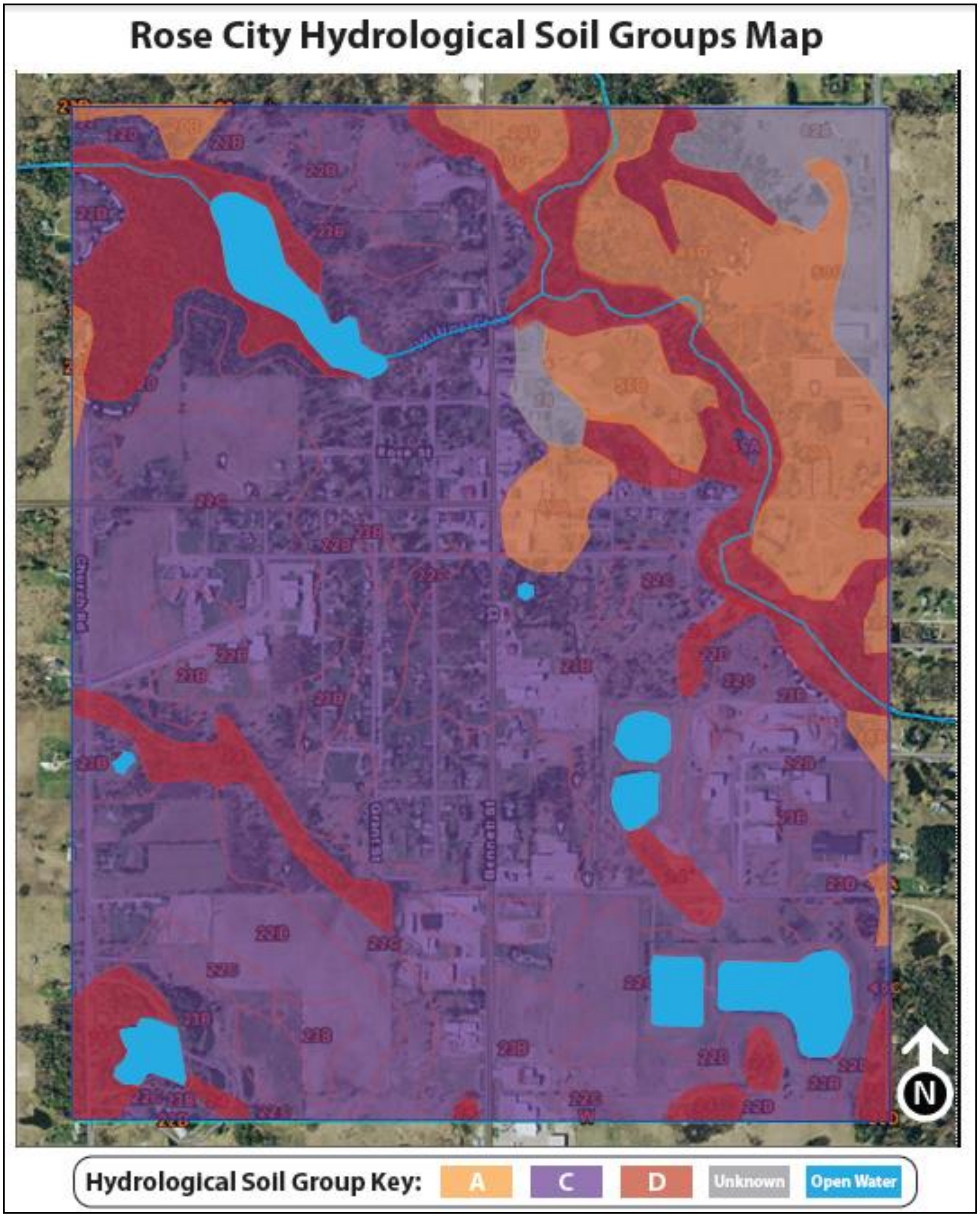


Figure A.2: Map of soil types within Rose City, MI. Map and data are from the Web Soil Survey available at http:// www.websoilsurvey.usda.nrcs.gov. Soil type names and hydrological groups of soil types shown on this map are listed in Table A.1. Colored overlays show broader hydrological soil group associations. Type A soils are well-drained; Type C and Type D soils are poorly drained. Blue areas represent natural and artificial water features.

Table A.1 Soil Types in Rose City, MI Area		
Soil Code (see Figure A.1)	**Soil Name**	**Hydrological Soil Group**
20 (B, C)	Montcalm loamy sand	A
22 (B, C, D)	Nester fine sandy loam	C
23 (B)	Kawkawlin loam	C
24	Sims loam	D
28	Udorthents loam	-
32	Angelica loam	D/B
46 (B, C)	Mancelona sand	A
47 (A)	Gladwin sand	A
49 (A)	Colonville silt loam	C
50 (B, C)	Menominee sand	A
52	Brevort mucky loamy sand	D/B
63	Evart sand	D
65	Arnheim silt loam	D
76	Lupton muck	D/A
77	Tawas mucky peat	D/A
82 (B)	Nester-Manistee complex	-
W	Open Water	NA

Appendix B
Detailed Stormwater Calculations

Table B.1 Calculations for stormwater discharge of storm sewer drainage zones.

Zone ID	Drainage area (acres)	Drainage area (sq mi)	Land Use Type	Hydrological Soil Group	Weighted Runoff Curve Number	Time of Concentration (hours)	Surface Runoff (first flush)	Surface Runoff (10-year)	Surface Runoff (25-year)	Hyrograph Peak (all storms)	First Flush CFS	10 Year CFS	25 Year CFS
1	106.5	0.16640625	25% commercial 75% residential 1/2 acre	C	83.5	0.334367562	0.00528	1.513776	1.9824362	585.8772649	0.514766412	147.583577	193.2749221
2	5.5	0.00859375	30% commercial 70% woods (fair)	C	79.3	0.110679718	0.00019	1.23628	1.6654731	1450.556478	0.002368487	15.4111212	20.76132126
3	6.6	0.0103125	commercial	C	94	0.097212986	0.13718	2.388789	2.9331571	1613.379478	2.282397529	39.7446186	48.80179752
4	2.9	0.00453125	woods (good)	A	30	0.110679718	0.90579	0.1219	0.0510978	1450.556478	5.953607347	0.80122901	0.335857388

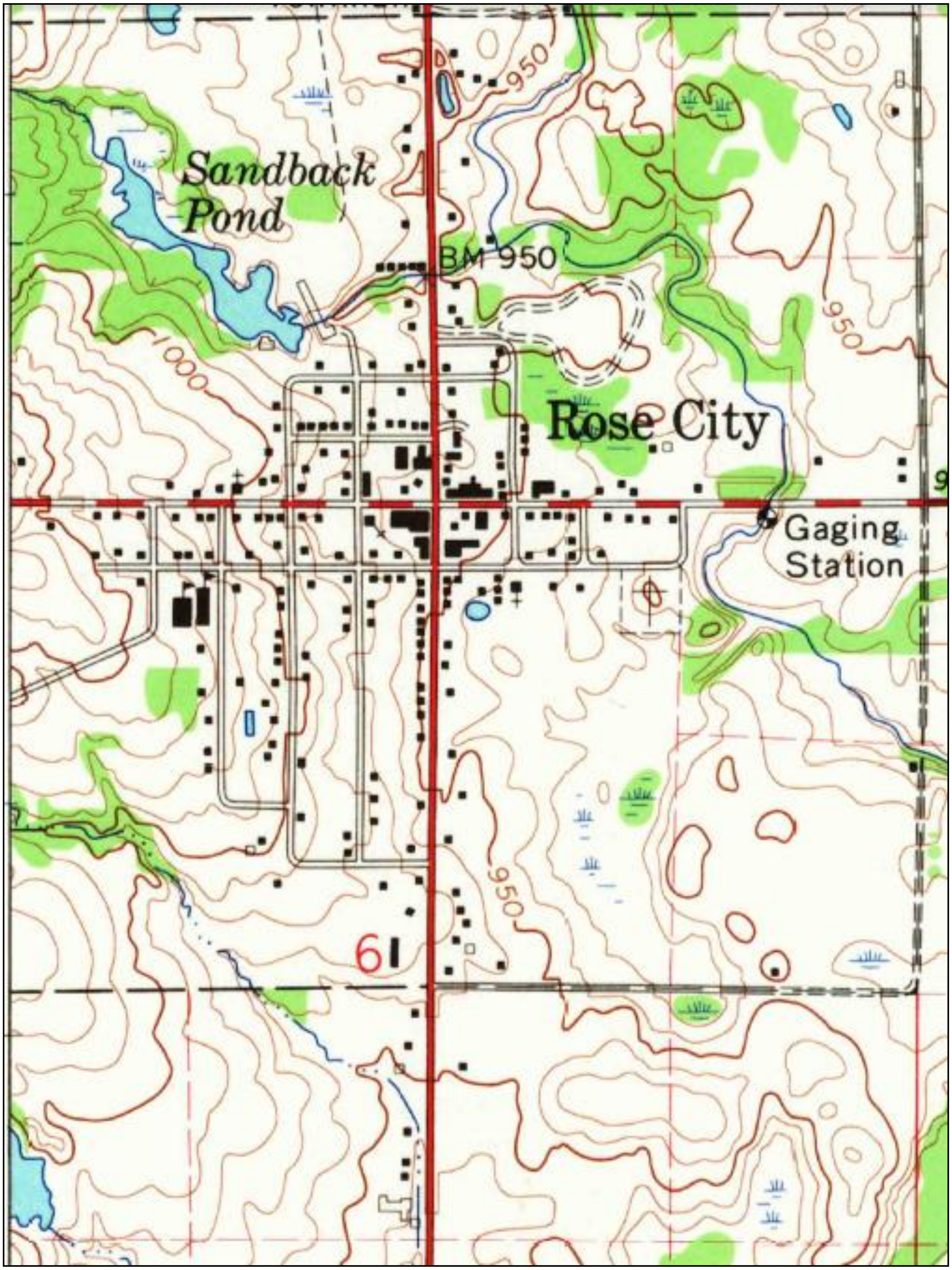
Time of Concentration calculations

Zone	Sheet flow distance (feet)	Small waterway flow distance (feet)	Rise/Run	Slope	Sheet Velocity (feet/sec)	Small waterway velocity (feet/sec)	Sheet Flow Travel time (minutes)	Small Waterway Travel time	Total Travel Time (Tc) minutes
1	200	3500	90/3700	0.024	0.0743613	0.325330601	1.084435337	18.9776184	20.06205373
2	200	1000	25/1000	0.025	0.0758947	0.332039154	1.106797181	5.53398591	6.640783086
3	200	950	20/950	0.021	0.0695586	0.304318912	1.014396372	4.81838277	5.83277914
4	200	1000	25/1000	0.025	0.0758947	0.332039154	1.106797181	5.53398591	6.640783086

Table B.2 Calculations for pollutant loadings of storm sewer drainage zones. Calculations are based on Schueler's Simple Method. Impervious cover percentages are weighted based on land cover type.

							Pollutant Concentrations (from table in Schueler 1987)			Annual Pollutant Loads			
Zone	Area (acres)	Land Use Type	Annual Rainfall (inches)	Weighted % imperviousness	Runoff Coefficient	Annual Runoff (inches)	TSS (mg/l)	P (mg/l)	N (mg/l)	TSS (lbs)	P (lbs)	N (lbs)	Total annual pollutant load per acre
1	106.5	25% Commercial 75% Residential ½ acre	29.5	43.75	0.450000	11.95	93.75	0.35	2.15	26964.8	100.6686	618.3928	259.942375
2	5.5	30% Commercial 70% Woods (low residential)	29.5	32.5	0.330000	8.76	95	0.34	2.14	1034.425	3.702151	23.30178	192.9870048
3	6.6	Commercial	29.5	85	0.800000	21.24	75	0.2	2	2376.119	6.336317	63.36317	370.578528
4	2.9	Woods (low residential)	29.5	10	0.140000	3.72	100	0.4	2.2	243.8088	0.975235	5.363794	86.257872
TOTALS	**121.5**									**30619.15**	**111.6823**	**710.4215**	

Appendix C
USGS Topographic Map – Rose City, MI



Appendix D
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