BARRIERS TO LOW IMPACT DEVELOPMENT IN THE CITY CODE OF SPRINGFIELD, MISSOURI

A Masters Thesis

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In Partial Fulfillment

Of the Requirements for the Degree

Master of Natural and Applied Science

By

Carrie Lamb

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BARRIERS TO LOW IMPACT DEVELOPMENT IN THE CITY CODE OF SPRINGFIELD, MISSOURI

Department of Geography, Geology, and Planning

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Master of Natural and Applied Science

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ABSTRACT

Stormwater runoff from urban areas is one of the major contributors to the impairment of the nation's waters. It mobilizes and transports a variety of pollutants into surface waters. In addition to degrading water quality, urban runoff also has geomorphic and hydrologic impacts on streams and is linked to declines in the health of aquatic communities. Low impact development (LID) is a land development approach that has been shown to be effective in minimizing these impacts by maintaining pre-development hydrology and water quality. Stormwater design criteria and techniques based on LID are increasingly recommended in federal and state guidance and have become required in some areas of the country. Local development codes can act as barriers to LID, such as codes that result in excess impervious cover or don't authorize and provide standards for LID practices. LID is on the rise but not yet mandated or in widespread use in Springfield, Missouri. The City of Springfield is under federal and state MS4 permit mandates to address the water quality impacts of urban runoff, including a proposed requirement to address LID code barriers. This thesis provides a review of Springfield's codes to identify LID barriers. Recommended code changes include narrower residential street widths, parking code changes, and authorizing the dual use of required landscape areas for stormwater management. These recommendations are intended to assist the City in making locally-appropriate code changes to remove LID barriers and support its more widespread use for water quality protection and improvement.

KEYWORDS: stormwater, urban runoff, low impact development, code barriers, MS4

This abstract is approved as to form and content

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CHAPTER 1: INTRODUCTION

The process of urbanization drastically changes the natural hydrologic cycle in a watershed (Federal Interagency Stream Restoration Working Group, 1998; National Research Council (NRC), 2008). Urbanization converts natural vegetation to impervious surfaces and compacted lawns, resulting in less infiltration and evapotranspiration of rainfall and more runoff (Figure 1). Stormwater runoff refers to water from a precipitation event that reaches a downstream waterbody shortly after the storm event via surface flow or shallow subsurface flow (NRC, 2008). In an urban environment, the increased volume of runoff from impervious surfaces is also delivered to the receiving waterbody more rapidly than in a natural environment due to the installation of storm sewers and artificial channels that increase the density of the drainage network (Figure 2).

Urban-related hydrologic changes have primary and secondary impacts. Primary impacts include increased frequency and magnitude of flooding, and decreased health of aquatic communities caused by altered stream flows (Center for Watershed Protection (CWP), 2003; Walsh et al., 2005). Secondary impacts include geomorphic changes and degraded water quality. The increased volume and velocity of runoff causes channel erosion and widening that can threaten properties and structures (Figure 3). Geomorphic changes also contribute to the decline of aquatic communities due to habitat degradation (CWP, 2003; Walsh et al., 2005). Activities and products associated with urbanization such as automobile use, construction, and lawn chemicals result in pollutants in the environment. Urban runoff mobilizes and transports pollutants, including heavy metals, hydrocarbons, sediment, and bacteria from the urban environment into receiving waters

(United States Environmental Protection Agency (USEPA), 1983; CWP, 2003; NRC, 2008). Degraded water quality from urban runoff has been linked to declines in the health of aquatic communities and can also impact recreational and other designated uses of receiving waters (CWP, 2003; Walsh et al., 2005; NRC, 2008, USEPA, 2012a).

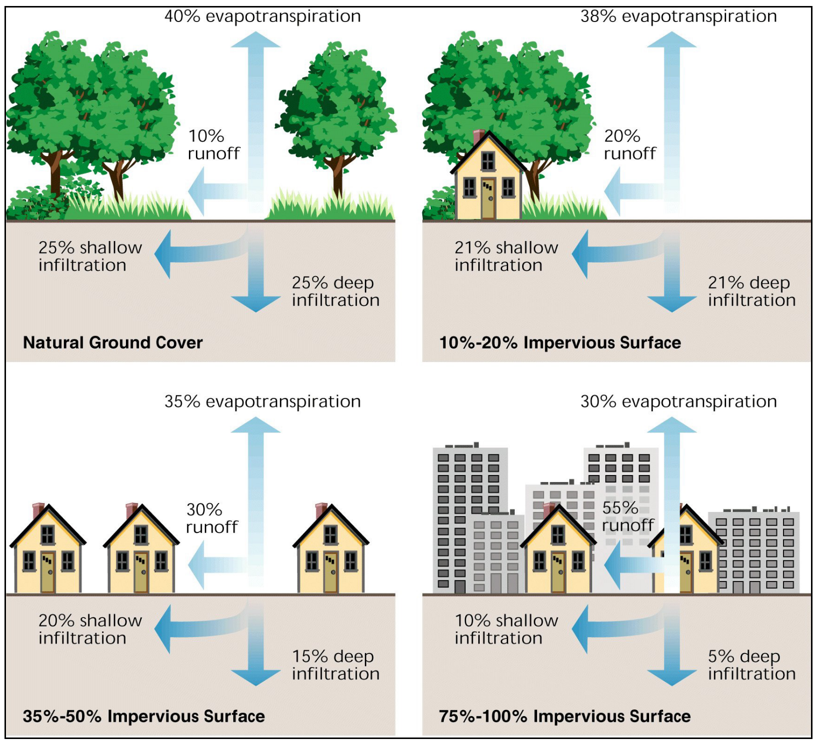

Figure 1. Impacts of urbanization on the hydrologic cycle. As vegetation is replaced by impervious surfaces, evapotranspiration and infiltration of rainfall is reduced, resulting in increased runoff (Federal Interagency Stream Restoration Working Group, 1998).

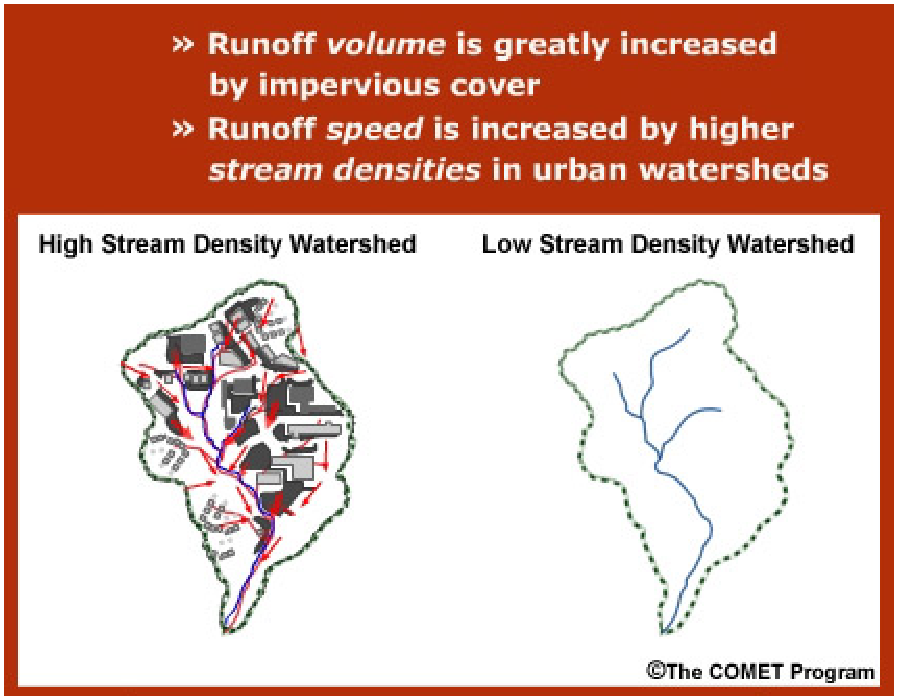

Figure 2. Effect of urban drainage density on hydrology. The installation of storm sewers and artificial channels in an urban area increases the density of the drainage network as compared to the system of natural channels and streams that existed prior to development. This dense drainage network carries runoff downstream more rapidly (COMET® Program, 2014).

Figure 3. Channel erosion and widening in Fassnight Creek in Springfield.

Stormwater runoff from urban areas is one of the major contributors to the impairment of the nation's inland and coastal waterbodies for both human uses and aquatic health (NRC, 2008; USEPA, 2012a). The impacts of urban runoff on the nation's waterbodies are growing as approximately 800,000 acres are developed in the U.S. each year (USEPA, 2013a). As these impacts have become more understood, regulation of urban runoff has increased and its management has evolved. The need to manage urban runoff in a way that minimizes its impacts requires changes to the traditional land development and stormwater design approaches that have dominated the urban environment. Approaches such as Low Impact Development (LID) that seek to minimize impervious cover and more closely mimic the natural hydrologic cycle are on the rise, but can face many barriers to widespread implementation (NRC, 2008). Local codes, which govern many aspects of land development and stormwater design, can be one of these barriers. They may contain street standards and parking lot ratios that result in unnecessarily large expanses of impervious cover. They may prohibit beneficial stormwater management practices such as roadside swales or rainwater harvesting. Codes may also be silent on whether such practices are allowed, creating regulatory risk for developers who may desire to use them.

Municipalities across the country are required under the federal Clean Water Act (CWA) to address the impacts of urban runoff on the nation's waters. In most states, including Missouri, the state environmental regulatory agency is delegated the authority by USEPA to administer these federal mandates through the issuance of Municipal Separate Storm Sewer System (MS4) permits. Identifying and addressing barriers to LID in local development codes is an important step that communities are taking as part of their overall efforts to comply with MS4 permit requirements and achieve more sustainable development practices in their communities. The City of Springfield, Missouri (City) has been regulated under a MS4 permit since 2002. This permit is currently being revised and reissued and is likely to contain a requirement that the City address barriers to LID in its development codes. The purpose of this thesis is to review the City's codes to identify barriers to LID and opportunities to encourage its use. Recommendations are provided to assist the City in beginning the process of making locally-appropriate code changes to facilitate more widespread implementation of LID as part of complying with MS4 permit requirements to protect and improve local streams and lakes.

Stormwater Management in Springfield, Missouri

Springfield, Missouri is located in Greene County in the southwest area of the state, in the region known as the Ozarks. It is the third largest city in Missouri with a population of 159,498 and an incorporated area of 82 square miles (U.S. Census Bureau, 2010). It is the anchor of a census-defined Metropolitan Statistical Area (MSA) which covers parts of five counties and has a population of 436,712 (U.S. Census Bureau, 2010). The MSA includes three other rapidly-growing suburbs with populations of 15,000-20,000 as well as many other smaller towns. As the largest city in the region, Springfield's codes and policies are influential on surrounding smaller communities.

The city is situated on the Springfield Plateau on a major watershed divide. The northernmost portion of the city drains north into the Sac River, while the majority of the city drains south into the James River, a tributary of Table Rock Lake. The area's abundance of rivers and lakes makes fishing and boating popular pastimes, and Table Rock Lake is an important driver of the regional economy. The area is also characterized by karst topography, with abundant sinkholes, springs, and caves that are susceptible to contamination by illegal dumping, sewage, and polluted runoff. Karst topography and the area's predominantly clay soils can also present unique challenges for the implementation of LID, such as low soil permeability and the risk of sinkhole collapses in areas of concentrated infiltration.

Despite being culturally and politically conservative, which often goes hand in hand with being conservative on environmental policies, Springfield has been proactive and progressive with water quality protection in a number of ways. In 1984, a local Watershed Task Force recommended the formation of the Watershed Committee of the Ozarks, a non-profit organization sponsored by the City, Greene County and City Utilities, which has now been in operation for 30 years to sustain and improve the area's water resources (Watershed Committee of the Ozarks, 2014). Three other non-profit organizations, James River Basin Partnership, Table Rock Lake Water Quality, Inc., and Ozarks Water Watch, are also focused on water quality protection in the region. Prior to being mandated to do so, the City adopted water quality treatment standards for runoff in 1999 and implemented improved nutrient removal at its Southwest Wastewater Treatment Plant in 2001 (City of Springfield, 1999; City of Springfield, 2014). Water quality protection was identified as a priority in 2004 by citizen stakeholders in the City's Vision 20/20 Strategic Plan (City of Springfield, 2004) as well as in the Field Guide 2030 Strategic Plan completed in 2013 (City of Springfield, 2013).

The City was issued a MS4 permit by the Missouri Department of Natural Resources (MDNR) in 2002. As previously mentioned, the City passed a Water Quality Protection Policy in 1999, ahead of its MS4 permit mandates, that established a water quality treatment standard for runoff from developments in certain watersheds for the purpose of drinking water supply protection (City of Springfield, 1999). Prior to the adoption of this policy, the City's stormwater management requirements focused solely on controlling downstream flooding. In 2005, the City expanded its water quality treatment standard city-wide to comply with its MS4 permit. Stormwater Control Measures (SCMs) commonly used to meet this standard include grass swales or grass buffer strips, which slow and filter runoff through vegetation, and extended detention basins designed to hold and slowly release the runoff over a 24-hour period to allow sediment and associated pollutants to settle out (Figure 4). While these SCMs improve the quality of the runoff, they provide little benefit in addressing the increased volume of runoff leaving the site.

LID techniques such as pervious pavement and rain gardens can also be used to meet the City's requirement (Figures 5 and 6). Instead of treating and releasing the runoff, they generally work by reducing the volume of runoff through infiltration and evapotranspiration. However, volume reduction is not required by the City, so use of these types of SCMs in Springfield has generally occurred only on developments seeking to achieve certification in the Leadership in Energy and Environmental Design (LEED) nationwide green building program. Springfield has several public demonstration projects of LID techniques (Figures 5 and 6) and a few LID examples (Figures 7 and 8) but widespread implementation of LID has not yet occurred.

Figure 4. Extended detention basin for water quality treatment in Springfield. Vegetation slows and filters runoff from the parking lot. The concrete outlet structure is designed to slowly release the runoff over a 24-hour period, allowing sediment and associated pollutants to settle out.

Figure 5. Pervious concrete (left) adjacent to regular concrete (right) on a public parking lot in Springfield. Pervious concrete allows rainfall to infiltrate, either into the underlying soil or into underlying gravel and perforated pipe, reducing the volume and/or velocity of runoff.

Figure 6. Rain garden at Horace Mann Elementary School in Springfield. Rain gardens are shallow planted depressions that reduce runoff through infiltration and evapotranspiration.

Figure 7. Green Circle Shopping Center, one of the first LID sites in Springfield (Green Circle Shopping Center, 2014). LID features include a pervious concrete lot, green roof, rainwater harvesting, shared parking, and tree preservation.

Figure 8. The C.W. Titus Education Facility at the Watershed Center in Springfield. It serves as a demonstration site for LID to educate the community about water quality protection (Watershed Committee of the Ozarks, 2014).

The City's MS4 permit was revised and put on public notice by MDNR in April 2013. Revision and issuance of permits is usually done every 5 years to allow the permitting authority to incorporate new or changing regulations and information. In some instances, permits are administratively continued at the 5-year mark rather than a new one being issued. This is the case with the City's permit, which was administratively continued by MDNR in 2007. The existence of older permits, along with the variation in permit language from state to state, contributes to the range in requirements and sophistication of MS4 programs across the country (NRC, 2008). Many cities in other states are on their third or fourth generation permit. These newer permits often look quite different than first generation permits, particularly the permit language for development standards because this field has evolved so rapidly over the past 20 years.

Not surprisingly, the permit language requiring the City to address the impacts of new development and redevelopment looks markedly different in its second generation proposed permit put on public notice in April 2013 than it did in its first generation permit issued in 2002. The second generation proposed permit requires that the City's stormwater design criteria address many of the site layout and design techniques used in LID, including minimizing and disconnecting impervious cover, preserving trees and natural areas, and using structural and non-structural SCMs that provide both runoff treatment and volume reduction. It also contains a requirement to identify barriers to the use of these techniques in City codes, ordinances, standards, and policies, and correct these barriers where appropriate. The issuance of this permit has been delayed in order to address comments received in response to the public notice. It is anticipated that the requirement to address LID code barriers will be in the permit whenever it is issued.

Purpose and Objectives

City codes can act as hindrances or barriers to LID by requiring larger than necessary parking lots or prohibiting the use of roadside swales or other LID techniques, but they can also act as barriers by being silent on LID principles and techniques. This increases a developer's perceived or real regulatory risk because certainty does not exist that local plan review staff will be knowledgeable of or approve LID (MacMullan and Reich, 2007). Codes also provide opportunities to encourage LID through language and standards that promote and provide incentives for its use. Removing barriers and encouraging LID are the first two steps towards having development codes and standards that result in LID. The third step is making LID mandatory (Duerksen, 2008). The purpose of this thesis is to address the first two steps by reviewing the City's development codes and standards for barriers to LID and opportunities to promote or provide incentives for its use. In some cases, suggestions for strengthening existing requirements in order to support LID are given, but in general, mandatory requirements for LID are beyond the scope of this thesis. The three objectives of this thesis are as follows.

1. Review the City's development codes and standards, and identify barriers to the use of LID as well as opportunities to encourage it.

2. Provide and discuss recommendations based on model codes and standards from the literature and other communities.

3. Describe and recommend next steps including assembly of a review team, stakeholder input, and adoption of code changes.

Benefits of Study

This thesis will assist the City in complying with the requirement proposed in its second generation MS4 permit to identify and address codes and standards that hinder the use of LID. The City is also facing requirements under its MS4 permit to address the impairments of Wilsons, Jordan, and Pearson Creeks. Under Section 303d of the CWA, states are required to list as impaired any streams that are not meeting state water quality criteria. These three streams have been listed as impaired due to low diversity of macroinvertebrates and fish that do not meet the state's biological criteria for healthy streams. A specific pollutant causing the impairments has not been identified. MDNR and USEPA are obligated under the CWA to complete a study, called a Total Maximum Daily Load (TMDL), to determine the pollutant load that the stream can handle and still meet water quality criteria, and establish an implementation plan for achieving that load. Because the pollutant causing the impairment has not been identified, USEPA issued TMDLs in 2011 that focused on reducing stormwater flow as the carrier of pollutants and the cause of hydrologic changes and physical impacts in the streams, the combination of which they determined was likely causing the decline of macroinvertebrate and fish communities (USEPA, 2011b; USEPA, 2011c).

The City challenged these TMDLs based on regulatory and technical flaws. USEPA withdrew the TMDLs in 2012 in response to this legal challenge and is currently collecting additional water quality data on these three streams in preparation for writing new TMDLs. Once new TMDLs are issued, the City will be required under its MS4 permit to develop and implement plans to comply with the TMDLs. LID has been shown to be effective at minimizing the hydrologic impacts and increased pollutant loadings from development and therefore may be one important tool in addressing pollutants or hydrologic conditions that are ultimately identified as the cause of the impairments.

On a regional scale, urban runoff from Springfield affects the James River and potentially Table Rock Lake, a major tourist attraction and recreational amenity that is an important driver of the regional economy. The James River was listed as impaired for excess nutrients in the late 1990s. Phosphorus controls on wastewater treatment plants have helped to address the problem, but nutrients are contributed to the James River by stormwater runoff as well (MDNR, 2004). LID could play an important role in the protection and improvement of these water resources. In addition to watershed protection, LID can have other benefits as well including improved air quality and wildlife habitat, and reduced cost of development as later discussed.

CHAPTER 2: URBAN HYDROLOGY AND STORMWATER MANAGEMENT

While urban stormwater management has a long history, its regulation for water quality protection has only occurred in the past couple of decades. The promulgation of federal CWA stormwater regulations in 1990 triggered a rapid evolution of urban stormwater management that is ongoing. A review of this history and evolution provides important insight about the current trend of LID and similar approaches that seek to more closely mimic natural hydrologic conditions. It also sheds light on how this rapid evolution has resulted in many communities needing to update their development codes to reflect and support this trend.

History of Urban Stormwater Management and Regulations

Management of runoff in urban areas has existed in some form or another for as long as humans have been building cities. Runoff must be managed to protect buildings from flooding, make roads safe for travel, and prevent nuisance drainage problems. The Roman Empire and other ancient civilizations had drainage systems to transport stormwater, often combined with sewage, out of the city into nearby water bodies (Pitt et al., 1999). Many U.S. cities were built with infrastructure not unlike these ancient systems, where combined sewer systems transported stormwater and wastewater in the same pipe. These systems drained directly into a stream or river where dilution was viewed as being a sufficient management method until wastewater treatment plants began to be built in the early 1900s (Pitt et al., 1999). In the late 1800s, U.S. cities began to be built with separate systems for sewage and stormwater (Pitt et al., 1999). This is the standard practice today. A sanitary sewer system is the modern day sewage system that is designed to flow to a wastewater treatment plant where the sewage is treated before being discharged to a waterbody. Separate systems to solely handle stormwater runoff are designed to drain directly into a waterbody (Figure 9). Until recently, urban stormwater management remained primarily an engineering discipline focused on efficient conveyance of stormwater for flood control and prevention of nuisance drainage problems (Reese, 2001). As the broader impacts of urban runoff have become more understood, urban stormwater management has evolved into a multi-disciplinary field with an increasingly holistic view and approach that considers water quality, aquatic and terrestrial ecology, and social benefits.

In the 1960s, the water quality impacts of urban runoff were beginning to be recognized by agencies and groups including the U.S. Public Health Service, the American Society of Civil Engineers, and the Federal Water Quality Administration (USEPA, 1983). In 1972, the federal CWA was passed, establishing the goal of making all the nation's waters fishable and swimmable. It authorized USEPA to establish the National Pollutant Discharge Elimination System (NPDES) program to regulate the discharge of pollution to the nation's waters (USEPA, 2014a). A 1973 report by the Council on Environmental Quality concluded that urban runoff needed to be addressed in order to achieve the CWA goals (USEPA, 1983). However, so much was still unknown about it and the task of regulating it was so daunting, that USEPA chose to exempt it from regulation, focusing exclusively on municipal and industrial wastewater discharges throughout the 1970s and early 1980s (USEPA, 1983; NRC, 2008).

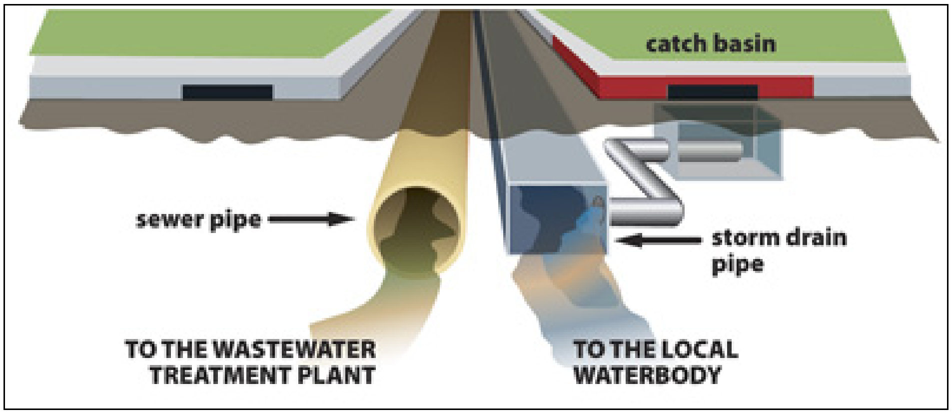

Figure 9. Separate sewer and stormwater systems (City of Columbia, Missouri, 2014).

In 1978, USEPA launched the Nationwide Urban Runoff Program (NURP), a large-scale study to further address the gap in knowledge about the water quality impacts of urban runoff. The 1983 NURP report found that urban runoff contains a variety of pollutants and concluded that concentrations of heavy metals are of primary concern, with concentrations of bacteria, nutrients, sediment, and oxygen-demanding substances also being a concern in some areas (USEPA, 1983). Based on the NURP report and other studies, 1987 amendments to the CWA expanded the NPDES permitting program to regulate urban runoff. This first phase of federal stormwater regulations (referred to as Phase 1 of the NPDES Stormwater Program) was promulgated in 1990 and required municipalities with a population of 100,000 or greater to obtain and comply with a permit to discharge stormwater into waterbodies. As previously mentioned, these permits are called Municipal Separate Storm Sewer System (MS4) permits. The City of Springfield is regulated under Phase 1 of the program but was not issued a permit until 2002 due to delayed implementation of the Phase 1 rule by MDNR. A second phase (referred to as Phase II) of these regulations was promulgated in 1999, expanding this requirement to include municipalities with a population of 10,000 or greater and smaller municipalities located in census-defined urbanized areas (USEPA, 2014b). Most states are delegated the authority to issue MS4 permits on USEPA's behalf and each state has some flexibility to write their permits differently (USEPA, 2010). Thus, although the federal regulations specify that permits contain certain broad requirements, the specifics of those requirements vary from state to state.

One of the requirements of all MS4 permits is a program to address the impacts of runoff from new development and redevelopment (USEPA, 2005). This requires that municipalities implement and enforce stormwater design criteria and standards that developers must meet. Criteria for redevelopment are generally less stringent because space constraints or other site conditions may make it difficult for redevelopments to meet the same criteria as a new development (USEPA, 1999; USEPA, 2010). Stormwater design criteria are met through the use of SCMs, also commonly referred to as best management practices (BMPs). Use of the term SCM appears to be on the rise nationally; therefore, SCM is used in this thesis. SCMs reduce or treat runoff, and can be structural or nonstructural (NRC, 2008). There are many types of structural SCMs. As previously discussed, extended detention basins (Figure 4) are a type of structural SCM that is commonly used to provide water quality treatment. As urban stormwater management has evolved towards LID, structural SCMs such as pervious pavement (Figure 5), and rain gardens (Figure 6) are becoming more common because they help to more closely mimic the natural hydrologic cycle. Nonstructural SCMs are practices that prevent (rather than reduce or treat) runoff and/or pollution. They are an important component of the LID approach and include designing developments in a way that minimizes impervious cover and preserves trees and natural vegetation (NRC, 2008).

The use of both structural and nonstructural SCMs may be influenced and even prohibited by local codes.

The Phase I federal stormwater rule did not specify or provide guidance on specific stormwater design criteria for new developments and redevelopments. The Phase II rule recommended, but did not require, that Phase II MS4 communities have design criteria that requires maintaining the pre-development hydrology of a site (USEPA, 1999; USEPA, 2010). Maintaining pre-development hydrology addresses the full range of impacts previously discussed - hydrologic, geomorphic, and water quality (NRC, 2008). The primary measurements used in evaluating the hydrologic changes caused by development are runoff volume, peak runoff rate, flow duration, lag time, and flow frequency (Prince George's County, Maryland (PGCM), 1999). Runoff volume is the amount of runoff from a given storm event, and is commonly meaured in cubic feet. Peak runoff is the highest rate of runoff during a given storm, commonly measured in cubic feet per second. Flow duration is the length of time that runoff occurs from a given storm event. These three metrics are illustrated in Figure 10. Lag time is the time between a given point in the storm and a given point on the runoff hydrograph, such as the time between the heaviest rainfall and the peak runoff (Figures 11-12). Flow frequency is the frequency that a given flow occurs, and is increased by urbanization (PGCM, 1999).

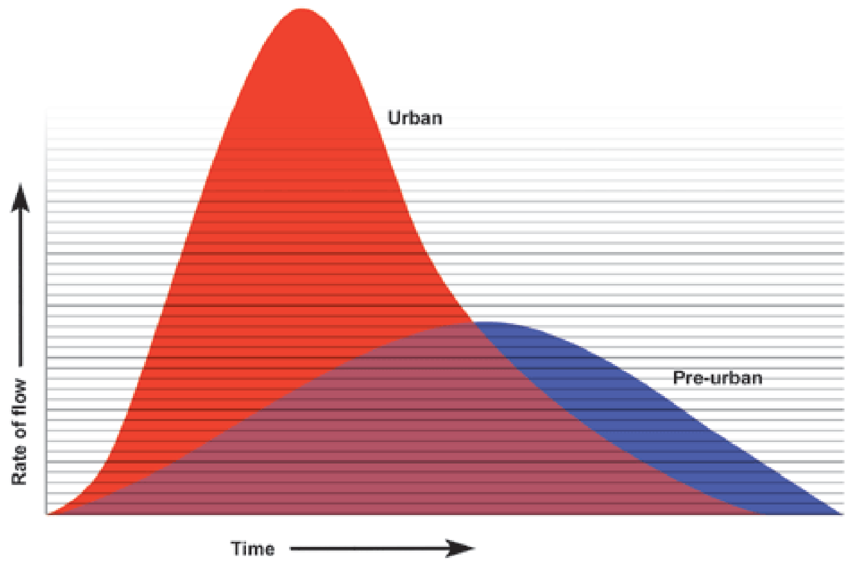

Figure 10. Effects of urbanization on the runoff hydrograph. Urbanization increases peak flow (height of curve) and runoff volume (area under the curve). Flow duration (width of base of curve) is decreased because runoff travels faster (Environment Canada, 2013).

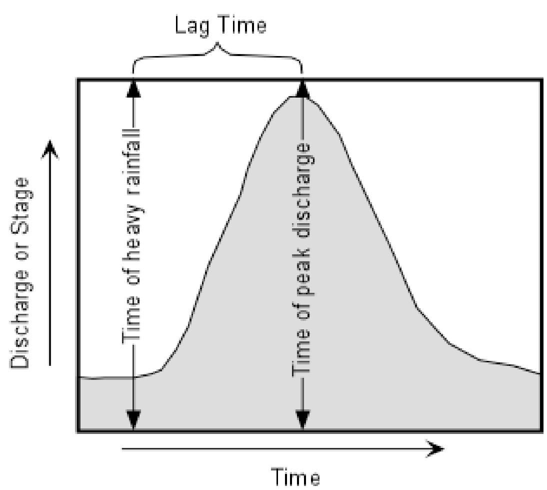

Figure 11. Runoff lag time. Lag time is the time between a given point in a storm event and a given point on the runoff hydrograph. In this figure, lag time is shown as the time between heavy rainfall and peak discharge (Nelson, 2012).

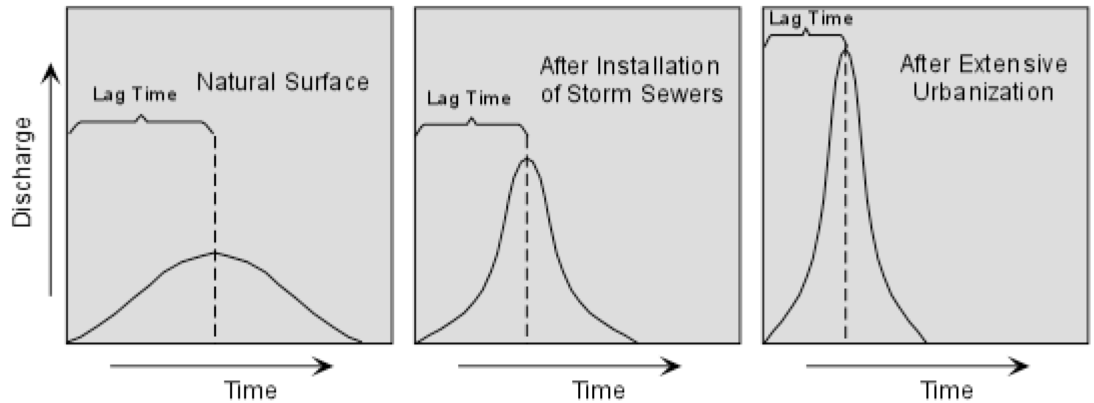

Figure 12. Decreasing lag time caused by installation of storm sewers and extensive urbanization (Nelson, 2012).

Despite the lack of a federal mandate, several states that have been delegated the authority by USEPA to issue MS4 permits have enacted criteria that require new developments, and in some cases redevelopments, to maintain pre-development hydrology to some degree (Tetra Tech, 2008; USEPA, 2011a). Other states have included similar criteria or language in MS4 permits, such as Missouri's requirement in its Phase II MS4 permits that new developments "reasonably mimic pre-construction runoff conditions." Such language guides communities towards addressing the full range of urban runoff impacts but leaves room for flexibility and interpretation as to how that is translated into local design criteria. Indeed, most MS4 permits issued across the country do not specify design criteria at all, leaving it up to the discretion of the municipality (USEPA, 2010).

Design criteria addressing peak runoff and water quality are the most common, and criteria addressing runoff volume are less common (NRC, 2008). This reflects the evolution of knowledge about stormwater impacts and the resulting evolution of urban stormwater management described by Reese (2001). Peak runoff criteria were commonly implemented by municipalities prior to MS4 regulations because it was recognized that the practice of collecting and conveying stormwater off site as quickly as possible was causing downstream flooding. Detention basins to reduce peak flows became widespread. However, detention basins were typically not designed to address the increased volume of runoff caused by development (NRC, 2008).

Next, it was recognized that urban runoff was a source of pollution. The language of the CWA and NPDES program focused on controlling these pollution discharges. Thus, state and local criteria focused on runoff treatment to improve water quality. Runoff treatment has commonly been achieved by designing detention basins so that they provide for both peak flow control and water quality treatment (NRC, 2008). The water quality treatment is often provided through a technique referred to as "extended detention" in which the outlet structure is designed to detain and slowly release the runoff from a given storm event, usually the 1-year storm, over a 24-hour period to allow pollutants to settle out (Figure 4). This method also helps to reduce bank erosion in the stream by reducing runoff velocities (Minnesota Pollution Control Agency, 2014).

In the past decade, state and local stormwater design criteria have evolved towards the goal of maintaining pre-development hydrology by seeking to match more hydrologic characteristics than just the pre-development peak flow. Such criteria generally require that the post-development runoff volume closely resembles the pre-development runoff volume (USEPA, 2011a). This can be accomplished through infiltration, evapotranspiration, or reuse (i.e. rainwater harvesting) of runoff on the development site. Some agencies such as the State of Washington have also recently enacted criteria for flow duration. Although the extended detention basin method discussed above provides some benefit in reducing channel erosion, the changed duration of flows caused by development and conventional stormwater management approaches can have significant geomorphic impacts on streams as well (Minnesota Pollution Control Agency, 2014).

In 2006, USEPA commissioned the NRC to assess the state of the science of urban stormwater management and the NPDES stormwater program and to provide recommendations for how to improve both in order to achieve the goal of addressing the impacts of urban runoff on the nation's waters. A major recommendation of the NRC (2008) is that development standards should focus on maintaining predevelopment hydrology through a holistic approach that considers nonstructural SCMs (e.g. designing to minimize impervious cover, preserving natural vegetation) to prevent runoff and pollution at its source first, followed by structural SCMs (e.g. rain gardens, pervious pavement) to reduce and treat runoff, an approach that is consistent with LID. Based on the recommendations in the NRC report and spurred by a legal challenge by the Chesapeake Bay Foundation (2013), USEPA issued a federal register in December 2009 announcing its plans to initiate a national stormwater rulemaking. A primary goal of the rulemaking was to establish more specific requirements and criteria for controlling runoff from new development and redevelopment in a way that will preserve or mimic the predevelopment hydrology of the site (USEPA, 2009). USEPA delayed the rulemaking several times, reportedly because of the many technical, economic, and political complexities of developing such a rule (National Association of Clean Water Agencies, 2013). In March 2014, USEPA announced that it was indefinitely deferring the rulemaking, and instead will focus on helping communities address their stormwater issues (National Association of Clean Water Agencies, 2014). Although a rulemaking is no longer on the horizon, the NRC findings were consistent with LID principles and techniques and provide support for its more widespread use, whether on a voluntary or mandatory basis.

Overview of Low Impact Development

There are several land development and site/stormwater design strategies that help to minimize the full spectrum of urban runoff impacts by preserving or mimicing pre-development hydrology. They include LID, better site design, green infrastructure, and conservation development. USEPA (2012b) provides a good overview of the similarities and differences between these strategies. LID is probably the most well-known and is a terminology in widespread use in the field of urban stormwater management. It is a land development approach pioneered by Prince George's County, Maryland, who published an LID design manual in 1999 with support from USEPA. LID has been shown to be effective at achieving its goal of maintaining pre-development hydrology as compared to traditional development (Hood et al., 2007; Deitz and Clausen, 2008; Damodaram et al., 2010). Another related term that is sometimes used interchangeably with LID is green infrastructure. It has recently come into widespread use in the field of urban stormwater management largely due to USEPA and partner agencies' efforts to support and promote its use (USEPA, 2012b; USEPA, 2013b). While LID is a development strategy, green infrastructure refers to the natural systems and structural SCMs that are used in LID at a site or neighborhood scale but can also refer to these systems and practices at a larger municipal or watershed scale (USEPA, 2013b). For simplicity, LID is the terminology used in this thesis; however, guidance on other similar strategies in addition to LID, such as the manual pubished by Center for Watershed Protection (1998) on better site design, provided the basis for many of the recommendations in this thesis.

The fundamental idea behind LID is that stormwater is a resource to be managed as close to its source as possible (PGCM, 1999). Impervious cover is minimized, trees and natural vegetation are preserved as much as possible, and SCMs are used to manage stormwater on-site through infiltration, evapotranspiration, and reuse. The basic steps of the LID design process are site planning, hydrologic analysis, and selection of SCMs (PGCM, 1999). These are the same basic steps used in traditional development design, but the methods and objectives are very different.

The purpose of site planning in the context of LID is to minimize the impact of development on the site's hydrology. Natural features that affect hydrology are identified and preserved as much as possible, including streams, floodplains, wetlands, woods, and high permeability soils. These natural systems provide free hydrologic services and their replacement with engineered systems can increase the infrastructure and maintenance costs of the development (Shockey Consulting Services, LLC et al., 2012). Streets and lots are laid out to accommodate the existing drainage patterns and minimize disturbance and impervious cover. This is different than traditional development site planning, in which streets and lots are often laid out first, followed by layout of the drainage system to accommodate placement of streets and lots, with an area reserved at the low end of the site for a detention basin (Shockey Consulting Services, LLC et al., 2012).

After site planning has been done to minimize hydrologic impacts, a hydrologic analysis reveals the impacts (e.g. increase in runoff volumes and peak flow) that could not be avoided with site planning so that SCMs can be selected and designed to mitigate these impacts. Two principles of SCM design in LID are to use open channel conveyance rather than pipes as much as possible and to design the SCMs to be small and distributed throughout the site to manage rainwater where it falls (PGCM, 1999). Projects such as the City of Seattle's 110th Street Cascade Project which added drainage swales to existing streets have been shown to be very effective at reducing peak flows and runoff volume (NRC, 2008). An example of the use of small, distributed practices on a site is the use of landscape islands in parking lots for bioretention (Figure 13), an SCM shown to be effective at reducing runoff volumes and removing pollutants (CWP, 2007; NRC, 2008).

Figure 13. Bioretention in a parking lot island. This is an example of a small, distributed SCM used in LID design (University of Maryland, 2014).

In addition to being an effective stormwater management approach, LID has other environmental, social, and economic benefits. Environmental benefits include groundwater recharge, reduced urban heat island effect, reduced energy use (with green roofs and shade trees near buildings), improved air quality, and wildlife habitat (MacMullan and Reich, 2007; USEPA, 2007a). Widespread implementation can also be effective in helping communities adapt to increased runoff from climate change (Roseen, 2011). The preservation of natural areas, the increased use of trees and vegetation, and SCM designs (green roofs, planters, cisterns) that provide opportunities for architectural interest can all contribute to improved aesthetics, recreational amenities, and increased property values and marketability (MacMullan and Reich, 2007; USEPA, 2007a). Public education and involvement in water quality issues is an important part of mitigating urban runoff impacts through individual behavior change and support of municipal stormwater programs. LID increases public awareness and involvement because SCMs are more visible than conventional underground conveyance, and are often located on individual lots (USEPA, 2007a).

LID can also be more economical than conventional stormwater management approaches. A summary of 12 case study developments by USEPA found that LID resulted in a savings of 15-80% on capital costs for 11 of the 12 developments compared to the costs of conventional site layout and stormwater management (USEPA, 2007a). The costs savings were primarily in the form of reduced paving and stormwater infrastructure, with some savings in site grading costs as well. Similar savings were found with an LID development in Greene County, right outside of Springfield. The County partnered with Habitat for Humanity on the design of a residential subdivision to demonstrate LID (Figure 14) and found it resulted in an estimated 20% savings over conventional design (Greene County Resource Management, personal communication, February 2014). In addition to reduced development costs, LID can also provide an economic benefit to developers by increasing the number of buildable lots (USEPA, 2007a). Economic benefits extend to the public sector as well. Managing stormwater onsite with LID reduces the size requirements of downstream infrastructure and the costs associated with mitigating channel erosion and other impacts of urban runoff on downstream waterways (MacMullan and Reich, 2007).

Figure 14. Legacy Trails LID subdivision developed by Habitat for Humanity in Greene County, Missouri. Site grading was minimized. Narrow, curbless streets and shared driveways minimize impervious cover. Roadside swales with native vegetation slow and filter runoff (Greene County Resource Management, personal communication, February 2014).

USEPA, state and local governmental agencies, academic institutions, and non-profit organizations such as the Center for Watershed Protection (www.cwp.org) and the

Low Impact Development Center (www.lowimpactdevelopment.org) have published a large body of literature on LID including fact sheets, case studies, research, and design manuals in order to promote its more widespread implementation at the local level. As part of this effort, there has been much focus on understanding and overcoming the barriers to implementation of LID. There are a broad range of barriers that have been identified, including lack of knowledge and training by those designing and approving developments, perceived and real costs, lack of performance data and design standards, physical constraints (soil, geology, etc.), and public acceptance of LID designs (Earles et al., 2008; Roy et al., 2008; Woolson, 2013).

Local zoning codes, design standards, and building regulations can also act as significant barriers to the implementation of LID (NRC, 2008) and have been the subject of several publications. One of the earliest was a handbook on better site design published by CWP in 1998 that provides model codes and standards to minimize impervious cover, conserve natural areas, and allow the use of SCMs that mitigate urban runoff impacts. A worksheet is provided for communities to use in reviewing and scoring their current codes and standards (CWP, 1998). A permit writer's guide published by USEPA in 2010 recommends that states and USEPA regions that are issuing MS4 permits include a requirement for municipalities to review their codes to identify provisions that contribute to unnecessary impervious cover (USEPA, 2010). Similar requirements to review codes for barriers to LID have shown up in MS4 permits around the country, including permits issued by USEPA Region 1 for New Hampshire and North Coastal Massachusetts (USEPA, 2011a), permits issued by the states of

Georgia, Oregon and Washington, and the City of Springfield's proposed permit put on public notice by MDNR in 2013.

Common LID Code Barriers

Site planning and selection of SCMs are the two steps in the LID design process that can be most hindered by local code barriers. Minimizing disturbance and impervious cover during site planning can be hindered by codes for minimum lot dimensions, parking requirements, and street widths that affect the footprint of the disturbed area and drive the amount of impervious cover on a site (CWP, 1998). Codes that prohibit or don't expressly authorize the use of pervious pavement also pose a barrier to minimizing impervious cover. Pervious pavement is an effective way to provide necessary paved surfaces while minimizing their hydrologic impacts (USEPA, 2000). Codes can act as barriers when selecting and designing SCMs. For example, street design standards may hinder the ability to incorporate drainage swales along roads. The use of parking lot islands as SCMs (Figure 13) may be hindered by parking lot design standards that dictate the location of landscape islands, require continuous curbing around the islands, or simply fail to authorize or provide design standards for them. An important way to encourage LID is to explicitly address its use in city codes and standards. If LID is not explicitly addressed, developers may perceive that the City is unfamiliar with it and that variances may be needed to approve it. These represent regulatory risks that will discourage a developer from proposing LID (MacMullan and Reich, 2007). Common barriers that hinder the selection and design of SCMs are listed in Table 1.

Table 1. Common code barriers to low impact development (CWP, 1998; Puget Sound Partnership (PSP), 2005, 2006a, 2009).

LID Objective	Code Barriers
Minimize impervious cover	Street width standard Cul-de-sac dimensions Parking lot stall dimensions Parking lot ratios (# of spaces required) Restrictive shared parking allowances Pervious materials prohibited or not explicitly authorized Lot frontage width and setback standards
Preserve natural vegetation and trees	Weak tree preservation requirements Lack of incentives for conservation/open space development
On-site SCMs to reduce runoff volume	Integration of SCMs into required landscape areas not explicitly authorized Lack of standards for SCMs
Open channel conveyance	Preference or requirement for piped conveyance and lack of standards for open channels in the right-of-way

A review of other communities' experiences with identifying and addressing code barriers can shed light on the usefulness of the exercise and provide lessons learned. A major regional effort to address code barriers to LID was undertaken in Washington state by the Puget Sound Partnership. In 2005-2006, technical assistance was provided to 19 local governments by identifying code barriers and providing new or revised code language. A 2008 survey of these 19 communities found that 9 of the 19 had adopted some or all of the recommended changes. Those that had not adopted the changes responded that the exercise had been extremely helpful. In addition to lack of available staff resources, they cited conflicting opinions between stakeholder departments (fire, streets, etc.) and difficulty of merging the recommendations into the exisiting codes and regulations as two reasons why the code changes had not yet been adopted (CH2MHILL, 2008). Based on their experience assisting a total of 36 communities from 2005-2009, the Puget Sound Partnership published a guidebook in 2012 to help local governments integrate LID into their codes. This guidebook provides information that may be helpful to the City as they move forward with the process of addressing the code barriers identified in this thesis.

CHAPTER 3: CODE REVIEW AND RESULTS

Development is shaped by a complex mix of regulations governing the zoning, subdivision, grading, and landscaping of property, the design and arrangement of streets, sidewalks, driveways, and parking lots, the placement of utilities, the design and construction of buildings, and the management of stormwater and wastewater. These regulations are usually contained in a complex mix of documents including zoning and subdivision codes, building codes, street design standards, grading and landscape ordinances, and stormwater design manuals (CWP, 1998). All of these regulations may contain LID barriers and opportunities.

Code Review Process

The first step in the process of reviewing Springfield's development codes for LID barriers and opportunities was to locate the relevant codes. The City's website was accessed to identify and obtain codes, standards, and guidelines governing zoning, subdivisions, site infrastructure, landscaping, land disturbance, and stormwater management. These codes, standards, and guidelines are contained in the following documents reviewed for this thesis:

- Zoning Ordinance (June 2013)
- Subdivision Regulations (December 13, 2010)
- Revised Multi-Family Development Location and Design Guidelines (March 23, 2009)
- Design Standards for Public Improvements (July 1, 2013)
- Standard Drawing Details for Public Improvements (July 1, 2013)

- Arboriculture Design Guidelines (January 1997)
- Stormwater Design Criteria Manual (Draft dated May 7, 2007 except Chapter 10 Water Quality dated October 24, 2012)
- City Code Chapter 96 Stormwater

The above documents were reviewed and compared to model ordinances, code review literature, and examples from other communities to develop a list of recommendations. The City's comprehensive plan and strategic plans guide its codes and standards, and thus provided important information and perspective in the code review process as well. The plan documents referenced in this code review process include the City's Vision 20/20 Comprehensive Plan chapters from the late 1990s/early 2000s, the 2004 Vision 20/20 Strategic Plan, and the Field Guide 2030 Strategic Plan that was adopted in 2013.

In addition to the codes and standards identified above, building codes can also contain LID barriers and opportunities. A local example was the lack of standards for rainwater harvesting systems in the City's building code. Although the lack of standards did not prohibit rainwater harvesting, it acted as a barrier by creating regulatory risk for developers and City plan review staff. The City addressed this barrier in March 2012 by adopting rainwater harvesting standards as part of its commercial plumbing code and residential building code (General Ordinances 5979 and 5981). In general though, because building codes primarily govern building construction, they have less potential to affect LID than zoning and infrastructure standards (NRC, 2008). Building codes were therefore not reviewed for this thesis.

A summary of the major identified barriers and opportunities is provided in Table 5 in Chapter 4, and a full list is contained in the Appendix. The codes and standards that were reviewed are grouped into the following categories for discussion:

- stormwater design and land disturbance
- lot and subdivision design
- street, sidewalk, and driveway standards
- parking requirements
- landscaping and tree requirements

While some of the codes compared favorably to the literature, barriers and opportunities exist in all categories. Barriers include outdated language reflecting past stormwater management approaches that are contradictory to LID, silence on whether certain LID techniques are authorized, and standards that work against minimizing disturbance and impervious cover. Identified opportunities include areas where code language and guidance can encourage LID, and incentives can be given such as density bonuses for conservation development. In some cases, ways to strengthen existing requirements in order to support LID were identified as well.

Stormwater Design and Land Disturbance

In 2007, the City consolidated, updated, and expanded its stormwater design criteria and standards into a document titled the Stormwater Design Criteria Manual. This document contains criteria and standards for all aspects of stormwater design including calculation of runoff, detention for flood control, infrastructure sizing, open channel design, and water quality protection to address the requirements of its MS4 permit. A draft version of the manual has been in use since 2007. Initially, its finalization was intentionally delayed to allow the development community to use it and provide feedback. In the meantime, the City recognized that additional revisions would be needed due to the rapid evolution of stormwater management towards LID and the increasing mandates of its MS4 permit (Wagner, 2011). The City has recently been working on revisions to the water quality chapter. A 2012 draft of that chapter, along with the remainder of the 2007 draft manual were reviewed for LID barriers and opportunities.

Overall, the draft Stormwater Design Criteria Manual was found to be very supportive of LID. It encourages and discusses LID principles and techniques, including site planning that minimizes disturbance and impervious cover, and preserves the natural hydrology, topography, and features of the site. Developments are required to meet standards for flood control (peak runoff) and water quality treatment. As previously discussed, these standards are the most common in municipalities around the country, with standards requiring runoff volume reduction (or maintaining predevelopment hydrology) being less common (NRC, 2008).

Although LID or runoff volume reduction are not currently required, they are strongly encouraged and discussed in the manual and can be used to meet the water quality treatment requirement. As previously stated, recommending mandatory requirements is beyond the scope of this thesis, and will be driven by the City's future MS4 permit requirements. The manual provides design criteria and guidance for a range of SCMs, including those typically used in LID such as bioretention, vegetated swales, and pervious pavement. The manual also references other publications for additional guidance on LID. One barrier that was identified by Wagner (2011) is that standards for determining how LID practices affect the calculation of runoff should be included in Chapter 5 of the manual. Including such standards would reduce regulatory risk for LID designers and aid in the plan review process. A related barrier is outdated language in the City's Subdivision Regulations that requires efficient conveyance of stormwater offsite and prevention of ponding. This language should be revised consistent with LID principles and the Stormwater Design Criteria Manual.

A primary principle of LID design is the use of vegetated channels rather than pipes to convey stormwater (PGCM, 1999). The manual supports this principle and devotes an entire chapter to open channel design. However, the Subdivision Regulations contain a provision regarding open channel drainage that needs to be updated to support and encourage open channels consistent with the manual. The current provision implies that open channels will only be allowed if the cost of pipes is prohibitive. It states that easements for open channels should usually be along the rear of lots, but may be alongside lot lines. It requires additional right-of-way for open channels along the street. This provision should be updated so that the stated preference is for vegetated open channels rather than enclosed systems. Language should be added supporting the orientation of streets, lots, and open channel easements to take into account the existing topography and hydrology of the site, and allow sufficient access for maintenance. Open channels in the street right-of-way should be encouraged in the Subdivision Regulations and reference made to a street design standard with open channels that should be developed and adopted as part of the Design Standards for Public Improvements.

Another aspect of the City's stormwater program is the regulation of land disturbance. Land disturbance requirements are found in City Code Chapter 96 Article III. There are two aspects of land disturbance that are important in LID – minimizing the amount of disturbance and controlling the discharge of sediment resulting from disturbance. A technique that is used to minimize disturbance is called site fingerprinting, which refers to disturbing only the areas necessary for the construction of roads and buildings (CWP, 1998). Federal and state guidance encourages minimizing disturbance, but in reality it is a practice that is rarely used locally or in other areas of the country (USEPA, 2007b; NRC, 2008; MDNR et al., 2011). The discharge of sediment from construction sites is regulated by the NPDES stormwater program. Regulation occurs at the state level by state agencies with delegated authority for the NPDES program. It also commonly occurs at the local level as a requirement of MS4 permits. This is the case in Springfield, where it is regulated by both MDNR and the City. The City's land disturbance code is consistent with the federal and state focus on controlling the discharge of sediment. The City may want to consider revisions to the land disturbance code in the future to require or provide incentives for minimizing disturbance (CWP, 1998; PGCM, 1999; Horsley Witten Group (HWG), Inc. and Millar, 2011).

The City's Subdivision Regulations contain a grading provision that could act as a barrier to minimizing disturbance. It requires the subdivider to grade lots so that they are usable and suitable for building. The subdivider of a property may be a different person or entity than the developer. A developer who wants to minimize disturbance as part of an LID approach may be limited in doing so by previous disturbance of the site by the subdivider. Grading by the subdivider may also result in graded lots that are not developed for years and which could have remained in their natural state. This section of the Subdivision Regulations should be revised so that the preference is for grading by the subdivider only as needed for installation of required public improvements (streets, sidewalks, etc.). The City could also consider ways to encourage or provide incentives for the practice of minimizing disturbance, such as training opportunities and reduced permit fees. The City should also ensure that incentives for minimizing disturbance are provided in the standards for calculating runoff in Chapter 5 of the Stormwater Design Criteria Manual. Strengthening the City's land disturbance ordinance to require site fingerprinting or other provisions that would further minimize the impacts of land disturbance could be a future consideration (HWG, Inc. and Millar, 2011).

Lot and Subdivision Design

The layout, size, and dimensions of lots are important considerations in LID design because of their potential to affect the amount of disturbance and impervious cover. The Subdivision Regulations currently include a general statement that lot size, dimensions, shape, and orientation shall be appropriate for the location of the subdivision and for the type of development and use contemplated. While this language does not preclude a lot layout consistent with LID principles, it does not explicitly encourage it. This section could be revised so that the stated preference is for layout of lots that preserves and works with the natural topography and hydrology of the site, minimizes impervious cover, and preserves hydrologically important site features (New Hampshire Department of Environmental Services (NHDES), 2008). The size of lots determines how compact a development can be. Compact development results in less impervious cover on a watershed scale (Figure 15) (USEPA, 2006a). The City's minimum lot size of 6,000 square ft and allowable density of 7 dwelling units/acre is at the low end of typical minimum lot sizes and density, allowing relatively compact development (CWP, 1998).

The regulated components of lot dimensions include lot frontage (or width), and yard setbacks. The front yard setback dictates the minimum distance of the building from the street. It affects impervious cover by determining driveway length (Figure 16). Lot frontage is the minimum required lot width at the street. Along with lot width and side yard setback, it affects the length of street needed to serve each lot (Figure 16), thereby influencing the amount of impervious cover in the development. The recommendations provided by CWP (1998) for lot frontage and setbacks are based on a ½ acre lot size, making them difficult to compare to the City's requirements, which are applicable to all lot sizes. But in general, the City's requirements appear to be in line with the recommendations, as shown in Table 2. Therefore, the City's minimum lot dimensions are not a barrier to LID. However, language could be added encouraging setbacks and frontages to be minimized to reduce impervious cover created by driveways and streets.

Another aspect of lot design dictated in the code is the maximum coverage allowed. Maximum building coverage and impervious area are less commonly addressed in the literature, and such standards vary widely across communities. The City may want to assess how the current coverage standards for various zoning uses would affect a LID development in Springfield. A comparison of building and impervious coverage standards is provided by the Puget Sound Partnership (2006b). An "effective impervious area" standard that takes into account the impact of the impervious area on the hydrology of the site could also be considered (PSP, 2012).

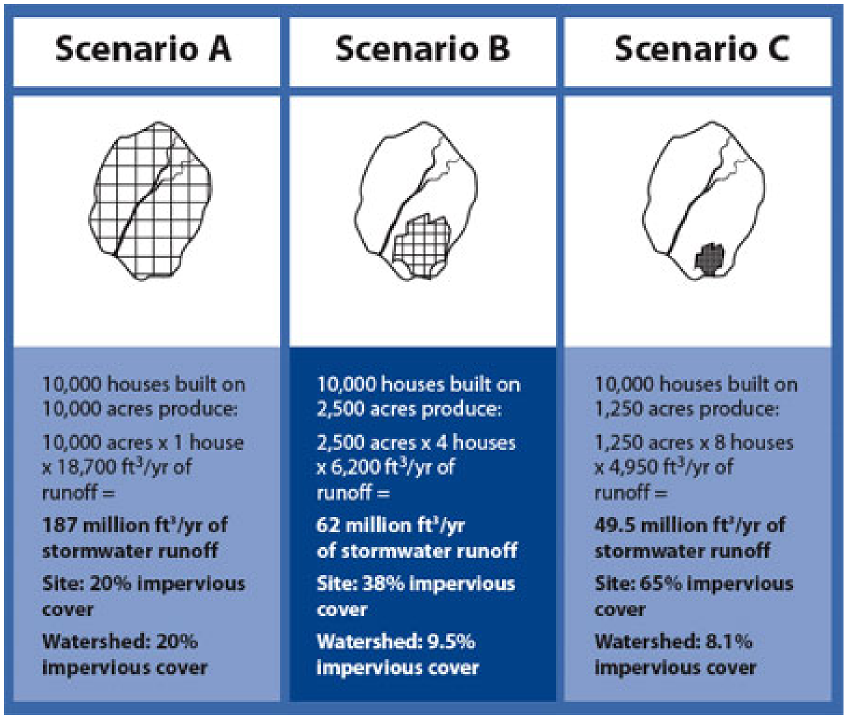

Figure 15. Effects of development density on site and watershed impervious cover (USEPA, 2006a). Less dense development (Scenario A) produces less impervious cover at the site scale than denser development (Scenarios B and C). However, at a watershed scale, Scenario A produces more impervious cover than Scenarios B and C, primarily due to the increase in street length needed to serve development that is spread out.

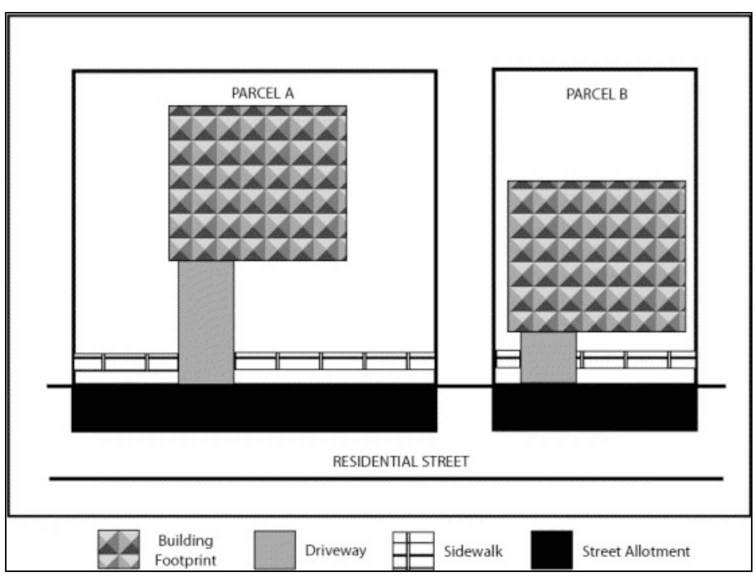

Figure 16. Effects of lot frontages and setbacks on impervious cover (Stone, 2004). The larger frontage and setback of Parcel A increases the length of the driveway and the length of street needed to serve the lot.

Table 2. Comparison of Springfield's yard setbacks and lot frontage codes with recommended codes in Center for Watershed Protection (1998).

Code	CWP (1998)	City of Springfield, MO
Minimum front yard setback	20 ft or less	15 ft (garages 20 ft) for a local street
Minimum rear yard setback	25 ft or less	10% of lot depth with min of 10 ft and no more than 20 ft being required.
Minimum side yard setback	8 ft or less	5 ft
Lot frontage	Less than 80 ft	No requirement for lot frontage; minimum lot width is 50 ft at the building line.

Cluster development, open space development, and conservation development are terms often used interchangeably to refer to a development where flexibility in lot size and dimensions allow lots to be concentrated in one portion of a site, with the remainder of the site preserved as open space. This type of development can help achieve the LID goal of maintaining predevelopment hydrology by reducing impervious cover and preserving the hydrologic functions of natural areas. Depending on the lot size of the conventional zoning, open space development can reduce impervious cover by 7-58% (CWP, 1998). A defining characteristic of conservation development is that a site analysis is performed to determine what portion of a site is most ecologically important to protect (HWG, Inc and Millar, 2011). This is not necessarily the case with cluster or open space development. Cluster development codes may also differ from both conservation and open space development by allowing common areas with some developed uses instead of open space. This is the case with the City's Cluster

Development code. It allows a reduction in lot size, along with flexibility in the setbacks and lot coverage, in exchange for an equivalent amount of land in open space or common area. The common area may contain schools, community buildings, historic buildings or sites, or other uses.

The City should consider renaming and revising its Cluster Development code, or adopting a separate conservation development code consistent with the following provisions. A model code is provided by Horsley Witten Group, Inc. (2007b).

- Remove the provision allowing common area with developed uses in place of open space.
- Require a site analysis to determine the most ecologically important area of the site to protect.
- Require a minimum percentage of the site be preserved to qualify as a conservation development.
- Provide modest density bonuses as an incentive (this was recommended in the City's Vision 20/20 Comprehensive Plan)
- Ensure that the review and permitting requirements are no more stringent than conventional development.

One factor that may inhibit the practicality of a conservation development code in Springfield is that the base zoning already allows relatively dense development (7 dwelling units/acre). In high-density residential zones, the flexibility, benefits, and space available for implementing conservation development may make it impractical (CWP, 1998).

In addition to a conservation development code, there are other growth management strategies and zoning tools that can help achieve LID development objectives and promote more sustainable development overall (USEPA, 2004; NHDES, 2008). Lot size averaging can achieve a similar result as conservation development but can be used for minor subdivisions as well (NHDES, 2008). It specifies an average minimum size for all of the lots in a subdivision rather than a minimum size that each individual lot must meet. This flexibility can be helpful in preserving existing topography and ecologically important areas of a site. Feature-based density is a zoning tool that varies the allowable density based on features or factors that are important to the community. For example, it can be used to limit development density on parcels with steep slopes or sensitive natural resources (NHDES, 2008). Another tool that the City could consider is infill development zoning. Infill development refers to the development of underutilized or vacant land in an existing developed area (USEPA, 2004). In the context of infill development zoning, it generally refers to larger parcels and not small individual lots in an existing subdivision. Infill development can help to minimize the amount of impervious cover on a watershed scale because it occurs in areas already served by roads and sidewalks, and results in a more compact city. Zoning can be used to encourage infill development by providing flexibility and incentives (USEPA, 2004; NHDES, 2008).

Street, Sidewalk, and Driveway Standards

Streets are a major contributor to the total amount of impervious cover in cities, typically constituting 40-50% of impervious cover in residential areas and possibly less in commercial areas where parking lots and large rooftops may be bigger contributors (USEPA, 2013c). In addition to their impervious cover hydrologic impacts, streets also impact water quality. Pollutants including heavy metals, oil, and phosphorus accumulate on streets and get washed into nearby waterbodies when it rains (Pitt and Amy, 1973;

Waschbusch et al., 1999). Both the hydrologic and water quality impacts of streets can be minimized by city codes and standards. The impervious cover of streets is determined by their width, length, and pattern, factors that are directly dictated or indirectly influenced by codes. The hydrologic and water quality impacts of streets can be mitigated by codes that allow curbless streets, roadside swales, and other designs to disconnect the impervious cover and allow treatment and infiltration of runoff.

Street width is a design concern of multiple city departments because of how it impacts clearing and stockpiling snow, access for emergency and service vehicles including fire trucks, trash trucks and school buses, and traffic and pedestrian flow and safety issues (CWP, 1998). Street width was found to be the biggest contributor to residential impervious cover in Madison, Wisconsin, accounting for 31% (Stone, 2004). Guidance and discussion on narrowing street widths to reduce impervious cover generally focuses on residential streets because their low traffic volumes and speed make it possible to narrow the street without sacrificing traffic flow and safety.

The City's Design Standards for Public Improvements (Design Standards) requires that residential streets have a pavement width of 27 ft with parking allowed on one side. Guidelines and standards for narrow residential street widths with parking on one side vary across the country from 20 to 28 ft (CWP, 1998; Water Environment Research Foundation, 2013). A state-wide stakeholder group in Oregon studied the issue of residential street widths and came to a consensus on a model standard of 24 ft for streets with parking on one side (Neighborhood Streets Project Stakeholders, 2000). The City's Vision 20/20 Comprehensive Plan also recommended a 24 ft width for residential streets with parking on one side. It is not known whether this has been considered.

Although Springfield's current standard falls within the range of widths considered to be a "narrow street" in the literature, it is at the top end of that range and consideration should be given to reducing it. In addition to reducing impervious cover, narrower streets also have the added benefits of improved safety and livability (Neighborhood Streets Project Stakeholders, 2000). A hierarchy of residential streets with different standards for width and parking based on average daily traffic counts or the number of dwelling units served could also be considered. This could be accomplished as part of the City's Field Guide 2030 Strategic Plan objective to create design guidelines for all types of streets that address aesthetics and safety for all users.

The required width of the street right-of-way can also be an LID barrier. Wide right-of-way widths require more land clearing and tree removal, and inhibit a compact design, while narrow right-of-way width requirements can restrict the ability to have swales or other SCMs in the right-of-way (CWP, 1998). The Design Standards specify a 50 ft right-of-way for residential streets. The width of a right-of-way is dependent on street width and sidewalk requirements and location but in general a right-of-way width less than 45 ft is considered to meet the definition of a narrow standard (CWP, 1998). A reduction in the City's current right-of-way width standard should be considered in conjunction with consideration of a narrower street width standard. Consideration should also be given to a right-of-way width standard that allows flexibility for the incorporation of SCMs in the right-of-way.

As is common in many communities, curb and gutter is required on new streets in Springfield. Curb and gutter has become the standard in urbanized areas in place of curbless roads and ditches more commonly found in rural areas because it prevents crumbling of the road edge and eliminates the maintenance and problems associated with roadside ditches (CWP, 1998). However, the use of flush curbs and properly engineered swales or SCMs can address these problems while allowing treatment and infiltration of stormwater runoff (CWP, 1998; HWG, Inc. and Millar, 2011). A pilot project in Seattle, Washington achieved a 99% reduction in the volume of street runoff by modifying an existing neighborhood with reduced street widths, flush curbs, swales, and tree and shrub plantings (Figure 17) (Seattle Public Utilities, 2013). The City should consider adopting a street design standard with no curb, flush curbs, or curb cuts to facilitate the use of swales or other SCMs in the street right-of-way. The City has used curb cuts and SCMs in the street right-of-way on a few projects (Figure 18) that could provide lessons learned in developing a standard.

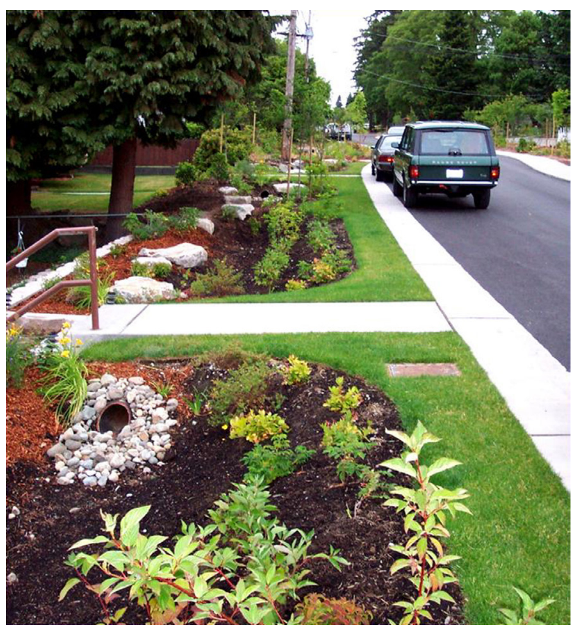

Figure 17. Seattle's Street Edge Alternatives Project. LID features include narrow streets, flush curbs, and swales in the right-of-way (Tackett, 2009).

Figure 18. Street curb cut and rain garden on Weller Avenue in Springfield. The curb cut allows the street runoff to flow into the rain garden.

Another way to minimize the hydrologic impacts of streets is to allow the use of pervious materials. The City has experimented with the use of pervious concrete as part of streetscape projects on Walnut Street (Figure 19) and Park Central West. Pervious asphalt and pervious paver block systems are also options. Pervious pavement is most suitable for low speed, low traffic volume streets or parking lanes where excessive sediment and debris that could clog the pavement is not anticipated (Better Streets San Francisco, 2010). The City should consider revising the street design standards to allow the use of pervious pavement for streets and alleys as appropriate (Chicago Department of Transportation, 2013). The current standard for alleys is a curbless design with an inverted crown so that it drains to the middle. This could be revised to also allow alley designs that drain into vegetated swales or other SCMs on one or both sides if adequate space is provided.

Figure 19. Pervious concrete on Walnut Street in Springfield.

Street length and network also determine impervious cover. Street length is primarily a result of lot frontages discussed earlier. Two common types of street networks are grid networks where streets are laid out in a grid pattern and dendritic networks characterized by cul-de-sacs. Grid networks result in less impervious cover than dendritic networks because of the additional impervious cover added by cul-de-sacs (Stone, 2004). The City's Zoning Ordinance is an opportunity to recognize the impact of street length and network on impervious cover and encourage efficient lot layouts and grid networks. An indirect way to discourage dendritic networks is to reduce the allowable block size or establish an intersection density that favors grid networks. It may not be desirable to prohibit the use of cul-de-sacs altogether, but the City can minimize their impact by reducing the right-of-way and pavement radius as described in the

Appendix, and adopting design standards for alternative turnarounds such as "hammerheads" that result in less impervious cover. Cul-de-sac islands should also be allowed and encouraged for use as SCMs or to provide tree canopy over the adjacent pavement.

Sidewalks are also a contributor to impervious cover whose impacts can be minimized through codes and standards. Sidewalk requirements that affect impervious cover and LID design include width, material, placement, and whether they are required on one or both sides of the street. The City's Subdivision Regulations require sidewalks on one side of residential streets where the density is five dwelling units or less per net acre and on cul-de sacs fronted by six or less dwelling units. Sidewalks are required on both sides of residential streets in higher densities. In non-residential areas, the sidewalk requirement is dependent on the zoning and street classification. Requiring sidewalks on only one side of the street in residential areas balances the need to reduce impervious cover while still providing for pedestrian safety and walkability (CWP, 1998). The City could consider raising the density threshold for when sidewalks are required on both sides of the street in residential areas, such as the maximum density for single-family residential districts of seven dwelling units/acre.

The City recently increased the required sidewalk width from 4 ft to 5 ft based on a recommendation in its Vision 20/20 Comprehensive Plan to allow two adults to walk comfortably side by side. Although 4 ft is recommended in the literature to reduce impervious cover (CWP, 1998), it may be desirable to maintain the 5 ft standard based on this community preference. Another option for reducing impervious cover is to allow sidewalks to be constructed of pervious materials. Pervious concrete is an option that meets Americans with Disabilities Act standards and has been successfully used in other areas (Hansen, 2011; City of Olympia, Washington, 2013). The current City standard for placement of sidewalks also presents an opportunity for encouraging LID design. The code specifies that sidewalks shall normally be placed 1-foot inside the right-of-way line with a pervious strip (usually grass) between the sidewalk and street. Although this wording does not preclude the incorporation of an SCM in this pervious strip, this is an opportunity where the code could be revised to explicity allow it in order to reduce regulatory risk.

Driveways account for approximately 20% of impervious cover in typical residential subdivisions (CWP, 1998; Stone, 2004). Driveway design characteristics that affect impervious cover are length, width, material, and alternative configurations such as shared and two-track driveways. The length of driveways is affected by front yard setbacks discussed earlier in this paper. Driveway width and material are the two design components that are commonly specified in local codes. The code governs the driveway approach, which is the portion of the driveway in the right-of-way. The current code specifies a minimum driveway width of 12 ft and a maximum of 22 ft at the right-of-way line. This is wider than necessary for one and two-lane driveways. A 9 ft width is recommended for one-lane driveways and 18 ft for two-lane driveways (CWP, 1998). Shared driveway approaches are allowed in the current code if a perpetual mutual access agreement approved by the City Attorney is filed. The City could encourage the use of shared driveway approaches (Figure 20) to reduce impervious cover by providing design standards that address common concerns regarding access and parking (HWG, Inc. and

Millar, 2011). A sample agreement could also be prepared that would address concerns over maintenance and be approved by the City Attorney.

Driveways are a good application for pervious materials due to their low speed, low volume use. In particular, there is a wide selection of pervious pavers that provide an attractive option for homeowners. A two-track design with conventional or pervious pavement tire tracks and a pervious median is a more economical option (Figure 21). The current City code requires that driveway approaches be constructed of concrete. Because the driveway approach forms part of the sidewalk, it may not be desirable to allow all types of pervious pavement, but pervious concrete could be considered. Although the code does not appear to govern the portion of the driveway outside of the right-of-way, it could be specified that other types of pervious pavement as well as two-track designs outside of the right-of-way are not governed by the code and are encouraged to reduce impervious cover.

Figure 20. Shared driveway with pervious strip in the middle in Seattle, Washington (Arazan, 2008).

Figure 21. Two-track driveway with vegetation that reduces impervious cover (McCrone, 2013).

Parking Requirements

Parking requirements can be broken down into three main categories, all of which effect the amount of runoff from a development site: parking ratios, parking codes, and parking lot design. Parking ratio refers to the number of parking spaces specified for a particular use. Minimum required parking spaces are specified for each category of use in the City's Zoning Regulations Sec. 5-1500. A primary recommendation in the literature is that communities should also set maximum parking ratios to prevent developers from building parking lots that are larger than needed and to provide a range which allows the developer some discretion in selecting a parking ratio best suited to the specific conditions of the development (CWP, 1998; HWG, Inc., 2007). Parking ratios are commonly based on guidance published by the Institute of Transportation Engineers (1995) which lists peak demand parking for various land uses based on a compilation of observational studies. Parking ratios based on the most parking spaces a land use will ever need rather than on its everyday needs results in an inefficent sizing of parking lots that has financial and environmental costs (USEPA, 2006b; HWG, Inc., 2007a). Large expanses of parking lot that are infrequently used (i.e. "Christmas parking") could have been preserved as green space or accommodated additional commercial space, resulting in more tax revenue and a more compact community.

CWP (1998) provides recommended maximum parking ratios and typical conventional minimum parking ratios for some common land uses that are useful in evaluating the City's current minimum ratios (Table 3). The City's minimum parking ratios are similar to the recommended maximums for office buildings and shopping centers and are at the low end of typical minimum ratios for convenience stores and medical/dental offices. Specific recommendations for other land uses could not be located; however, the LEED program provides an option for obtaining credit for reducing the environmental impacts of parking infrastructure that could be used as a rule of thumb for assessing the City's parking ratios for other land uses. In the absence of a local minimum parking ratio, LEED allows a parking ratio of 25% less than the ratio listed in the 2003 version of the Institute of Traffic Engineers Parking Generation Study (U.S. Green Building Council, 2013).

In addition to evaluating current parking ratios for all land uses in comparison to LEED or other standards, the City should consider revising the parking ratios to be maximums or providing a maximum and a minimum. Communities such as the Town of Exeter, Rhode Island simply changed their minimum parking ratios to maximums and have had very few requests for variances for more parking than the maximum (HWG, Inc. and Millar, 2011). A parking ratio range would allow the developer to select the most appropriate parking ratio based on experience and local factors including location, demographics, development density of the area, and neighboring uses, factors which can affect the parking demand and opportunities for shared and off-site parking (USEPA, 2006b). Another option for consideration is to require that any parking area above the minimum ratio be constructed using pervious pavement or other LID techniques such as bioretention parking lot islands.

Table 3. Comparison of Springfield's parking ratios for common zoning uses with Center for Watershed Protection (1998).

	CWP (1998)		City of Springfield, MO	
Land Use	Minimum[1]	Maximum[1]	Minimum[1]	Maximum
Office building		Recommended: 3	2.86	None
Shopping center		Recommended: 4.5	4.5 (per 1000 ft^2 gross leasable area)	
Convenience store	Typical conventional: 2-10 (common example is 3.3)		2.85	
Medical/dental office	Typical conventional: 4.5-10 (common example is 5.7)		4	

[1] Number of parking spots per 1000 ft^2 of gross floor area, unless otherwise noted.

There are other parking codes in addition to parking ratios that affect the size of parking lots. These include provisions for shared parking and reductions in automobile parking spaces if bicycle parking is provided or if the development is in close proximity to mass transit. The City's Zoning Ordinance does allow up to 10% of the required automobile parking to be substituted with bicycle parking at a rate of two bicycle spaces for each required automobile space. There are no reductions for proximity to mass transit. However, the rate of usage of the City's public bus system may not support such reductions. Shared parking refers to an arrangement where adjacent properties, structures or uses with different primary hours of operation share parking so that the overall number of parking spaces needed is reduced. The City's Zoning Ordinance refers to this as "Cooperative Parking". A Cooperative Parking Plan is required that provides a parking demand schedule showing the hours of operation and projected parking demand for each building, structure, or use during each hour of each day. This plan is signed by all parties having a legal interest in the development and recorded in the county land records.

There are two types of Cooperative Parking situations – off-site and on-site. Off-site refers to shared parking between two adjacent sites. It is allowed if they have different principal operating hours, but only up to 50% of the required parking spaces can be provided by the other site. Off-site Cooperative Parking is not a matter of right; it is subject to discretionary approval by the City. A local example is the arrangement between the Green Circle Shopping Center on Republic Road and the adjacent church. The shopping center and the church have different primary hours of operation, allowing additional parking for shopping center patrons in the church parking lot. On-site Cooperative Parking refers to a development with multiple uses, such as a strip mall with offices, restaurants, and shops, that will be sharing the same parking lot. Instead of providing the number of parking spaces required for each use, parking spaces can be shared to meet the requirements if the uses have different principal operating hours. Otherwise, the number of spaces required is the sum of the required parking for each use.

While the code provides the provisions and process for shared parking, the City should consider code revisions that would encourage its more widespread use. One simple way to encourage it is to change the code language to state that shared parking is preferred where possible, and making it a matter of right if the requirements are met rather than a matter of City discretion. The City could also consider amending the code to allow a greater percentage of parking to be provided off-site and allow some reduction in on-site shared parking even if principal operating hours of the uses overlap. For example, a Massachusetts model bylaw allows 100% of parking to be provided off-site and allows up to a 30% reduction in on-site parking for mixed-use developments even if the principal operating hours of the uses overlap (HWG, Inc., 2007a).

Other potential code revisions to encourage shared parking include the adoption of model language for the shared parking agreement between property owners, and zoning incentives such as an increase in floor area ratio, building coverage, or height (Abeles Phillips Preiss & Shapiro, Inc., 2002). Providing or referencing acceptable methods or resources for determining parking demand for shared parking lots may also help to facilitate shared parking. The Institute of Transportation Engineers (1995) and the Urban Land Institute (Smith, 2005) have both published data that can be used in determing parking demand for shared parking lots. Other communities have gone a step further by requiring developers to evaluate and implement shared parking where possible as part of the development review and approval process (CWP, 1998; HWG, Inc., 2007a). The City may want to consider requiring a shared parking evaluation for mixed use developments owned by one entity. This may be a more palatable proposal to the development community than requiring shared parking evaluations that would include other property owners.

Parking lot design standards govern the physical dimensions, surfacing, and landscaping of parking lots. These standards can conflict with LID by resulting in unnecessarily large parking lots and prohibiting or restricting the use of LID practices to mitigate parking lot runoff. The City requires that standard parking stalls are 9 ft wide and 18.5 ft long. The recommended dimensions in the literature are 9 ft wide by 18 ft long (CWP, 1998). The City should consider reducing the required length by six inches. Allowing a percentage of the required parking spaces to have smaller dimensions for compact cars is another way to reduce the size of parking lots. The City currently allows compact spaces for employee parking lots only, with 40% of the required spaces allowed to be compact size (8 ft x 16 ft) after the first 100 standard size spaces. The literature recommends that up to 30% of parking spaces be required to have smaller dimensions for compact cars (CWP, 1998; HWG, Inc., 2007a).

The City requires that parking lots be an all-weather, hard surface and lists concrete, asphalt, and pavers as acceptable. Porous pavers are the only pervious material specifically listed as acceptable, but are prohibited in parking areas serving single-family-detached, single-family-semi-detached, duplex, townhouse, or mobile homes. The reason for this code language is unknown and likely pre-dates current knowledge on the performance of various pervious pavement materials. It does not appear to have restricted the use of various types of pervious pavement on parking lots in Springfield. There are numerous local examples of pervious concrete parking lots, as well as some porous paver and grass paver parking areas. However, the City should amend this code language to specifically allow pervious concrete and pervious pavers to be used in parking areas in all zoning districts, and adopt construction specifications for it. Pervious asphalt has been used in other areas and should also be considered. Grass pavers have been used as emergency building access lanes to meet the fire code on a few local commercial developments (Figure 22). They would also be appropriate for overflow parking that is infrequently used. The City Code could be amended to specifically allow grass pavers for these types of uses.

Figure 22. Grass pavers used for a building fire access lane in Springfield.

Landscaping and Tree Requirements

Interior and perimeter landscaping for parking lots is a common requirement of development codes. Poorly designed parking lot landscaping provides little to no aesthetic or environmental benefit (Figure 23). However, if adequately sized and designed correctly, parking lot landscaping can improve aesthetics while managing stormwater, providing shade, and reducing the urban heat island effect (Figure 24). Parking lot landscaping requirements can be inadequate to achieve these objectives and can serve as a hindrance to LID design by being overly prescriptive in the location of landscape areas and the types of vegetation (HWG, Inc., 2007a; HWG, Inc. and Millar, 2011). Review of parking lot landscaping requirements in the City's Zoning Ordinance focused on the lot size threshold and percent landscaping required and whether these requirements pose barriers to LID, either by being too inflexible or by not explicity addressing the use of required landscape areas for stormwater management.

The City's Zoning Ordinance requires that parking lots with 30 or more spaces or at least 12,000 square ft of gross area provide a minimum of 5% interior landscaping. One canopy tree or two understory trees are required per 30 spaces or 12,000 square ft. The City could consider lowering the lot size threshold to require interior landscaping on smaller lots, and increasing the amount of landscaping/trees required. Common requirements in the literature range from a threshold of 10-20 parking spaces, with 10% landscaping required (CWP, 1998; HWG, Inc. and Millar, 2011). Examples for comparison from some of Springfield's benchmark cities (City of Springfield, 2008) and others nearby are shown in Table 4.

Figure 23. Parking lot landscaping that provides little environmental or aesthetic benefits in Springfield.

Figure 24. Parking lot landscaping that provides environmental and aesthetic benefits at the Missouri Botanical Garden (Missouri Botanical Garden, 2014).

Table 4. Parking lot interior landscape requirements from Springfield's benchmark and nearby cities.

City	Lot Size Threshold	Requirement
Columbia, MO	4500 ft^2	Minimum 1 tree for every 4500 ft^2
Wichita Falls, Tx	20 parking spaces	1 landscape area of not less than 160 ft^2 per 20 parking spaces for lots with less than 100 spaces, and 1 per 10 parking spaces for lots with 100 or more spaces. Each landscape area requires 1 canopy tree or equivalent as described.
Columbia, SC	3200 ft^2	Minimum 1 tree for every 3200 ft^2
Grand Rapids, MI	25 parking spaces	Minimum 20 ft^2 of landscape area and 1 tree per parking space

The City's Zoning Ordinance provides flexibility in the location of interior landscape areas, specifying only that they be located so as to best relieve the expanse of paving. It also does not preclude the use of these areas for stormwater management by requiring continuous curbing, allowing wheel stops to be used instead. However, not explicitly addressing the use of interior landscaping for stormwater management creates regulatory risk for developers wishing to do so, and fails to encourage those who may not have considered it (Hinds and Zielinski, 2011). The City should consider adding a stated preference that interior landscaping be used for stormwater management, and provide flexibility for placement and plant selection. A standard drawing of a swale or bioretention in a parking lot island that provides some detail but still allows design flexibility would further reduce regulatory risk. Another option is to provide a separate landscape standard for LID parking lot designs that developers can choose to follow in place of the conventional landscape standards (HWG, Inc., 2007a).

Perimeter landscape areas, which are required when a parking area is within 50 ft of a public right-of-way, and bufferyards, which are required between abutting zoning districts, may also be appropriate locations for stormwater management. The current standards prescribe the number of trees and shrubs required in these areas. While these standards may not prohibit SCMs in perimeter landscape areas and bufferyards, adding language to specifically authorize them and allow flexibility in plant selection would encourage their implementation. Allowing SCMs to fulfill not only the City's stormwater requirements, but also the landscaping and bufferyard requirements, is an incentive to developers to design their sites using LID (Hinds and Zielinski, 2011).

The landscaping requirements found in the City's Zoning Ordinance are supplemented by a separate document titled Arboricultural Design Guidelines (Gross, 1997). It is presented as a descriptive interpretation of the ordinance and provides guidelines on plant species, selection, arrangement, installation, and maintenance. The City should consider updating this document to include a discussion of LID and landscape guidelines for SCMs. A good example is the landscape guide for SCMs published for the St. Louis, Missouri area (Metropolitan St. Louis Sewer District et al., 2012). It includes general and specific guidance on the landscape design, soils, and plant selection for various SCMs. It may be appropriate to include a limited discussion in the City's Arboricultural Design Guidelines with reference to this type of detailed information which could be provided in a separate document or in the City's Stormwater Design Criteria Manual. As development in Springfield evolves more towards LID over time, a future consideration may be an LID landscape ordinance that specifies requirements and guidance for preserving existing natural vegetation, minimizing turf grass, and protecting and amending soils. A model ordinance is provided by HWG, Inc. and Millar (2011).

Trees help to slow down and reduce the amount of runoff from a site by intercepting and storing rainfall, utilizing it through evapotranspiration, and improving soil infiltration (Center for Urban Forest Research, 2002). Therefore, preserving and planting trees is an important LID strategy. The City's Zoning Ordinance specifies that existing trees are to be preserved to the maximum extent practicable, and prohibits clear cutting unless its prohibition will substantially and unreasonably restrict the ability to develop the property and the development's economic viability. A credit system is also included in the ordinance so that existing trees that are protected may count towards meeting the required number of trees for bufferyards and interior and perimeter parking lot landscaping.

Despite the intent of the City's Zoning Ordinance in discouraging clear cutting and the availability of credits for tree preservation, clear cutting is the common practice in Springfield (Figure 25). Some tree replacement takes place as a result of the tree planting requirements for bufferyards and interior and perimeter parking lot landscaping, but this is probably marginal in comparison to the number of trees removed. In this case, there are no code barriers to tree preservation, but other barriers probably exist such as a lack of knowledge about the benefits of tree preservation, a lack of desire by developers and contractors to take the time to preserve trees during the design and construction process, and a perception that it will cost more to do so. An online resource called the Watershed Foresty Resource Guide provides guidance on developing effective local regulations to conserve trees during development (CWP and U.S. Forest Service, 2008).

Figure 25. Clear cutting on a development in Springfield in 2009.

In 2006, the City convened a citizen task force to provide input on multi-family development issues. The resulting guidelines published in 2009 include a tree preservation/replacement requirement. Trees 6 inches or greater in diameter must be preserved or replaced with a tree at least 2 inches in diameter for a maximum total of 7 trees per acre. If this requirement is working well for multi-family developments, the City should consider extending it to other types of development. The Vision 20/20 Comprehensive Plan called for a tree preservation requirement to protect significant wooded areas and require replacement of young trees. It also recommended that developers be required to plant street trees in residential developments. The City's new Field Guide 2030 Strategic Plan supports and builds upon these previous recommendations for an effecive tree preservation and mitigation ordinance.

CHAPTER 4: SUMMARY AND CONCLUSIONS

This thesis provides a review of Springfield's development codes and standards to identify barriers to LID and opportunities to encourage its use. While some codes and standards compare favorably to recommendations in the literature, barriers and opportunities were identified in all areas. In the category of stormwater design and land disturbance, narrative design standards in the Subdivision Regulations are outdated and inconsistent with LID design principles. These are "low-hanging fruit" that should be non-controversial to address. The primary opportunity identified in the category of lot and subdivision design is to adopt conservation development or similar zoning options and incentives that will allow and encourage developments with smaller lots in exchange for preservation of hydrologically valuable open space. There are several barriers and opportunities in the categories of street, sidewalk, and driveway standards and parking requirements. These include street width and curb design, cul-de-sac design, and parking lot ratios and design. These codes have the potential to significantly impact LID implementation and may be more controversial to address. In the category of landscaping and tree requirements, the absence of any reference in the code to the dual use of required landscape areas as SCMs was identified as a barrier in several code sections. Opportunities include updating the Arboricultural Design Guidelines to include a discussion of LID, and strengthening the parking lot interior landscaping requirements and tree preservation requirements. Major recommended changes are summarized in Table 5 and the full list of barriers and opportunities is provided in the Appendix. Table 5 is organized in the order of least to most difficult, based on the technical difficulty of drafting the code change or how controversial it might be to achieve consensus on the code change among various stakeholders.

Changing development codes is a challenging and often controversial process because it can trigger a variety of concerns by code enforcement officials and the community, including safety and liability, property values, parking congestion, and the cost of development and long-term maintenance (CWP, 1998). The code changes may cut across many departments, including the public works, planning, and building departments. In addition, the fire department and utility providers may have a stake in some of the codes, particularly codes for street and right-of-way design that can impact access for fire trucks and utility installation and maintenance (PSP, 2012). A team with representatives from all of these areas should be assembled for the task of reviewing and addressing code barriers and opportunities. Individuals who are advocates for LID should also be included in the process. This role may be served by stormwater program staff who are spearheading the code review process in order to comply with MS4 permit requirements, but there may be other environmental/natural resources staff or local watershed groups who could be included as well. It is also vital to get input from external stakeholders, including the engineering and development community. They can be included on the team, or consulted once a draft of code updates has been developed by the team (CWP, 1998; PSP, 2012).

Table 5. Summary of major recommended code changes in order of difficulty.

Level of Difficulty	Recommendations
Low	Update narrative language in the Subdivision Regulations to encourage LID and be consistent with the Stormwater Design Criteria Manual.
	Revise the Zoning Ordinance to allow other types of pervious pavement besides pavers to be used in parking lots. Pervious concrete is already being used but is not explicitly authorized in the code.
Medium	Revise Chapter 5 (Calculation of Runoff) of the Stormwater Design Criteria Manual to support LID.
	Revise the Zoning Ordinance to explicitly allow parking lot interior and perimeter landscaping and bufferyards to be designed as SCMs.
	Revise the Arboricultural Design Guidelines to support LID.
High	Evaluate how the building coverage, open space, and impervious area coverages in the Zoning Ordinance could affect an LID development and revise if needed to support LID. Consider changing to an "effective impervious area" standard.
	Change the Cluster Development option in the Zoning Ordinance to conservation development, or adopt a separate conservation development zoning option. Incentivize it with density bonuses or other zoning tools.
	Consider increasing the density threshold in the Zoning Ordinance for requiring sidewalks on both sides of the street, and consider revising the Design Standards to allowing sidewalks to be pervious concrete.
	Revise the Design Standards to reduce the residential local street width to 24 ft and right-of-way width to 45 ft. Reduce the cul-de-sac pavement radius to between 35 and 45 ft. Develop design standards for a curbless or flush curb street with open channels or other SCMs in the right-of-way. Allow pervious pavement for streets and alleys, as appropriate.
	Revise the Zoning Ordinance to change the parking ratio minimums to maximums or provide a min-max range. Allow up to a 30% reduction for shared onsite parking for mixed/joint uses with the same operating hours.
	Revise the Zoning Ordinance to reduce the lot size threshold for interior landscaping requirements to 10-20 spaces, and increase the landscape coverage to minimum 10% and/or tree canopy coverage of 25-30%.
	Adopt more stringent tree preservation/replacement requirements city-wide.

There are some key steps and recommendations to facilitate a successful code review and adoption process. A third-party facilitator may be helpful to guide the process (CWP, 1998). This could be a staff member who is not part of the stakeholder departments, or an outside consultant. The first step is to educate the project team on LID. Team members are likely to have varying levels of knowledge on LID. A presentation by knowledgeable staff will help to ensure that discussions and decisions are based on a common understanding of LID benefits and regulatory drivers. The next step is to review the codes to identify potential code changes based on model codes and guidance from the literature and other communities. This thesis provides a code review and suggested changes that can be used as a starting point for a consensus process in which the assembled team carefully evaluates whether code changes should be proposed and what those changes should be. This evaluation may involve research to understand the rationale behind current codes, and should take into consideration local conditions, concerns, and priorities (CWP, 1998; PSP, 2012). The drafting of code changes should be an iterative process in which guidance from the literature and model codes from other communities are taylored to address local conditions and concerns of the team.

Once the project team has developed a consensus-based draft of code changes, solicitation of input from external stakeholders who were not part of the team, and adoption by local elected officials are the next steps in the process. External stakeholders may include engineers, developers, realtors, home builders, the local chamber of commerce, watershed/environmental advocates, and perhaps the general public (CWP, 1998). The project team should be prepared to address common concerns about increased costs of development, property values, aesthetic and maintenance issues, parking shortages, and public safety. Keeping local elected officials informed throughout the process is an important step. Officials can be included on the team or provided periodic updates on the process. A presentation to the elected officials by a representative of the project team to educate them on the proposed changes will help to facilitate informed approval of the changes.

In closing, LID is on the rise in Springfield, Missouri but its use is not yet widespread. A revised version of the City's MS4 permit that was put on public notice by MDNR in April 2013 requires the City to identify and address hindrances to LID in its codes and standards. The review and recommendations in this thesis are intended to assist the City in meeting this proposed requirement. The City is also facing regulatory obligations to address current and future TMDLs, and LID is likely to be one important tool in achieving the water quality improvements needed to address those TMDLs. LID has been shown to be an effective strategy for minimizing the water quality, geomorphic, and hydrologic impacts of urban stormwater runoff on receiving streams, and to provide other environmental and community benefits as well. USEPA and others continue to publish a growing body of literature and guidance supporting its implementation and effectiveness. Some state agencies and local jurisdictions have already mandated it. Local development codes that act as barriers to LID are a problem that many municipalities around the country are working to address. City staff and stakeholders should evaluate the barriers and opportunities identified in this thesis and propose locally-appropriate code changes for adoption. Water quality is a regional economic driver, community priority, and regulatory obligation, and LID is likely to be an important part of continued water quality protection and improvement in the Ozarks.

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APPENDIX: LIST OF BARRIERS AND OPPORTUNITIES

Code or Standard	Topic	Current Requirements	LID Barriers and Opportunities	Supporting References
		Stormwater Design and Land Disturbance		
Stormwater Design Criteria Manual	Stormwater Management	Flood control – post-development peak runoff cannot exceed pre-development peak runoff for selected design storms. Water quality - Treatment of the first ½ inch of runoff from directly connected impervious area or the first 1 inch of runoff from the entire development, whichever is greater. LID/runoff volume reduction strongly encouraged and discussed but not required. Can be used to meet water quality treatment requirement. Design criteria provided for a range of SCMs that provide treatment and volume reduction. Preference for natural/vegetated open channels rather than enclosed or concrete systems. Devotes chapter to open channel design.	Chapter 5 (Calculation of Runoff) may need updated to support LID (Wagner, 2011).	PGCM, 1999

Code or Standard	Topic	Current Requirements	LID Barriers and Opportunities	Supporting References
		Stormwater Design and Land Disturbance (continued)		
Subdivision Section 410(4)	Stormwater Management	The detailed plans for the proper disposal of stormwater…shall show the location of all open drainage channels, together with such improvements which may be necessary, such as detention basins or the widening, straightening, surfacing or other improvements of such channels…and the construction of all underground enclosed pipe sewers…necessary to efficiently carry off the stormwater and prevent ponding on the surface…	This language requiring efficient conveyance of stormwater offsite and prevention of ponding should be revised to allow and encourage management of stormwater onsite using LID principles and techniques, consistent with the Stormwater Design Criteria Manual.	PGCM, 1999.
Subdivision Section 405(4)	Open Channels	Easements for open channel drainage may be required where the cost for the installation of storm sewers is considered to be prohibitive. These easements may be alongside lot lines, but usually the design should be such that the drainage will be carried along the rear of the lots. If open channel drainage is to be carried in the street right-of-way, additional right-of-way width shall be provided.	Update to support and encourage open channels rather than enclosed systems consistent with the Stormwater Design Criteria Manual. Orientation of streets, lots, and open channel easements should take into account the existing topography and hydrology of the site. Open channels in the street right-of-way should be encouraged and a street design standard with open channels adopted as part of the Design Standards for Public Improvements.	CWP, 1998; PGCM, 1999.

Code or Standard	Topic	Current Requirements	LID Barriers and Opportunities	Supporting References
		Stormwater Design and Land Disturbance (continued)		
Subdivision Section 410(2) and City Code Chapter 96 Article III.	Land Disturbance	Subdivision Section 410(2): The subdivider shall, wherever necessary, grade any portion of the property subdivided into lots so that each lot will be usable and suitable for the erection of residential or other structures thereof. City Code Chapter 96 Article III: Requires a permit for land disturbance of 1 acre or greater (or smaller disturbances that are part of a larger common plan of development). Stormwater pollution prevention plan (SWPPP) requirements are based on the USEPA/MDNR requirements. The primary focus is on controlling the discharge of sediment but it does encourage minimizing disturbance and protecting trees and surface waters.	Revise so that the stated preference is for grading by the subdivider only as needed for installation of public improvements (streets, sidewalks, etc.) to allow lot developers the option of preserving soils and natural vegetation and protecting areas that will be used for infiltration. Ensure that minimizing disturbance is incentivized in the standards for calculating runoff in the Stormwater Design Criteria Manual.	CWP, 1998; PGCM, 1999; HWG, Inc. and Millar, 2011.

Code or Standard	Topic	Current Requirements	LID Barriers and Opportunities	Supporting References
		Lot and Subdivision Design		
Subdivision Section 407	Lot Layout	There are no specific requirements for layout of lots other than that lot size, dimensions, shape and orientation shall be appropriate for the location of the subdivision and for the type of development and use contemplated.	This language does not preclude the arrangement of lots consistent with LID principles, but does not explicitly encourage it. Revise so that the stated preference is for layout of lots to preserve and work with the natural topography and hydrology of the site. Include factors that should be considered when arranging lots such as minimizing impervious cover and preserving ecologically important site features.	NHDES, 2008.
Subdivision Section 407(1)(a)(1) and Zoning Section 4-1005 and 4-1006	Lot Size, Density and Coverage	Single-Family Residential: - Maximum density – 7 dwelling units/acre - Minimum lot area: 6,000 ft^2 - Max. building coverage (including accessory buildings: 40% - Minimum open space 30% - Maximum impervious area 70%	Evaluate how the building coverage, open space, and impervious area coverage would affect an LID development and revise as needed. These standards vary depending on community characteristics. Consider changing the impervious area standard to an “effective impervious area” standard.	PSP, 2012.

Code or Standard	Topic	Current Requirements	LID Barriers and Opportunities	Supporting References
		Lot and Subdivision Design (continued)		
Zoning Section 4-1005 and 4-1006	Lot Dimensions	Single-Family Residential: - Minimum lot width (at building line): 50 ft (street frontage width not specified) - Minimum lot depth: 80 ft - Front yard setback (on a local street): 15 ft (garages 20 ft) - Side yard setback: 5 ft - Rear yard setback: 10% of lot depth with min. of 10 ft and no more than 20 ft being required.	Developers are allowed to use larger than the minimum setbacks and lot dimensions (i.e. there are no maximums); therefore, consider adding language encouraging that front yard setbacks and street frontages be minimized to reduce the impervious cover created by driveways and streets.	CWP, 1998.
Zoning Section 3-3100	Cluster Development	This is a zoning option that allows lot sizes to be reduced if an equivalent amount of land is preserved in open space or common area for schools, community or historic buildings, or related uses. For single-family residential, the lot size can be reduced to 3,000 ft^2.	Change the current cluster development zoning option to conservation development or adopt a separate conservation development zoning option. Consider incentivizing it with modest density bonuses. Ensure that the review and permitting requirements are no more stringent than a conventional development. Lot size averaging is another option that should be considered.	HWG, Inc., 2007b; NHDES, 2008.

Code or Standard	Topic	Current Requirements	LID Barriers and Opportunities	Supporting References
		Street, Sidewalk, and Driveway Standards		
Subdivision Section 410(6)(a)(2)	Sidewalks: Requirement	Required on one side of local residential streets where the design density is less than 5 dwelling units per net acre and on cul-de-sacs fronted by 6 or less dwelling units. Required on both sides of residential streets where the design density is more than 5 dwelling units per net acre.	Requiring sidewalks on both sides of the street in densities higher than 5 dwelling units/acre may not be necessary and is a barrier to reducing impervious cover. Consider adjusting the threshold for requiring sidewalks on both sides of residential streets to a higher density, such as the maximum single-family residential density of 7 dwelling units/acre.	CWP, 1998.
Subdivision Section 410(6)(f)	Sidewalks: Placement	Sidewalks shall normally be placed 1 ft inside the street right-of-way line and shall be separated from the street curb by a strip of pervious area.	While this language does not explicitly prohibit SCMs in the strip of pervious area between the sidewalk and street, its silence on the topic creates regulatory risk. Revise to explicitly allow SCMs between the sidewalk and the street.	CWP, 1998.
Design Standards 10.1.2	Sidewalks: Material	Class "A" Portland Cement Concrete	Pervious materials are not approved for sidewalks. Revise to allow sidewalks to be constructed of pervious concrete.	Hansen, 2011; City of Olympia, WA, 2013.

Code or Standard	Topic	Current Requirements	LID Barriers and Opportunities	Supporting References
		Street, Sidewalk, and Driveway Standards (continued)		
Design Standards 10.1.4 and Subdivision Section 410(6)	Sidewalks: Width	Sidewalks shall be a minimum width of 5 ft.	The width was recently increased from 4 ft to 5 ft based on the Vision 20/20 comprehensive plan recommendation to allow two adults to walk comfortably side-by-side. Although 4 ft is recommended in the literature, 5 ft may be the community preference.	CWP, 1998.
Subdivision Section 403	Streets: Arrangement	Arrangement…and location of all streets shall conform to the Official Map and Master Plan and shall be considered in their relation to existing and planned streets, to topographical conditions…	This language does not preclude a street arrangement that minimizes impervious cover, but does not explicitly encourage it. Revise to state that streets should be arranged to minimize impervious cover, through reducing the number of cul-de-sacs and efficient lot layout.	Stone, 2004
Design Standards 8.1.1	Streets: Design and materials	City streets shall be constructed of Portland Cement Concrete with integral curb (or concrete curb and gutter) or bituminous plant mix roadway with a concrete curb and gutter. Alley pavement shall be of either asphalt or concrete design, with an inverted crown and the curb omitted.	Pervious materials are not approved for streets and alleys. Alleys are required to have an inverted crown (drain to the middle). This can work for LID design but flexibility should be provided. Revise to allow the use of pervious pavement for streets and alleys as appropriate. Allow flexibility in alley design to allow drainage to the side or the middle.	Better Streets San Francisco, 2010; Chicago Department of Transportation, 2013.

Code or Standard	Topic	Current Requirements	LID Barriers and Opportunities	Supporting References
		Street, Sidewalk, and Driveway Standards (continued)		
Design Standards 8-5	Streets: Pavement Width	Residential Local: 27 ft with parking on one side.	Reduce the street width to 24 ft with parking on one side. (Note: This appears to be recommended in the City's Vision 20/20 Comprehensive plan published in 2000.)	Neighborhood Streets Project Stakeholders, 2000.
Design Standards 8-5; Subdivision Sec 403(9)	Streets: Right-of-way width	Residential Local: 50 ft with parking on one side	Right-of-way width is larger than necessary, increasing the amount of area that needs to be disturbed. The standards are silent on the topic of including SCMs in the right-of-way, creating regulatory risk. Reduce the right-of-way width to less than 45ft and provide flexibility for including SCMs. Allow for the placement of utilities below the street pavement if necessary for the use of roadside SCMs. Adopt a street design standard and typical section for vegetated channels in the right-of-way.	CWP, 1998; HWG, Inc. and Millar, 2011.
Design Standards 10.2.1 and 10.2.2 and Standard Drawing ST-1	Streets: Curb and Gutter	Curb and gutter are required on all public improvement street projects. Curb and gutter are to be constructed from Class "A" Portland Cement Concrete. The curb height is to be 6in.	Adopt a street design standard and typical section drawing with no curb, flush curbs, or curb cuts to facilitate the use of open channels or other SCMs next to the street. Revise the definitions of improved and unimproved street accordingly (Design Standards 1.1 Definitions).	CWP, 1998; HWG, Inc. and Millar, 2011.

Code or Standard	Topic	Current Requirements	LID Barriers and Opportunities	Supporting References
		Street, Sidewalk, and Driveway Standards (continued)		
Standard Drawings ST-5 and ST-20 and Subdivision Regulations Sec 403(6)	Streets: Cul-de-sac	ST-5: Right-of-way radius 60 ft; Pavement radius to back of curb 48.5 ft. 403(6): Turn-around with an outside roadway diameter of at least 80 ft and street property line diameter of at least 100 ft. ST-6: Permanent dead-end turnaround with 121 ft length and 21 ft width.	Reduce pavement radius to 35 to 45 ft, and reduce right-of-way radius accordingly. Allow a landscaped island if it will be used for stormwater management or provide tree canopy over the pavement. Provide a design standard for alternate turnarounds that create less impervious cover such as “hammerheads” on short (less than 200 ft) low-density streets. The standard drawing ST-6 for a permanent dead-end turnaround is a hammerhead but its dimensions are larger than necessary. Reduce the dimensions to 60 ft length by 21 ft width.	CWP, 1998.
Design Standards 10.3	Driveways	Driveway approaches shall be constructed using Class “A” Portland Cement Concrete. The width of residential driveway approaches shall not exceed 22 ft…and shall not be less than 12 ft at the right-of-way line. Joint (shared) driveway approaches are permitted if there is a perpetual mutual access agreement approved by the City Attorney and filed in the Greene County Recorder’s Office.	Reduce residential driveway widths to a minimum of 9 ft and a maximum of 18-20 ft. Allow pervious materials for driveway approaches as appropriate. Clarify that driveway design outside of the right-of-way is not governed by the code and encourage pervious materials and two-track designs (paved tire tracks and pervious median) to reduce impervious cover. Provide design standards for shared driveways and a sample agreement that would be approved by the City Attorney.	CWP, 1998; HWG, Inc. and Millar, 2011.

Code or Standard	Topic	Current Requirements	LID Barriers and Opportunities	Supporting References
		Parking Requirements		
Zoning Section 5-1500	Parking Ratios	Parking ratios are set as minimums. Up to 10% of the required parking can be substituted for bicycle parking at a rate of 2 bicycle spaces for each required automobile space.	The current minimums may be too high, creating unnecessary impervious cover. Having no maximums may result in larger than necessary parking lots. Specify the current minimums as maximums or provide a min-max range of ratios to allow flexibility while ensuring that developers won't build a bigger than optimum parking lot. A general rule of thumb for new minimums is ½ to 1/3 below the current minimums.	HWG, Inc., 2007a.
Zoning Section 6-1301(B) and Standard Drawing ST-6	Parking Stall Dimensions	Standard: 9 ft width by 18.5 ft length; Compact: 8 ft width by 16 ft length, allowed only for employee parking and only 40% after first 100 standard size spaces.	The stall length is 6 inches longer than necessary, creating unnecessary impervious cover. Compact spaces should be more widely allowed. Reduce the standard stall length to 18 ft. Allow or require compact spaces for up to 30% of required parking for all types of parking lots.	CWP, 1998.

Code or Standard	Topic	Current Requirements	LID Barriers and Opportunities	Supporting References
		Parking Requirements (continued)		
Zoning Section 5-1500	Shared Parking	For on-site shared parking, the number of spaces required for a lot with mixed or joint use can be reduced by showing that uses in the development have different principal operating hours. Off-site shared parking is shared parking between two sites and is allowed if they have different principal operating hours, but only for up to 50% of the required parking, and not by right (subject to City discretionary approval). Both situations require a Cooperative Parking Plan to be signed by all parties, and filed with the County Recorder.	Include language that shared parking is preferred where possible. Some communities require it. Consider making off-site shared parking a matter of right. Allow offsite shared parking for more than 50% of required spaces. Allow up to a 30% reduction for shared onsite parking for mixed/joint uses even if they have the same principal operating hours. List or incorporate acceptable references/methods for determining shared parking demands and provide a sample shared parking agreement.	CWP, 1998; HWG, Inc., 2007a.
Zoning Section 6-1301(F)	Parking Surfacing	Concrete, asphalt, conventional pavers and porous pavers are allowed. Porous pavers can only be used within an off-street parking area open to the sky that does not serve the following uses: single-family-detached, single-family-semi-detached, duplex or townhouse dwelling unit or mobile home.	Update approved materials to allow all acceptable types of pervious pavement dependent on the situation (i.e. grass pavers may only be appropriate for fire lanes and overflow parking). Adopt specifications for pervious materials to remove uncertainty about approval of their design and construction. Encourage or require parking above the minimum ratio to be pervious pavement.	CWP, 1998; HWG, Inc. and Millar, 2011.

Code or Standard	Topic	Current Requirements	LID Barriers and Opportunities	Supporting References
		Landscaping and Tree Requirements		
Zoning Section 6-1209(A) and Arboricultural Design Guidelines	Parking Lot Interior Landscaping	Parking and vehicular use areas with 30 or more parking spaces or gross area ≥12,000 ft^2 (50 spaces or 20,000 sq ft in Center City district) require minimum 5% interior landscaping meeting the following requirements: - Landscaped area must abut pavement on 3 sides or more than 75% of its perimeter to qualify as interior landscaping. - Protected from vehicles with a minimum 2.5 ft overhang provided by wheel stops or curbs - Minimum of two understory trees or one canopy tree for each 30 spaces or 12,000 ft^2. Planting areas shall be a minimum of 100 ft^2 for each understory tree and 200 ft^2 for each canopy tree. - Interior landscape areas shall be located so as to best relieve the expanse of paving.	The code is silent on whether interior landscape areas can be designed as SCMs, creating regulatory risk. Include a stated preference that interior landscaping be designed as SCMs, and allow flexibility for placement and tree requirements. Provide a design detail for an interior landscaping SCM but still allow acceptable alternate designs for flexibility. The lot size threshold for requiring interior landscaping is relatively high and the minimum % required to be landscaped is relatively low compared to the literature and other communities (see Table 4). Increasing these requirements will increase tree canopy coverage for parking lots and may help to drive their use for stormwater management. Minimum 10% landscaping is a common standard. Common lot size thresholds are 10-20 parking spaces. Tree canopy coverage of 25-30% is common. Evaluate current tree requirements in comparison to a canopy coverage requirement.	CWP, 1998; HWG, Inc. and Millar, 2011; Hinds and Zielinski, 2011.

Code or Standard	Topic	Current Requirements	LID Barriers and Opportunities	Supporting References
		Landscaping and Tree Requirements (continued)		
Zoning Section 6-1209(B) and Arboricultural Design Guidelines	Parking Lot Perimeter Landscaping	Required where a parking lot or vehicular use area is within 50 ft of a public right-of-way with no intervening building. Dictates number of trees and shrubs per linear feet of landscape area, with the remaining area required to be grass or other living ground cover.	The code is silent on whether perimeter landscape areas can be designed as SCMs, creating regulatory risk. Include language allowing perimeter landscape areas to be designed as SCMs, and allow flexibility for plant selection. Placement of trees in these areas such that they provide canopy coverage over paved areas should also be explicitly encouraged. Provide a design detail for a perimeter landscaping SCM but still allow acceptable alternate designs for flexibility.	Hinds and Zielinski, 2011.
Zoning Section 6-1211	Bufferyards	Required where different zoning classifications abut or are separated by an alley. Dictates number of trees and shrubs per linear feet of landscape area.	The code is silent on whether bufferyards can be designed as SCMs, creating regulatory risk. Include language allowing bufferyards to be designed as SCMs and allow flexibility for plant selection as appropriate.	Hinds and Zielinski, 2011.
Arboricultural Design Guidelines	Landscape design	Provides guidelines on plant species, selection, arrangement, installation, and maintenance to meet the landscaping requirements in the Zoning Ordinance (interior and perimeter parking lot and bufferyard landscaping).	Include a discussion of LID principles and techniques as it relates to landscaping. Provide landscape guidelines for SCMs, as part of this document or separately and referenced in this document. A future consideration is an LID landscape ordinance.	HWG, Inc. and Millar, 2011; Metropolitan St. Louis Sewer District, et al., 2012.

Code or Standard	Topic	Current Requirements	LID Barriers and Opportunities	Supporting References
		Landscaping and Tree Requirements (continued)		
Zoning Section 6-1200; Multi-Family Development Location and Design Guidelines	Trees	Zoning Section 6-1200: Trees are to be preserved to the maximum extent practicable. Clear cutting is prohibited unless its prohibition substantially and unreasonable restricts the ability to develop the property and the development's economic viability. Preserved trees can be credited towards meeting tree requirements for interior, perimeter, and bufferyard landscaping. Multi-Family Guidelines: Trees 6 inches or greater in diameter (measured 4.5 ft above ground) must be preserved or replaced with a tree of at least 2 inches diameter for a maximum total of 7 trees per acre. Trees meeting the landscape requirements in the zoning ordinance may be counted toward this requirement. A tree survey site plan must be submitted to assess this requirement.	The existing zoning language is not successful in prohibiting or discouraging clear-cutting. Evaluate the effectiveness of the multi-family development tree preservation/replacement requirement compared to model tree ordinances and revise if needed. Consider extending tree preservation/mitigation requirements to other types of development.	CWP, 1998; CWP and U.S. Forest Service, 2008.