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ENGINEERS

South Campus
Stormwater Master Plan

University of Illinois

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ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Submitted by

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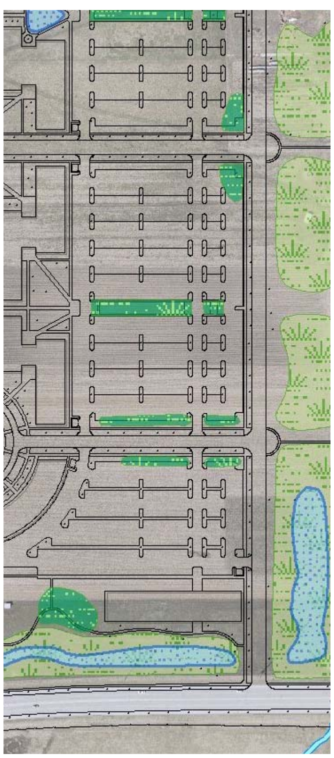
South Campus Stormwater Master Plan

EXECUTIVE SUMMARY

Existing Detention Pond at Research Park

Low Impact Development (LID) is a tool used to minimize the impact of land development, promoting a sustainable infrastructure



As the University relocates agricultural facilities south of Windsor Road, the opportunity exists for an expansion of the University's Research Park, a vital element of the University and the regional economy.

The University has expressed interest in incorporating sustainable design into its infrastructure. Although sustainable design has traditionally focused on elements within the building footprint, this concept also applies to the entire building site.

In the context of stormwater, sustainable design requires the designer to consider the impact of development on stormwater runoff, providing a developed landscape that reduces or eliminates negative impacts downstream. Conventional stormwater design often ignores the impacts of water quality and the degradation of receiving streams due to increased runoff volumes.

Communities throughout the country (and the world) are embracing a concept called Low Impact Development (LID) which is a tool used to minimize the impact of land development, promoting a sustainable infrastructure. Innovative stormwater infrastructure design is one of the most dominant LID components.

South Campus Development

The development (and redevelopment) of areas north of Windsor Road provide an opportunity for the University to demonstrate the effectiveness of LID. Recommendations for the South Campus area include the installation of stormwater management facilities that promote stormwater *infiltration*, thereby enhancing stormwater quality and controlling stormwater runoff volume.

The overall intent of this Master Plan is to reduce stormwater pollution, minimize impacts on the Embarras River, and provide guidance for the University in future site design. Properly designed and implemented LID projects can also boost *Leadership in Energy and Environmental Design* (LEED) scores for University facilities.

Development Costs

Numerous studies have been performed on the costs of LID compared to conventional site development. These studies reveal a reduction in infrastructure costs when using LID design techniques. This is usually due to a reduction of the required detention pond footprint and less (or smaller) storm sewer pipe. Several studies show that a properly designed site can reduce storm sewer system capital outlays by as much as 20 to 30 percent.

Effective stormwater management can boost LEED scores for University facilities

Early Implementation Recommendations

The University should consider the following key projects for early implementation (this list was developed with an assumption that early development will occur east of First Street, especially along Windsor Road and First Street):

Stormwater Infiltration (Rain Garden)
Image Source:
University of Wisconsin – Stevens Point

1) Construct a primary outlet channel from Windsor Road to the Embarras River (near Fourth Street). This channel will be approximately 800-900 feet long and should be designed to handle stormwater conveyance for approximately 160 acres of full development. This channel should have a wide, flat cross section (as opposed to a typical narrow roadside ditch with steep sideslopes). This channel should eventually serve as a central site amenity, so it should be planned and designed accordingly.

2) Construct regional detention ponds immediately north of Windsor Road (on both sides of the future Fourth Street alignment). These ponds will discharge to the outlet channel described in Item 1 (see Section 4 for additional detail).

3) Construct a storm sewer from the proposed detention ponds north of Windsor Road northwest towards First Street, then north along the east side of First Street to north of Hazelwood Drive. This sewer will serve as the new backbone for stormwater runoff from development along the east side of First Street.

LID design can reduce overall infrastructure costs by reducing detention pond footprint and storm sewer components

4) Coordinate with the developer of the proposed commercial site northeast of the Windsor/First intersection to plan their site within the context of these recommendations. The changes would likely include eliminating the proposed detention pond, incorporating stormwater BMPs as recommended in this study, and redirecting the drainage outlet to the east (towards the proposed regional ponds).

The above projects will help facilitate development along Windsor Road and First Street. Additional stormwater detention areas, as recommended in Chapter 4, can be constructed as Fourth Street is extended and development pushes eastward.

Engineering Research Opportunities

The implementation of LID stormwater design in the South Campus area can provide a unique opportunity for College of Engineering faculty and students to study the impacts of this design on water quality, stormwater runoff volume, and downstream impacts.

1.0 INTRODUCTION

1.1 PURPOSE OF STUDY

The University of Illinois at Urbana-Champaign (UIUC) wishes to develop a plan to manage stormwater in the developing South Campus Research Park area with an emphasis on sustainable design. In the context of stormwater management, sustainable design seeks to minimize the impact of development on the hydrologic response (i.e. intensity and duration of stormwater runoff).

Clark Dietz, Inc. has developed a Stormwater Master Plan that focuses on innovative stormwater infrastructure design for the areas that will be developed or redeveloped as the South Campus Research Park expands. This report contains an illustrative layout of a preferred stormwater management scenario with supporting calculations demonstrating compliance with City of Champaign stormwater requirements. This scenario should allow for flexible construction phasing while maintaining the recommended design philosophy.

Increases in impervious cover (due to land development) result in decreased infiltration, which changes the hydrologic response within a watershed and often results in degradation to water quality, damage to downstream receiving streams, and can increase flood potential. Careful planning in the South Campus area can produce a stormwater infrastructure which mitigates the impacts of development and protects the Embarras River watershed.

Conventional

Low Impact

Figure 1-1
Conventional vs. Low Impact Stormwater Design

1.2 STUDY AREA

The study area is bound on the south by Windsor Road, on the east by Fourth Street (extended), on the west by the railroad, and on the north by St. Mary's Road. Figure 2-1 (following chapter) illustrates the study area. The area west of First Street is mostly developed, but the majority of this area will be redeveloped as part of the University's South Campus Master Plan. The area east of First Street consists mostly of undeveloped lands that are currently devoted to agricultural research.

The general drainage pattern in the study area is from north to south. The primary outlet for the study area is the Embarras River, south of Windsor Road.

1.3 INTRODUCTION TO LOW IMPACT DEVELOPMENT

The addition of impervious surfaces (i.e. rooftops and parking lots) increases runoff potential. Traditional stormwater control consists of storm sewers and a detention pond. In the City of Champaign, the detention pond is designed to control peak flows for the 100-year storm. This allows for peak flow control, but does not explicitly address stormwater quality. Most current stormwater management literature recommends stormwater infiltration as an effective method to reduce the impact of development on stormwater runoff quantity and quality. Low Impact Development (LID) is a practice through which decentralized stormwater controls (i.e. stormwater Best Management Practices (BMPs)) are used to intercept stormwater and allow it to infiltrate, as opposed to flowing directly to a detention pond and to a receiving stream.

Key results of LID are:

- Complete or near-complete infiltration for first-flush storm (approximately 1 inch of rainfall in 1 hour).
- Reduction in concentrations of known stormwater pollutants, including (but not limited to) Nitrogen, Phosphorus, Lead, Zinc, Copper, Fecal Coliform, etc.
- Reduced stress on receiving streams, as runoff volumes are maintained (traditional stormwater management results in prolonged periods of increased flows in receiving streams, which accelerates streambank erosion).
- Increased land values, as properly-designed BMPs create an attractive landscape, and can often be integrated into green space otherwise delegated to turf grass.

1.4 BENEFITS OF LID IN CHAMPAIGN

Installing and maintaining stormwater BMPs to promote infiltration will allow UIUC (and Champaign) to take credit for these practices in their respective NPDES Phase II (stormwater) permits. These BMPs can also be used to educate local residents, developers, and engineers on innovative stormwater management, allowing UIUC and Champaign to satisfy the public education requirement for their NPDES permits.

Practicing LID in the South Campus area may help to encourage other local developers to adopt similar practices. As a leader in the community, UIUC can set the standard for sustainable site design with respect to stormwater.

Upon our review of the UIUC Notice of Intent (for the IEPA Stormwater Permit), the following BMPs are closely related to the type of design/construction recommended in this report:

- BMP B.1.2 (*Meet with Environmental Stewardship Committee to review storm water quality and storm water issues around campus*)
- BMP E.2.1 (*Upgrade stormwater management policy*)
- BMP E.3.1 (*Evaluate feasibility of bio-retention areas for new or redeveloped surface parking lots*)

Any significant steps forward the UIUC can make with respect to stormwater design in the South Campus area can be documented to show the UIUC is serious about its compliance with the IEPA NPDES stormwater rules and is willing to be a local leader in implementing design methods that will enhance stormwater quality.

2.0 EXISTING CONDITIONS

2.1 HYDROLOGIC METHODOLOGY

The south campus area of the University of Illinois for the purposes of this stormwater master plan is shown in Figure 2-1. This area is bounded on the west by the railroad tracks east of Neil Street in Champaign and on the east by Fourth Street. The bounding road on the north is St. Marys Road and the south boundary is Windsor Road.

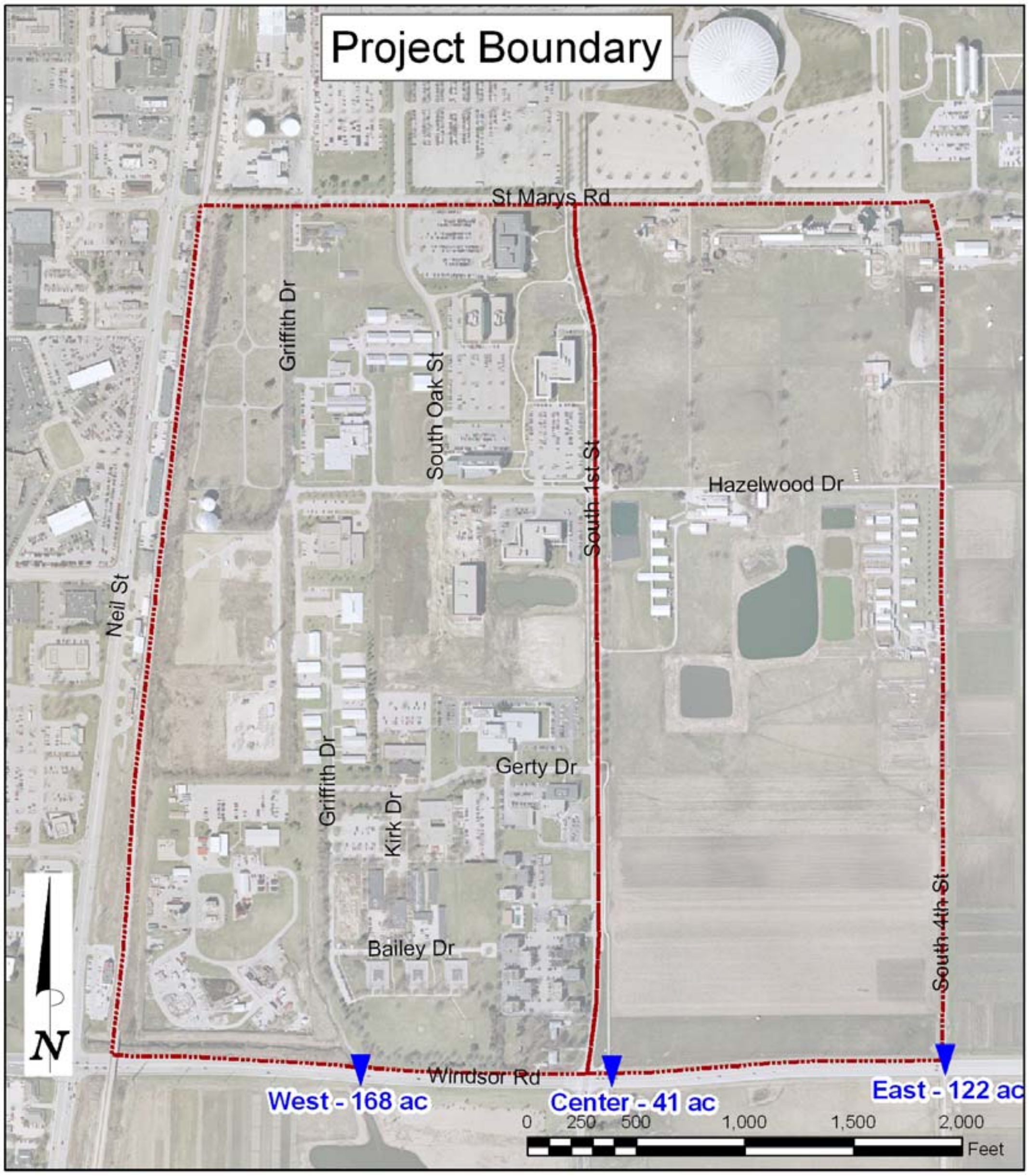


Figure 2-1
Project Boundary

The area east of First Street is mostly undeveloped. This area once housed UIUC swine research facilities, cattle barns, and agronomic field research plots. The area west of First Street is much more developed. St. Marys Cemetery is on the northwest corner of this area. This area also contains the Illinois State Water Survey buildings, the Illinois Fire Service Institute, and the burgeoning Research Park.

South Campus area stormwater generally flows south and exits under Windsor Road at three locations (see Figure 2-1). To the west, 168 acres of the South Campus area drains to the Embarras River headwater stream. Along First Street, 41 acres flows through a culvert. On the east, 122 acres flows through a culvert under Windsor Road.

On the west, Embarras headwaters receives flow from a UIUC 84-inch storm sewer that outlets approximately 900 feet north of Windsor Road and a channel from the west that goes under Neil Street and the railroad tracks. South of Windsor, the Embarras River flows into the First Street Detention Basin, which has a normal pool surface area of approximately six acres.

On the east, between First Street and Fourth Street, most of the stormwater exits through a square box culvert flows under Windsor Road on the west side of Fourth Street. However, some of the runoff exits via round culverts immediately east of First Street (this includes the discharge from the iCyt pond, which represents a large portion of the existing Research Park west of First Street).

From First and Fourth Streets stormwater flows south 500 feet to 1,000 feet to the Embarras River, which flows in an easterly direction immediately south of the study area.

First Street serves as a general drainage divide for the South Campus area. However, there are a few areas that cross the divide. The northern area east of First Street flows north to St. Marys Road and then west, before flowing south. In addition, the new Research Park detention pond southwest of the Hazelwood Drive – First Street intersection (hereafter referred to as the “iCyt Pond”) outlets to a storm sewer east of First Street.

2.2 HYDROLOGIC VARIABLES

Using the 2005 aerial photos and contour maps, the project area was divided into ten subareas, as shown in Figure 2-2. USDA-NRCS WinTR-55 methods were used to develop the runoff curve numbers for the project area and the times of concentration. The soils in the project area are primarily hydrologic soil group “B” soils. However, for the developed areas, hydrologic soil group “C” was used to represent compacted “urban” soils which have a higher runoff potential than undisturbed “native” soils.

For the time of concentration, the hydraulic flow path for each subarea was delineated. Then the flow path was subdivided into sheet flow, overland flow, and sewer flow.

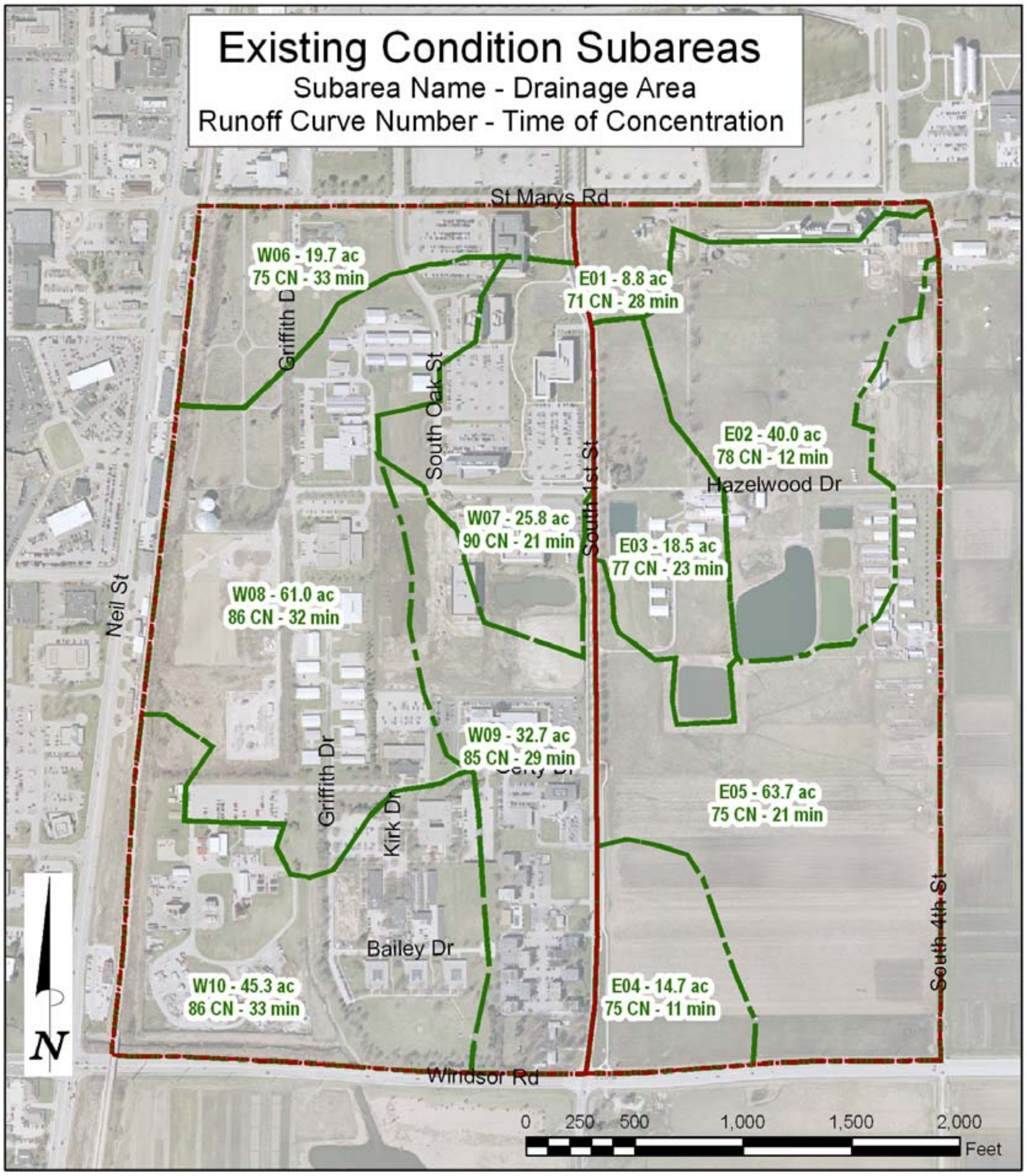


Figure 2-1
Existing Condition Subareas

2.3 LIMITATIONS OF STUDY

The hydrologic analysis for the South Campus Stormwater Master Plan is confined to the project boundaries described in this chapter. Although areas north of St. Marys Road (including Assembly Hall and associated parking lots) drain into the study area, it was assumed this flow would be completely contained within the 84-inch storm sewer parallel to Griffith Drive. As such, no hydrologic analysis was conducted for areas north of St. Marys Road. UIUC staff indicated that the 84-inch storm sewer functions normally with no known occurrences of surcharging or flooding.

Fourth Street serves as the eastern boundary of the project area and as a natural drainage divide. Stormwater runoff east of Fourth Street generally stays east of the project area. Since flow is to the south through the South Campus Area, no stormwater enters the study area from south of Windsor Road.

Analysis of the First Street detention pond (see Figure 2-3) and floodplain south of Windsor Road is also outside the scope of this Stormwater Master Plan. Existing as-built plans for the First Street detention pond show that design normal pool elevation is 707.1' and the 706-foot long concrete overflow weir is elevation 712.3'. The average ground elevations immediately north of Windsor Road range from 716' to 719', which is safely above the design overflow elevation of the First Street detention pond.

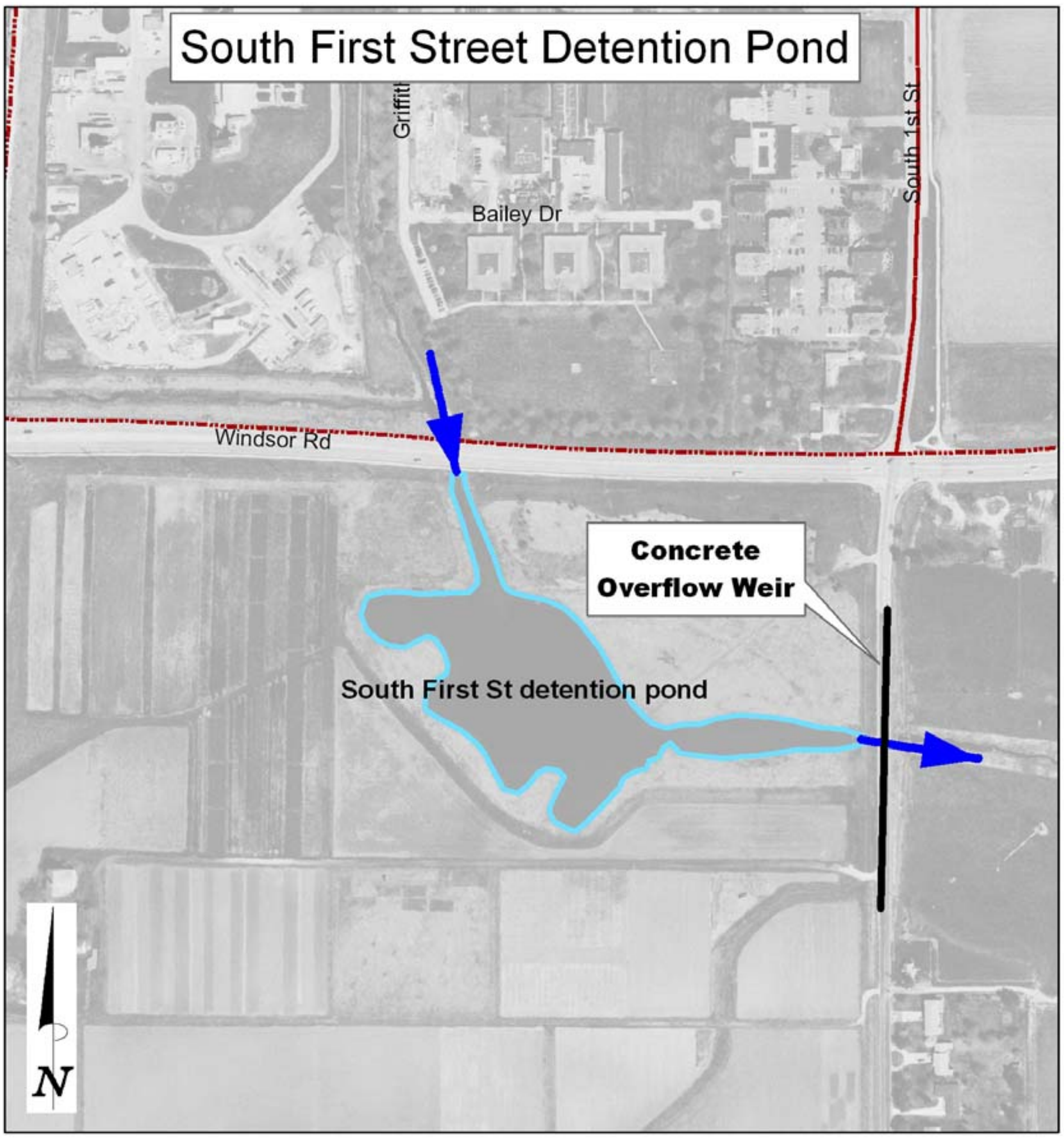


Figure 2-2
First Street Detention Pond

2.4 KEY ASSUMPTIONS

This study was performed without the benefit of field survey. As such, calculations and recommendations are based on available information from existing site plans, existing contours, and interviews with UIUC staff. Several key assumptions were made with respect to existing conditions, including the hydraulic capacity of existing sewers and drainage channels.

Prior to detailed design of any stormwater improvements, we recommend a detailed survey to verify the capacities of receiving sewers, culverts, and streams.

2.4.1 Outlet conditions

The South Campus Stormwater Master Plan assumes that existing storm sewers discharge freely with no significant surcharging which would cause localized flooding. The South Campus drops nearly 45 feet in elevation from St Marys Rd to Windsor Road, and the overall slope is 1% to 1.5% (steeper than average slopes in Champaign). The existing open drainage channels within the project area are assumed to be free flowing with no significant hydraulic restrictions that would cause localized flooding.

The largest storm sewer in the South Campus area is a 3,700-foot long, 84-inch diameter sewer that begins north of St Marys Road and outlets 900 feet north of Windsor Road (Figure 2-4). This storm sewer roughly parallels Griffith Drive. University staff are unaware of any problems with this storm sewer. Therefore it was assumed that the storm sewer is flowing at capacity and no surcharging occurs. An objective of the South Campus Stormwater Master Plan is to maintain or reduce peak flows in this storm sewer.

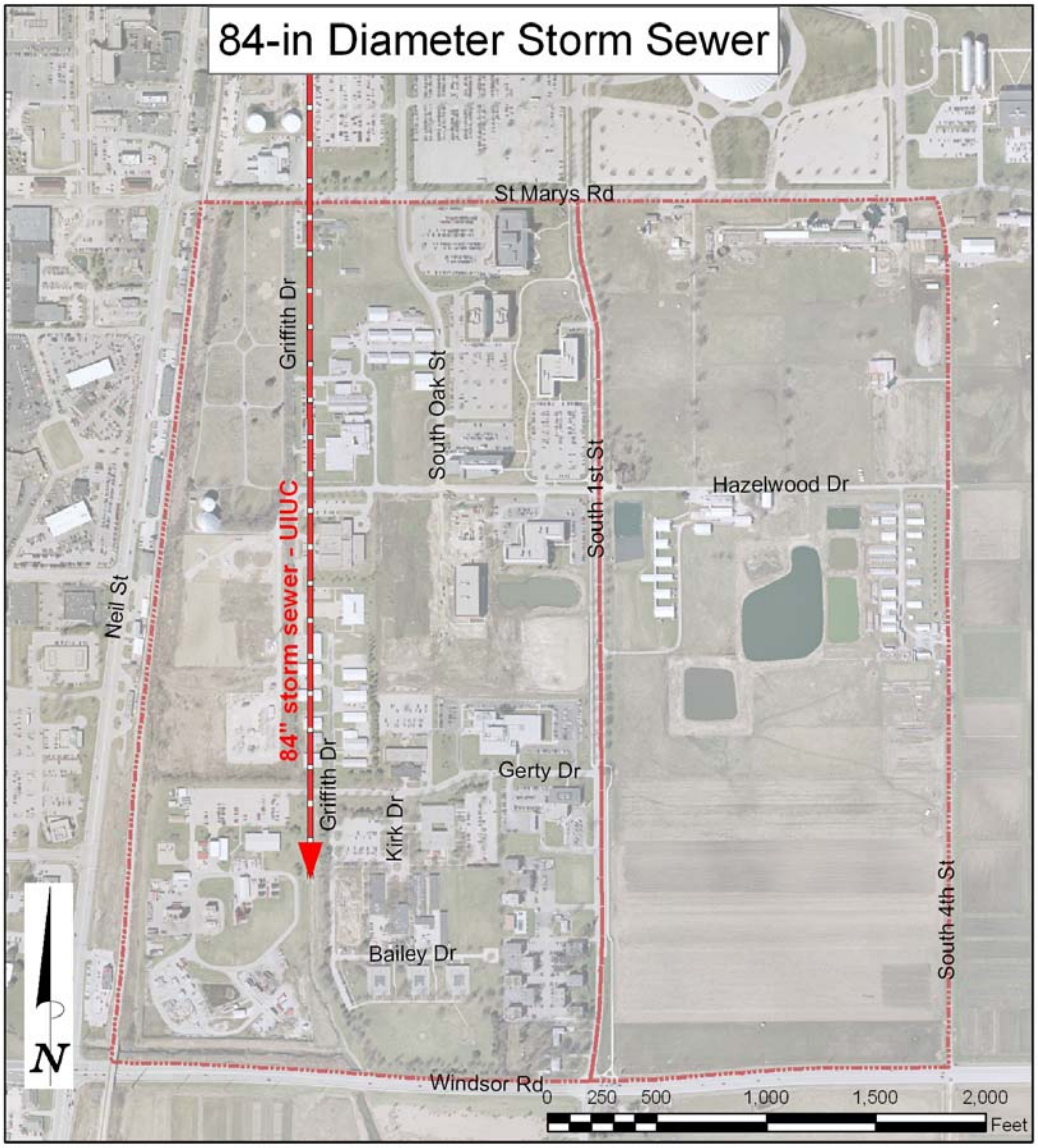


Figure 2-3
84-inch Storm Sewer Location Map

2.5 EMBARRAS RIVER FLOODPLAIN

The purpose of the South Campus Stormwater Master Plan is to maintain or reduce stormwater peak flows *and* volumes from the South Campus area. If these goals are met during development, there should be no adverse impacts on the First Street detention basin south of Windsor Road or the Embarras River.

However, the South Campus area is only a small part of the drainage area flowing to this reach of the Embarras River. Additional runoff enters the system from north of St. Marys Road and west of Neil Street. Therefore, if stormwater runoff from these offsite areas were to increase in the future, the performance of the proposed stormwater management system could be affected. Nonetheless, the South Campus area is the largest undeveloped tract in the drainage area tributary to this reach of the Embarras River, so it is unlikely that stormwater flows from other areas will change significantly.

2.6 SUMMARY OF EXISTING HYDROLOGIC RESPONSE

The XP-SWMM hydrologic model reveals that the 2-hour rainfall duration produces the highest 100-year frequency peak flow for the South Campus area, as shown in Figure 2-5. The longer duration storms have higher rainfall depths, but are less intense because the rainfall is distributed over a longer period of time. The peak 100-year flow from the area east of First Street is approximately 90-95 cfs. The peak from the developed area west of First Street is approximately 225-230 cfs. The difference in these flow rates can be explained by the amount of developed properties west of First Street.

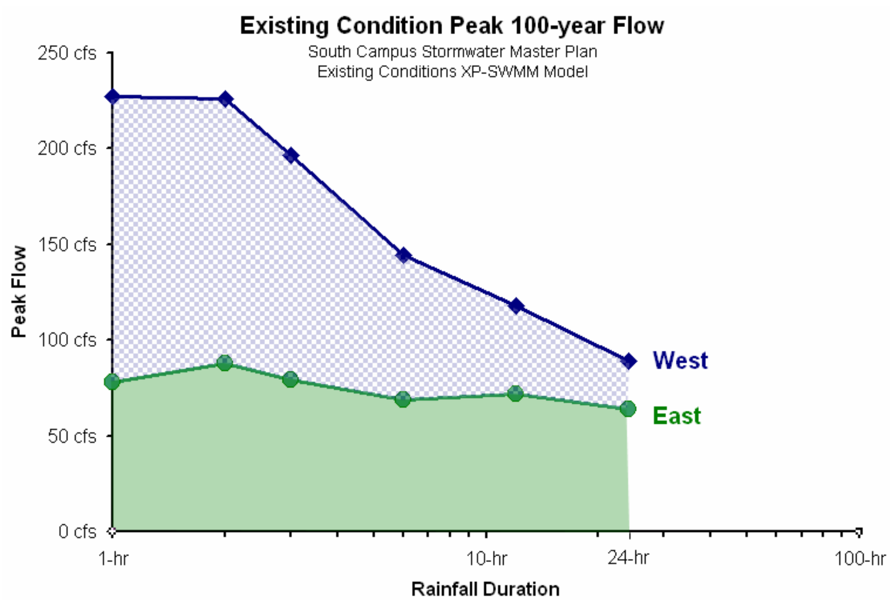


Figure 2-4
Existing Conditions: 100-year Peak Flows

In terms of existing runoff potential with respect to the 100-year peak flow, the following results demonstrate the high runoff potential in this area:

- East of First Street (mostly undeveloped): Peak flow = 0.58 cfs/acre
- West of First Street (mostly developed): Peak flow = 1.34 cfs/acre

Runoff potential in both areas is significantly higher than the City of Champaign 100-year detention pond design criteria of 0.18 cfs per developed acre.

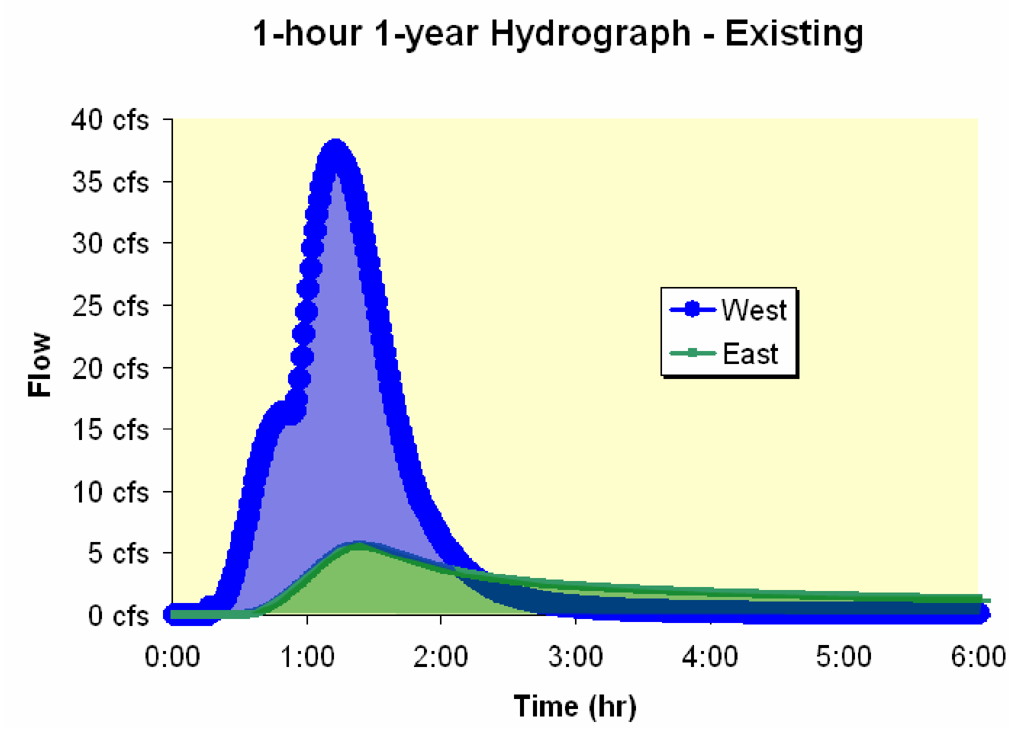


Figure 2-5
Existing 1-hour 1-year Hydrographs

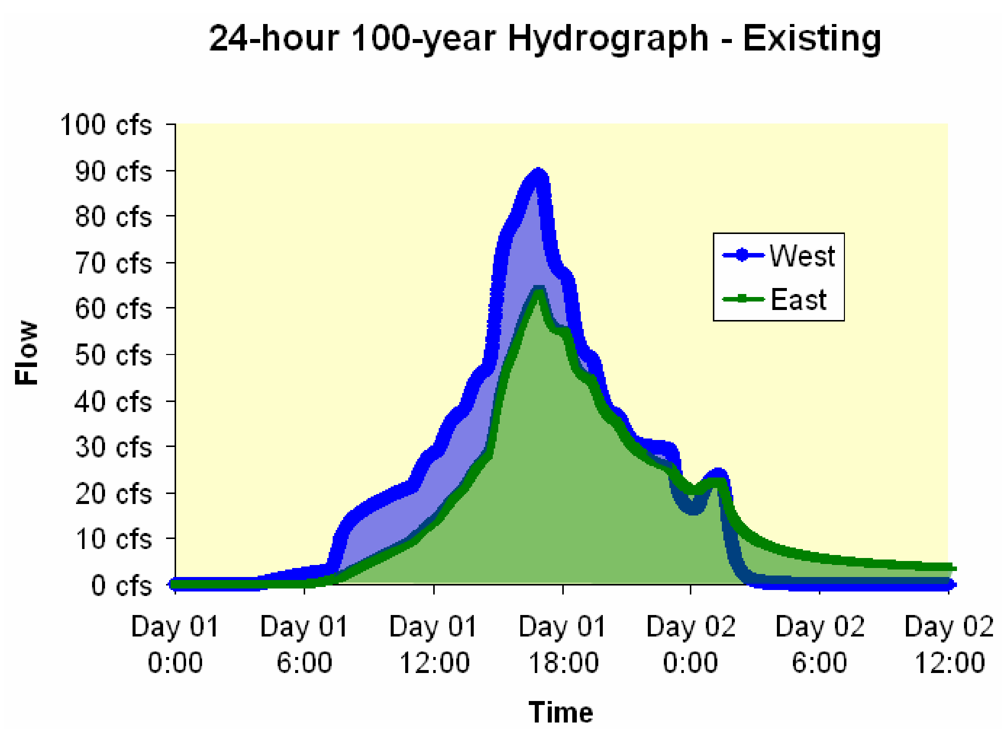


Figure 2-6
Existing 24-hour 100-year Hydrographs

When comparing the existing hydrology to the proposed hydrology, it is important to look at more than just the peak flow from the infrequent (high magnitude) storms, such as the 100-year event. For water quality and channel stability purposes, the relatively frequent storms, such as the 1-year event, is a very important "design" storm. As demonstrated in Figure 2-6, the 1-year storm runoff response in developed areas is very intense when compared to an undeveloped area (Figure 2-6). It is this change in runoff response that often leads to downstream channel erosion and general degradation of natural drainage systems.

2.6.1 Modeling Existing Ponds

There are seven existing water features in the South Campus area, as shown in Figure 2-8. The only water feature that serves as a stormwater detention facility is the pond east of the iCyt building in the Research Park area (hereafter referred to as the "iCyt pond"), west of First Street. The ponds east of First Street will likely be removed to accommodate the expanding Research Park.

University staff revealed that the ponds east of First Street are intended primarily for research and therefore do not have surface outlets.

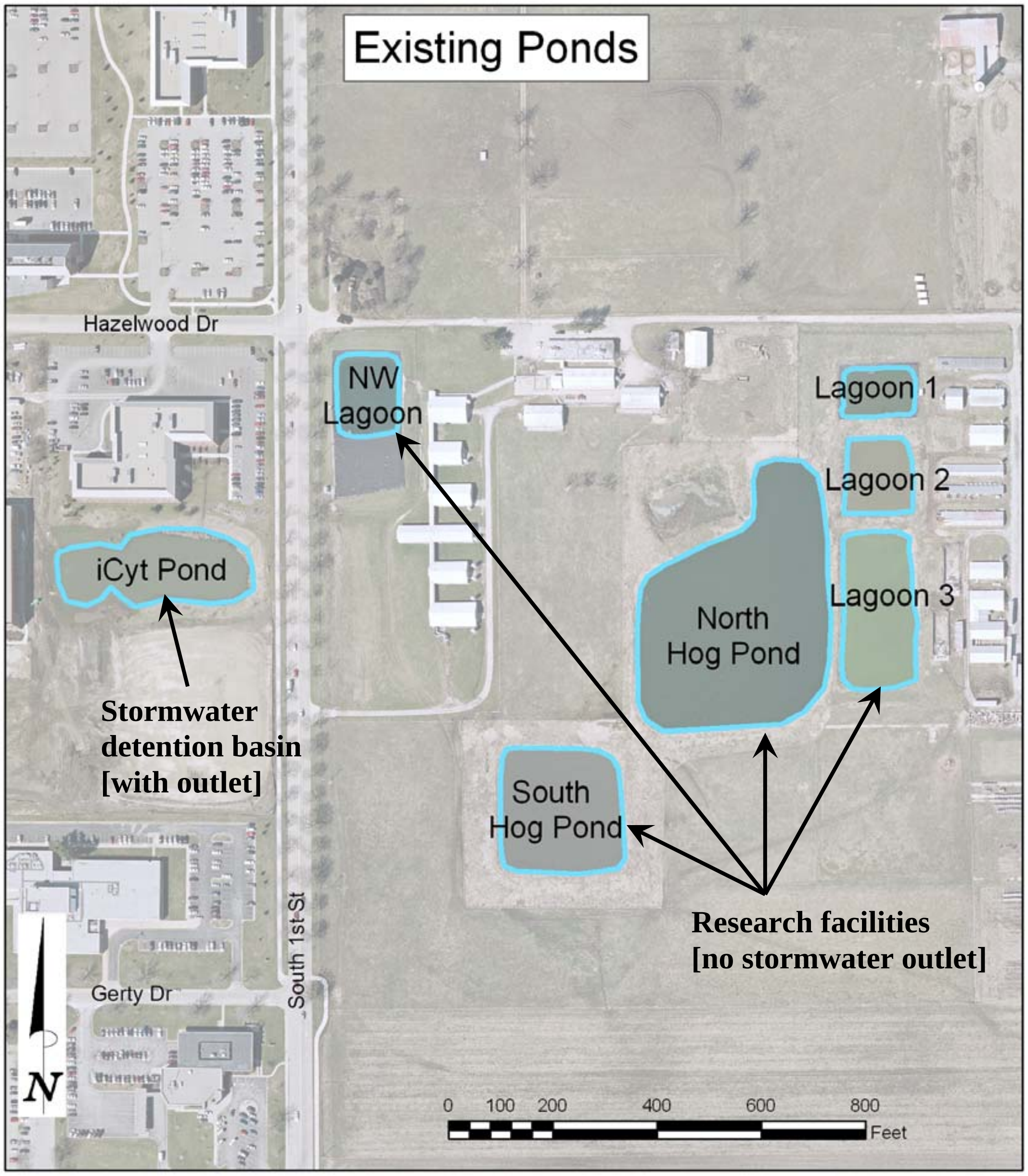


Figure 2-7
Existing Water Surface Features

Most of the water surface features illustrated in Figure 2-8 do not accept surface runoff and have no stormwater outlet. The "North Hog Pond" does have a small drainage area tributary to the pond (directly north of the pond) but the pond is essentially isolated from the watershed, as it has no apparent outlet. The "North Hog Pond" provides significant flow attenuation under existing conditions, and was therefore modeled as having stormwater storage characteristics.

In general, the research facilities south of Hazelwood Drive reduce the runoff potential for this drainage area, as significant land areas are isolated and have little to no runoff. This further reduces the stormwater runoff potential for the area between First Street and Fourth Street (with respect to existing land use conditions).

The 100-year storm (City of Champaign design storm for ponds) raises the water level in the iCyt pond 4 to 5 feet above the normal water elevation, which should not cause the pond to overflow. This pond was modeled assuming the outlet sewer capacity was similar to a 15-inch diameter sewer at a 0.5% slope.

3.0 PROPOSED DEVELOPMENT

3.1 TRADITIONAL STORMWATER MANAGEMENT APPROACH

The traditional approach to stormwater management is to address flooding caused by large, infrequent storms, such as the 24-hour duration 100-year recurrence event (that is, a rainfall depth, measured over a 24-hour period, which has a 1-in-100 chance of being exceeded in any given year). For example, the City of Champaign requires the post-development 24-hour, 100-year peak site discharge to be no greater than 0.18 cfs per developed acre. Although this requirement helps to prevent widespread flooding, current rules to not specifically address the smaller, more frequent storms.

Detention basins designed to meet the City of Champaign standard are effective at controlling runoff from the 100-year recurrence interval event. However, if the detention pond outlet is sized to only control the 100-year event, more frequent storms pass through the detention basin relatively uncontrolled.

As a result, the peak flows from the more frequent events (say, about 1 inch of rain) are higher under developed conditions than under pre-developed conditions, despite the existence of stormwater detention (see Figure 2-6 in the previous chapter). Although flooding is addressed with a detention pond, there can be problems with water quality, longer periods of sustained flow in downstream drainage channels, and channel erosion.

Figure 3-1 shows how a detention basin prolongs flow from a hypothetical subdivision with a detention basin that limits the peak 24-hour duration, 100-year recurrence interval flow. The green hydrograph represents the flow from the subdivision. The flow peaks quickly and recedes quickly. The blue hydrograph represents the flow out of the detention basin. The flow peaks in about the same amount of time, but the receding flow is two to three times longer. As runoff from impervious areas increases, the runoff volume is increased and the flow duration increases as well.

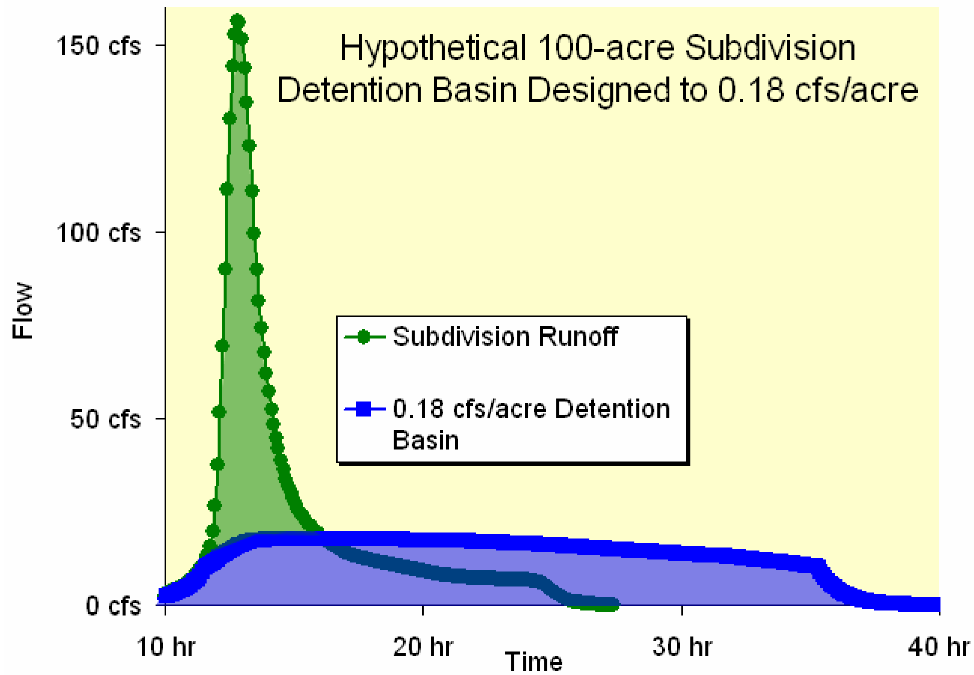


Figure 3-1
Hydrograph Showing Sustained Flow Downstream of Detention Basin

The traditional approach to stormwater management, as typically practiced in the Champaign-Urbana area (and also throughout the country) is to create a single detention basin for flood control (or controlling stormwater *quantity*). The detention basin is often the single component that addresses peak runoff. This has been effective in the past, but new stormwater regulations are requiring communities to focus on stormwater *quality*.

3.2 INFILTRATION AS AN EMERGING STORMWATER PRACTICE

Low Impact Development (LID) is a technique that minimizes the environmental impact of development. Although LID practices reach beyond stormwater, much of the foundation of LID is effective stormwater management. Simply put, LID design aims to maintain a similar hydrologic response when a site is developed. In terms of stormwater management, it is desirable to maintain existing peak flows *and* volumes.

LID design usually incorporates a detention pond, but also employs a decentralized approach to stormwater management. Recognizing that frequent (i.e. 1-inch) rainfall events drive stormwater quality, smaller features called Best Management Practices (BMPs) are situated to collect small runoff volumes and promote infiltration. This is usually accomplished with a technique called *bioretention*, which uses low-lying green space to intercept stormwater and allow it to infiltrate. Higher flows (resulting from intense storms) are allowed to overflow into a traditional stormwater collection and detention system.

If infiltration design is successfully implemented, the post-development runoff response will more closely mimic that of pre-developed conditions. The runoff volume will be reduced, especially for the more frequent runoff events.

The "first flush" of runoff (first ½ to 1 inch) washes collected sediment and other pollutants off impervious surfaces such as parking lots, streets, and roofs and transports them into receiving streams. Infiltration practices can intercept and this first flush volume, thereby improving water quality.

3.3 REQUIRED FOOTPRINT

Many sources are available for guidance on the proper amount of green space to reserve for stormwater infiltration (bioretention) BMPs. Based on our research of applicable manuals of practice, approximately *5 percent* of impervious area should be reserved to adequately infiltrate the first one inch of rainfall. For instance, each 1,000 square feet of pavement or rooftop would require 50 square feet dedicated for infiltration purposes.

Chapter 4 contains a list of sources with comprehensive design and maintenance manuals for bioretention BMPs. *Prince Georges County (Maryland) is a leader in the enforcement of LID design. They are often referred to as the best source of materials related to effective bioretention BMPs.*

3.4 INFILTRATION BMPs APPLIED TO SOUTH CAMPUS

Drainage design for large, highly impervious site development traditionally incorporates storm sewers and detention ponds into a network that effectively directs wet weather runoff offsite. Local regulations, discussed earlier in this chapter, require site discharge limits that are routinely satisfied by using storm sewers and detention ponds. Inlets and catch basins are installed in low areas and periodically along slopes to direct wet weather runoff into storm sewers and away from buildings and parking lots. These flows discharge into containment structures (i.e. detention ponds) that often require large continuous areas to properly attenuate peak flows.

These detention ponds use areas of land that have the potential to be developed, but must be designated for stormwater use to satisfy runoff regulations. These ponds eliminate developable area while often failing to integrate visually with the site layout. Smaller, more localized BMPs, shown in Figure 3-2, can be incorporated into the site layout, providing a water quality benefit while also reducing the need for conventional stormwater detention.

***Author's note**: Engineers and planners often refer to "wet" ponds as "retention" ponds and "dry" ponds as "detention" ponds. For the purpose of simplicity, all existing and proposed ponds referenced in this paper are referred to as detention ponds. If necessary, a distinction is made between "wet" (i.e. contains a permanent water volume) and "dry" (i.e. intended to completely drain after a storm).*

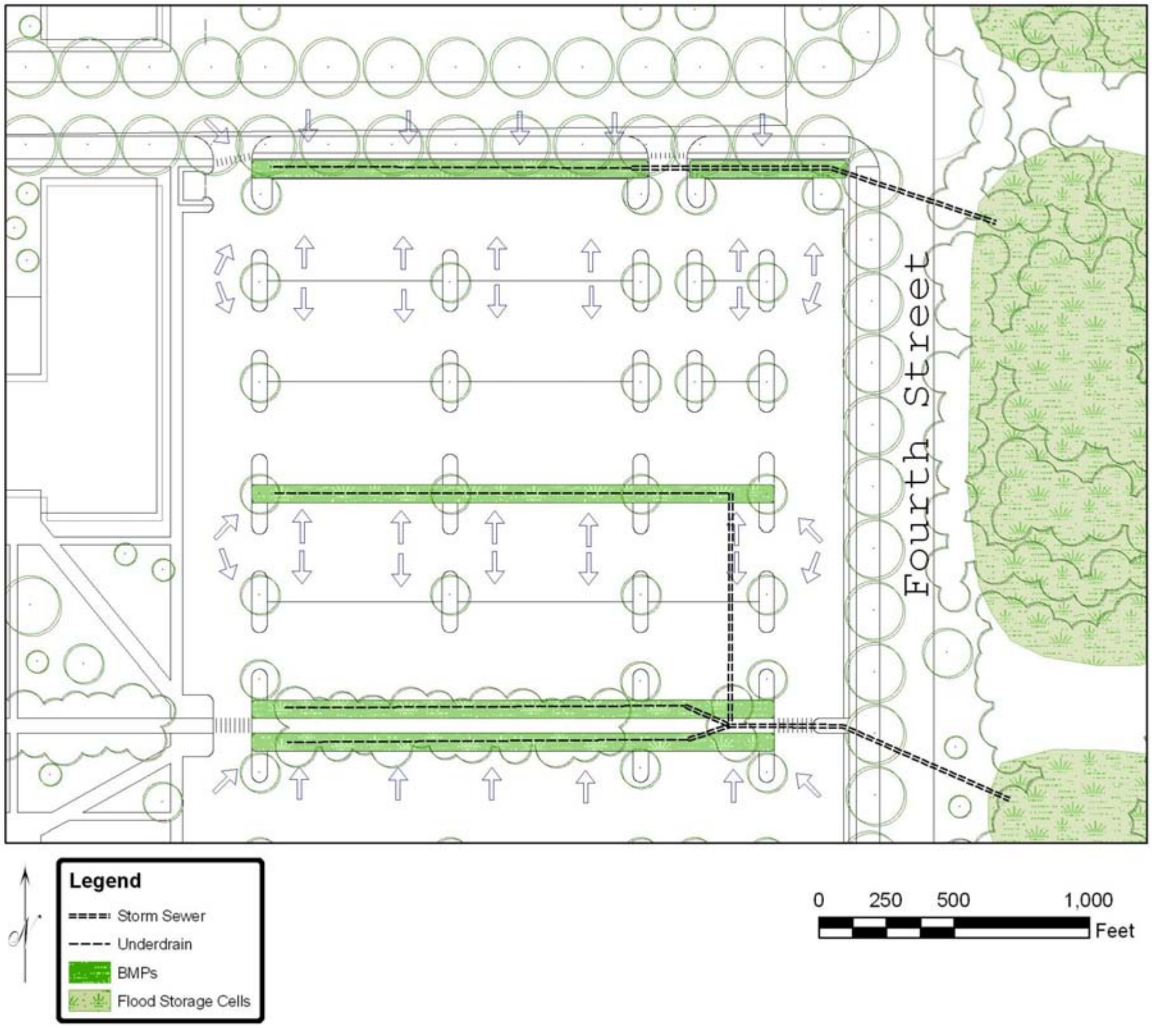


Figure 3-2
Proposed BMP Layout for a Typical South Campus Parking Lot

Bioretention BMPs, such as rain gardens or bioswales, are capable of being implemented in a variety of locations and conditions to provide relief to local drainage concerns. Placing these BMPs amongst proposed or existing structures and parking lots is often possible by utilizing the unused green space that exists (and goes unused) in most traditional site design.

Figure 3-2 illustrates a potential BMP layout (based on the South Campus Master Plan parking lot layout along Fourth Street) that adjusts parking row locations to disperse the site green space throughout the parking lot. This green space can then be used as a stormwater BMP feature while eliminating only a few parking spaces in a lot that was originally designed to consist of almost 320 parking spots. The arrows display the intended surface drainage (sheet flow) to each BMP.

The BMPs in this scenario would consist of bioswales. A typical bioswale, illustrated in Figure 3-3, provides a small depressional area for runoff to collect and soak into the soil. These areas are carefully engineered and constructed to allow for higher-than-average infiltration rates. Furthermore, each BMP must have an overflow structure allowing stormwater access to a "traditional" storm sewer system. An underdrain system is recommended to allow for effective dewatering after rain events.

Figure 3-3
Bioswale Detail
Image Source: Virginia Department of Conservation & Recreation

Bioretention areas typically have a depth of approximately 0.5 to 1.0 foot (1.0 foot recommended in this study), which allows for placement of these features in small islands within parking lots. Strategic planning and placement of these natural treatment and detention areas require specific site layout and design requirements for proper operation.

In a typical parking lot, the design emphasis is changed to promote sheet flow to a BMP (as illustrated in Figure 3-2). This generally eliminates the need for inlets, catch basins, and storm sewers through most of the parking lot areas, although some storm sewer is still necessary to direct higher flow rates to a conventional detention system.

The operation of a LID-inspired stormwater management system would begin with impervious surfaces, directing and conveying flow to the bioswales. Catch basins would be located in the bioswales to serve as overflow structures and prevent flooding into the parking area. These bioswales are intended to collect and infiltrate storms smaller than the 1-year 1-hour storm ("first flush"). The catch basins convey runoff from larger storms and discharge the excess water into a conventional storm sewer system.

The combined storage volume created by the decentralized BMPs is not insignificant and can be counted towards the ultimate storage volume required for the 100-year storm. This typically allows for a smaller 100-year detention pond footprint.

3.5 MODELING TECHNIQUE

XP-SWMM (a fully-integrated hydrologic and hydraulic modeling program) was used to model the impacts of the South Campus development/redevelopment under a LID scenario. XP-SWMM was also used to determine the existing conditions hydrology (described in Chapter 2). This allows for a comparison between existing and fully-developed conditions.

There are four main modeling components to each of the bioretention BMPs modeled as part of this study.

- *Storage Basin 1* → A storage volume is applied over the bioretention BMP (bioswale). The model accounts for stormwater volume stored within the BMP (up to 12 inches of depth) as the stormwater infiltrates into the underlying soil.

- *Pump* → Although a pumping system is <u>*not*</u> required for the recommended BMPs, the model uses a pump to mimic the effects of infiltration by allowing a changing infiltration rate as the soil becomes saturated with water. The volume of stormwater that infiltrates into the underlying soil is accounted for separately than stormwater that flows into the receiving sewer system. Infiltrated stormwater is directed into Storage Basin 2 (described below).

- *Storage Basin 2* → This is a hypothetical storage volume that is used to intercept infiltrated stormwater. The purpose of Storage Basin 2 is to account for the entire amount of stormwater that is "treated" via infiltration.

- *Overflow Weir* → provides conveyance of stormwater runoff (exceeding 1-inch storm) to a conventional storm sewer system and flood detention areas. This weir prevents the BMP from overfilling and flooding adjacent parking spaces. The overflow weir would be similar to a catch basin, but would have a rim elevation raised 12 inches above the base of the bioswale.

These preceding model components were used to approximate the effects of bioretention BMPs on individual areas that will be developed or redeveloped as part of the South Campus Master Plan.

Properly modeling bioretention areas requires the infiltration rate to be input as a pumping rate that changes over time. Infiltration is a function of ponding depth, soil moisture, soil type, ground cover, temperature, soil homogeneity and many other factors that can greatly impact the infiltration rate. The ponding depth was assumed to have a negligible impact on the infiltration rate, which simplifies the model and should have virtually no impact on peak flows. Water depth would only be a real concern for the larger storm events that result in ponding depths greater than a foot, which then bypass the rain garden by design. Soil has a higher infiltration rate when the soil moisture is low and initial conditions assume low moisture content. By assuming that a rainfall event has not occurred in the previous few days and given that the soils in this area are well drained, the infiltration rate will gradually vary with the soil moisture.

The ground cover within the BMPs will consist of a sandy-loamy uncompacted soil, mulch, and native deep-rooted plants that promote infiltration, while variables such as temperature and soil homogeneity are assumed to have a minimal impact on the modeled infiltration rate for short duration, localized analysis. The climate in Central Illinois would only be a factor in storms that occur in early spring and late fall, but this should only marginally increase flows to the downstream detention ponds, which have the capability to manage additional flow and prevent flooding. BMP maintenance (as further described in Chapter 4) will help to maintain the infiltration capacity of the BMPs.

Identical infiltration rates were used for all the proposed BMP areas with an initial infiltration rate of 2.0 in/hr that reduces to 0.75 in/hr as the soil moisture increases. Infiltration rate decay can be approximated using Horton's (1939) Equation

$$f = f_c + (f_o - f_c) \cdot e^{-kt}$$

f = infiltration capacity (in/hr) at any time, t (hr)
f_o = initial infiltration capacity, in/hr
f_c = final infiltration capacity, in/hr
k = infiltration decay constant, hr^{-1}
e = base of the natural logarithms

McCuen (1988) reports that f_c can vary from 0.01 in/hr to 2 in/hr, f_o can be 2 to 5 times greater than f_c, and values of k can range from 1 hr^{-1} to more than 20 hr^{-1}. The large variations in the possible values of these numbers creates virtually limitless combinations of acceptable values, but several sources on bioretention design recommend a soil with an initial infiltration rate near 2 in/hr. The 0.75 in/hr was derived from a combination of McCuen's recommendations and site soil properties. The pump curves in XP-SWMM require a linear approximation of the pumping rate which means that the infiltration rate used was a linear approximation of the equation above. The decay curve was approximated using a line that would be equivalent to using a k value of 3 hr^{-1}, which is a conservative value in the range of acceptable k values. A lower k value results in a faster decay to the constant infiltration rate, which is apparent in the model results that show infiltration rates reaching constant values in 30 to 40 minutes for the 24 hour storm. Figure 3-4 shows the infiltration rate decay curve that is based on Horton's Equation and the parameters used for the Research Park site. This duration is even shorter for the more intense 1-hour storms modeled. The model also assumed uniform infiltration throughout each BMP as a necessary simplifying step in the modeling of these BMPs.

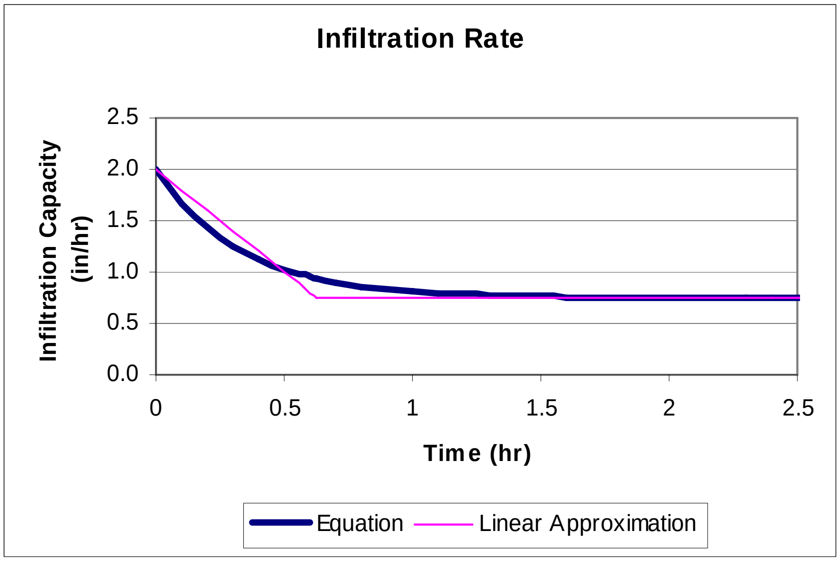


Figure 3-4
Infiltration Rate Decay Curve

Reliance on Underdrains

Infiltration BMPs (as recommended in this study) can contain underdrain systems, meant to provide a hydraulic relief when the underlying soils have little to no permeability. This allows the BMP to effectively drain without causing a nuisance or maintenance concern. These underdrains are typically designed to limit flow to a "trickle" by limiting the pipe diameter to 4 inches. An individual BMP has two outlets for infiltrated stormwater:

- *Deep infiltration (below the lower limits of the amended soil)*
- *Underdrain outlet to traditional storm sewer system*

Although there are not much data available on the distribution of deep infiltration versus underdrain outlet volumes, Clark Dietz is confident that the majority of infiltrated stormwater into a well-designed and maintained BMP will outlet via deep infiltration for the following reasons:

- *Soil types in the study area primarily consist of SCS Type B soils, which are documented to have moderate permeability, which is desirable for the use of infiltration BMPs (actual soil permeability should be verified with soil borings during the design phase).*
- *Planting and maintaining native prairie vegetation within a BMP provides deep root structures which help to break up native soils below the amended soil layer. Well-maintained BMPs contain mature prairie vegetation with root structures exceeding a depth of 10 feet (see Figure 3-5). This helps provide a "conduit" to promote deep infiltration, thereby reducing the runoff volume entering the traditional storm sewer.*
- *The underdrain can be constructed in a "perched" condition, promoting infiltration below the pipe elevation, thus promoting deep infiltration.*

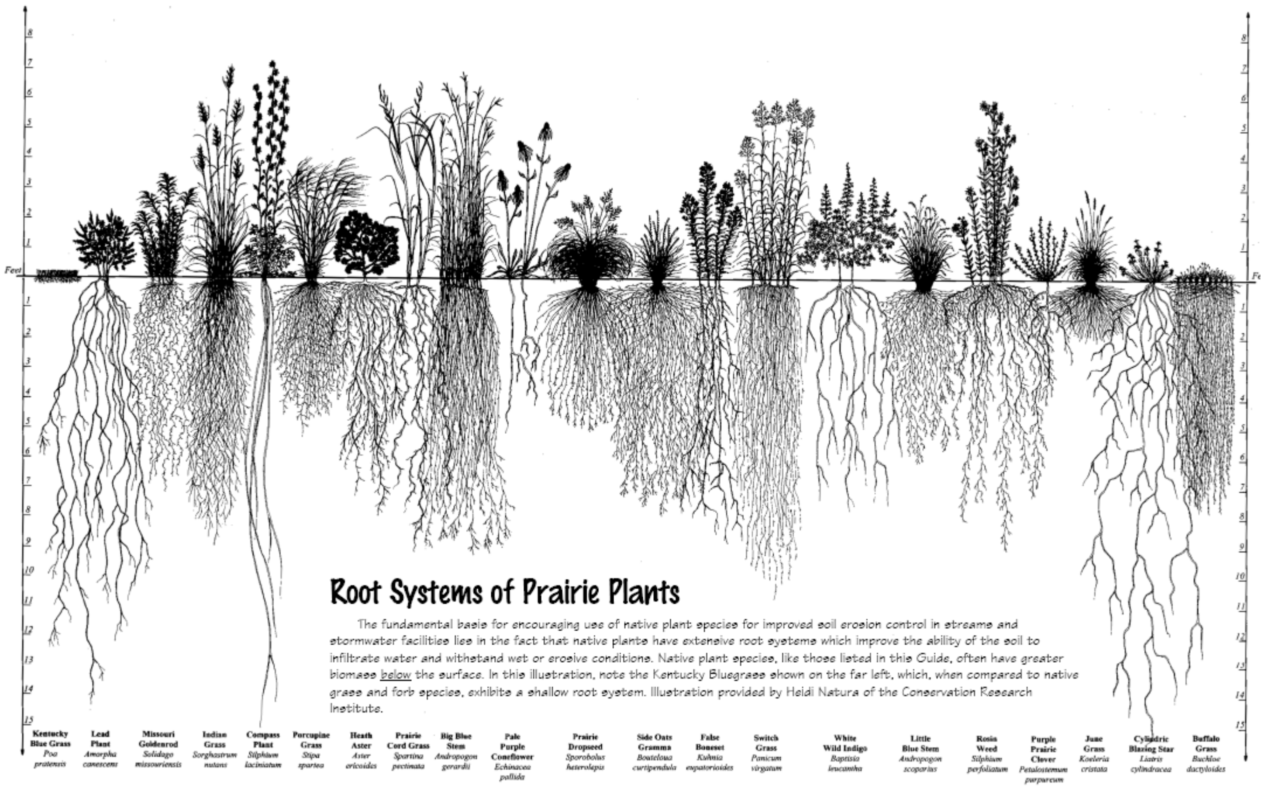


Figure 3-5
Deep-Rooted Native Vegetation – Root Profile
Image Source: NRCS, Illinois Native Plant Guide

The proposed hydraulic model was developed using the University of Illinois South Campus Research Park Plan and the existing 2-foot contours. The site layout and ground elevations will change through the development of the site, but the model was built using the most recent data for the site.

For drainage areas west of First Street, site development is either ongoing or proposed in many areas; however, these areas have existing development and drainage patterns that will only be modified slightly. Bioretention BMPs in areas west of First Street can be incorporated into existing sites and designed into future site layouts so that these stormwater structures become amenities throughout the research park (see Figure 3-6 for potential retrofit areas west of First Street). Although BMPs may not be possible for every new redevelopment west of First Street, it is encouraged to implement them wherever possible to maximize the treatment of stormwater runoff prior to discharge to the Embarras River.

The iCyt pond discharge sewer should be directed into a new regional detention pond that will be located east of First Street and north of Windsor Road (further described in Chapter 4). The drainage areas southwest of the iCyt pond will discharge to a proposed regional detention pond northwest of the First Street and Windsor Road intersection. Developments immediately adjacent to the existing 84-inch storm sewer will continue to discharge stormwater runoff into this storm sewer.

Existing green space between parking areas can be excavated and replaced with bioretention BMPs. Existing storm sewer within the parking area would convey BMP overflow.

Existing catch basin

BMP Locations

Even areas with curb and gutter can be retrofitted. The landscaped area next to the parking lot west of the IEPA building would be an ideal candidate for a bioretention BMP.

Figure 3-6
Potential BMP Retrofits – West of First Street

The proposed model utilizes the site layout in the University Research Park Master Plan to estimate the ultimate (fully developed) impervious area. Existing contours were used to estimate average land slopes for developed conditions. These hydrologic variables assumed are only approximate values, which should be expected to change upon development. Values for the curve number and time of concentration (hydrologic variables that predict runoff volumes and peak flows) were selected to provide reasonable results for the flow entering the bioretention BMPs and stormwater detention areas under fully-developed conditions.

Rain gardens and bioswales are proposed wherever adequate green space is identified in the South Campus Master Plan. Regional detention pond locations are selected based on those areas specifically identified for stormwater management in the Master Plan. Details of recommended stormwater management facilities are included in Chapter 4.

For new development east of First Street, the building and parking lot layout will dictate the number and shape of bioretention BMPs needed to satisfy the 5% impervious area recommendation. The drainage areas were determined through consideration of both the general site topography and the proposed Master Plan. These drainage areas would need to be graded and paved so that the appropriate slopes exist to direct flow towards the proposed BMPs. The XP-SWMM model lumps every BMP within an individual drainage area into a single BMP to simplify the modeling effort (see Figure 3-7 for a schematic of the proposed hydrologic model).

The layout and elevations developed for the proposed model are for planning purposes only. Detailed site design will require site-specific stormwater and grading calculations to determine the appropriate layout and sizing of BMPs and sewer size/layout. Although the model developed as part of this study is preliminary only, it provides useful information on the overall system performance with respect to local stormwater requirements and sustainable design philosophy.

Modeling results for proposed conditions are summarized in Chapter 4.

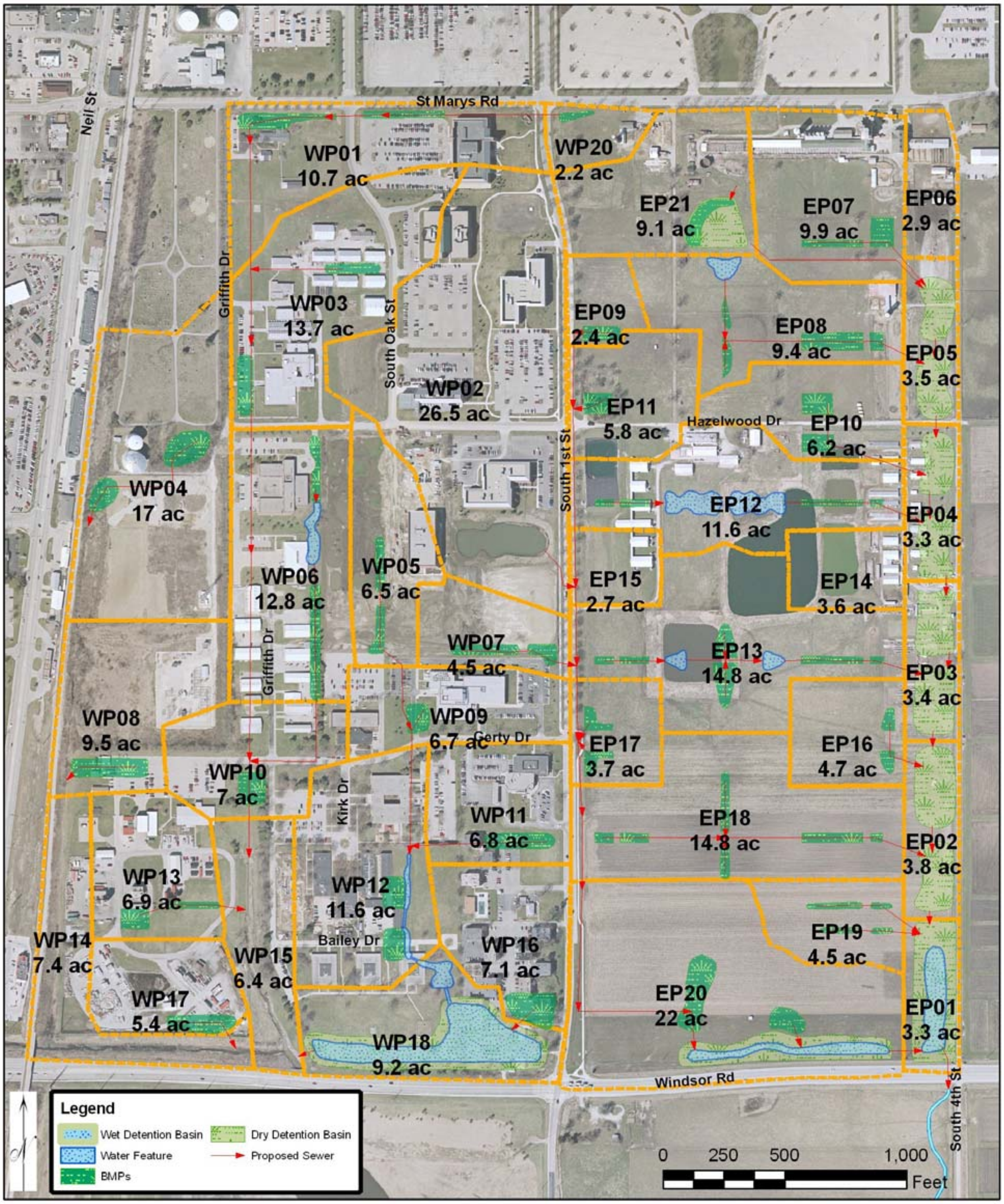


Figure 3-7
Hydrologic Model Schematic – Proposed Conditions

4.0 RECOMMENDATIONS

4.1 BMP LOCATIONS AND PROPER DESIGN/MAINTENANCE

Figure 4-1 (following page) depicts the locations of stormwater management features in the South Campus Research Park area. Summaries of key components are as follows:

- **Bioretention (rain gardens and bioswales)***:* The long, narrow BMPs identified in the proposed parking lots identify the approximate footprint necessary in each development area to provide adequate stormwater infiltration. These BMPs were included in the hydrologic/hydraulic model explained in Chapter 3.

  The actual location of parking lot BMPs will be determined by individual site design (see example illustrated in Figure 3-2), provided that the BMPs represent approximately 5 percent of the impervious area draining to them. We recommend a minimum bioswale width of *12 feet* to provide for adequate side slopes and a grassed buffer between the parking lot and the bioswale.

  BMPs illustrated in the center of the future Research Park area (mall area) are intended to intercept runoff from rooftops of adjacent buildings. We recommend that roof drainage is directed towards the mall area, where surface swales will direct the runoff to individual BMPs.

- **Fourth Street Dry Detention Cells:** The dry detention basins along the planned green space along Fourth Street are intended to provide storage for high-magnitude storm events (i.e. 10-year, 100-year). Each detention basin should be graded with gentle slopes so as to hide the fact that they serve as detention storage. Trees, shrubs, and other vegetation can be planted in these areas, as they are designed to receive water on an infrequent basis.

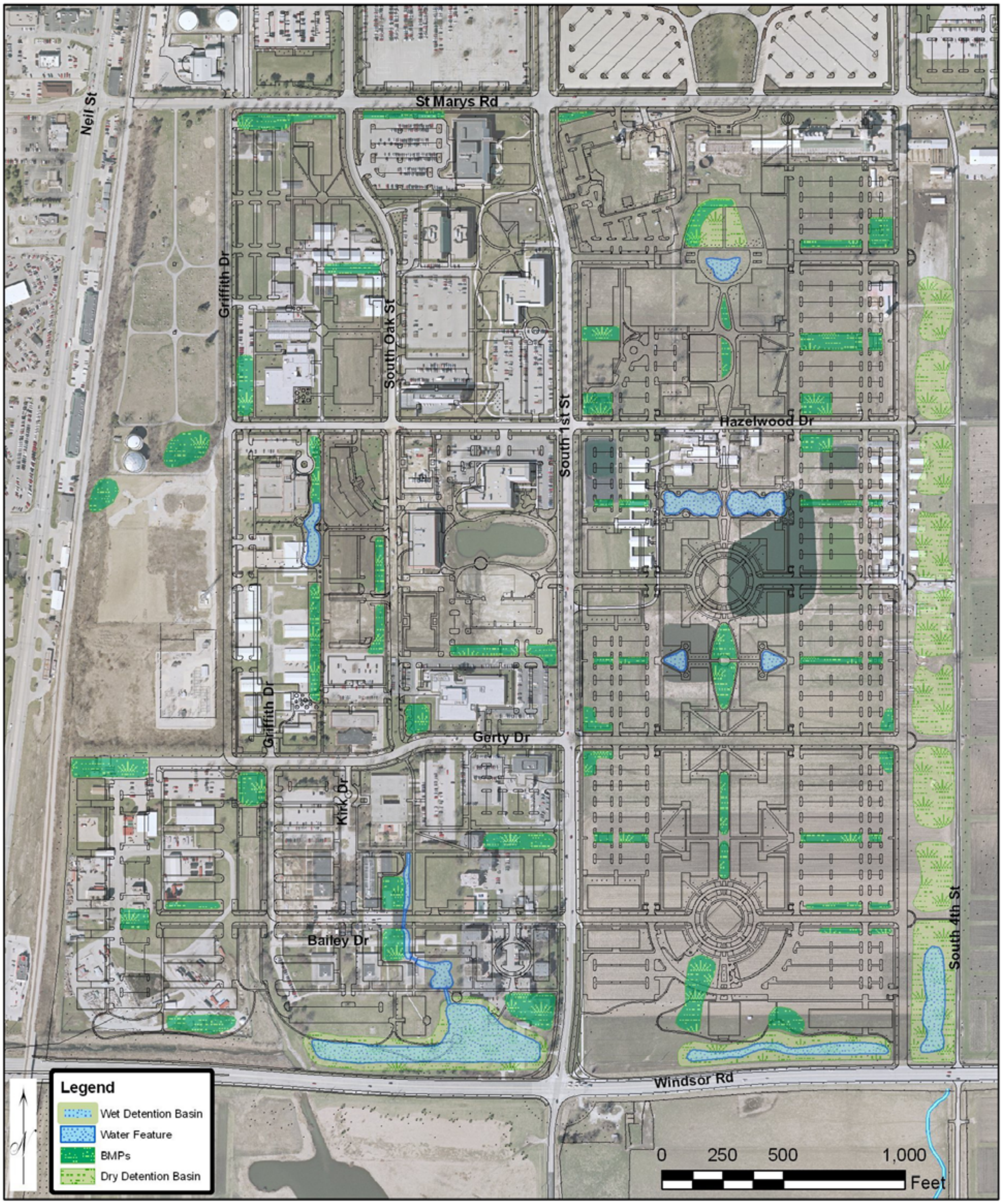


Figure 4-1
Proposed BMP Layout for the South Campus Research Park

The identified BMP locations in Figure 4-1 shows a possible site layout that utilizes green space within parking lots and between buildings to provide localized stormwater detention and treatment for each drainage area. The South Campus Research Park Master Plan provided the building and parking lot layout used to fit the 5% impervious area BMP target coverage.

The actual site layout will most likely deviate from this initial plan, so the BMP locations and sizes will need to be updated during site design.

As stated in Chapter 3, the bioretention BMPs will provide a significant portion of the storage necessary for the City's 100-year design storm criteria. This master plan distributes the 100-year storage volume among the stormwater components as follows:

- Bioretention BMPs: 20% of 100-year storage volume
- Dry detention ponds (Fourth Street): 28% of 100-year storage volume
- Wet detention ponds (along Windsor): 52% of 100-year storage volume

Localized BMPs should be positioned so that treatment for a section of a parking lot or a building can be accomplished using a single or a few smaller BMPs while these rain gardens and bioswales are linked through the overflow sewer network. The proposed BMP layout shows how each drainage area can be served by bioretention for small storms (decentralized stormwater management) while including detention ponds for large storms (regional stormwater management).

4.1.1 BMP Design and Maintenance Guidance

Prince Georges County Maryland has been experimenting with LID concepts such as rain gardens and bioswales for nearly twenty years. Numerous communities across the country have adopted bioretention as a viable stormwater detention and treatment alternative. Like many BMPs, design and maintenance are unique to each site and depend on land use, size of the site, soil type, location and many other factors. The literature on bioretention design generally recommends a proposed water depth between 6 and 18 inches with an intended drainage time near 24-48 hours. The site characteristics would be used to design the intended operation of the BMP structures. For the South Campus Research Park, we recommend a 12-inch detention depth and a 24-hour draw down time for all BMPs.

The Prince Georges County (Maryland) LID Manual was not the exclusive source on bioretention design and performance information. The Milwaukee Metropolitan Sewerage District, Minnesota Stormwater Manual, Virginia Manual of Bioretention Basin Practices, USEPA Guidance, and the Georgia Stormwater Management Manual were all referenced when planning the basic shape, size and operation of the proposed bioretention within the South Campus Research Park Development.

The proper operation of a rain garden requires appropriate soil and vegetation conditions and routine maintenance to ensure suitable operation of the BMPs. The soil conditions and treatment are intended the promote infiltration of surface runoff by improving water storage in these soils. Native vegetation that can survive periodic wet soil conditions and have a deep root structure would be the optimal ground cover to minimize maintenance and promote infiltration. The best way to improve the sustainability of the BMP is to create a micro ecosystem in each individual rain garden or bioswale. Compatible native vegetation, treated soils and a properly maintained mulch layer have been shown to operate as wet weather quantity and quality treatment techniques for LID. A properly designed rain garden or bioswale should develop into a micro ecosystem that has the ability to sustain infiltration rates near initial design parameters as vegetation roots break up soils and provide conduits for water to flow into the soil. The leaves of the vegetation would increase evapotranspiration along with the evaporation that occurs at the surface of these BMP structures. Rain gardens and bioswales are intended to be living stormwater treatment techniques that will provide color and texture to a development, while improving the water quality of the wet weather runoff for the site.

During construction, extreme care must be taken to protect newly-constructed BMPs from construction erosion. Either the BMPs should be constructed after full establishment of site vegetation OR onsite erosion control measures must be carefully maintained to avoid clogging the BMP with sediment.

Numerous design and O&M manuals have been written for stormwater BMPs. These materials were written for cities/counties/states with requirements for sustainable stormwater design and contain useful guidance for proper selection and layout of BMPs. Some of the more reputable sources of these materials are listed in Table 4-1:

Table 4-1
Sources of Low Impact Development Guidance Materials

Location/Source	Website	Description
Prince Georges County, Maryland	http://www.epa.gov/owow/nps/lid/lidnatl.pdf	Prince Georges County is considered a national leader in the development and enforcement of stormwater BMP regulations. Their design and O&M manuals are considered by many the most relevant (as they have been field-tested and enhanced)
Low Impact Development Center	http://www.lowimpactdevelopment.org/	A comprehensive resource for sustainable development tools, including specific design examples
Center for Watershed Protection	http://www.cwp.org/PublicationStore/bsd.htm	This website includes a listing of site design manuals and guidance documents on sustainable site design.
Northeastern Illinois Planning Commission	http://www.nipc.org/environment/sustainable/conservationdesign/cost_analysis/	A useful paper documenting the cost savings of Low Impact Development, including specific examples of Illinois developments

4.1.2 BMP Costs

Stormwater BMPs as recommended in this report require the following specific construction efforts:

- Excavation
- Bioswale soil media (an uncompacted sandy loam mixture ideal for growing and infiltration)
- Filter fabric
- Underdrain
- Trees
- Vegetation (plugs, shrubs, and seeding)

Costs to install will very depending on the shape and location of the bioswale. Based on our preliminary cost estimates for the BMP layout in Figure 4-1, bioswales and site rain gardens will cost approximately $10-$15 per square foot to install in the newly-developing areas (due to efficiencies of scale in site construction). Retrofitting existing developments to include BMPs can be less cost-efficient, due to the smaller scale of construction. Costs for retrofitted BMPs could exceed $20 per square foot in existing sites where a retrofit is necessary.

When considering the cost of stormwater BMPs, it is important to consider the cost savings due to less storm sewer and stormwater detention. Numerous sources indicate that Low Impact Development (such as recommended in this report) can reduce overall infrastructure costs by 20% to 30%. As the proposed stormwater BMPs in this report will help reduce the required stormwater detention pond footprint and will significantly reduce the amount of storm sewer pipe necessary, we anticipate that similar cost savings could be achieved in the South Campus area.

Selecting a contractor to install stormwater BMPs is critical. Using local contractors under a low-bid selection process may not provide desirable results. We recommend that the developer be required to include a provision for contractor qualifications for the construction of the stormwater BMPs. The selection of the contractor (or subcontractor) should depend on their experience installing stormwater BMPs. Many contractors in the Chicago area have this experience.

4.1.3 Maintenance Recommendations

Proper maintenance of BMPs is critical for their continued function. Within the first 3-5 years, careful attention must be directed to establishing deep-rooted vegetation in the rain gardens and bioswales. Generally, annual or bi-annual maintenance is required for mulch replacement.

The University should determine who will be responsible for maintenance. If the land tenant is managing the properties, they should be responsible for

BMP maintenance. If this occurs, onsite training and annual inspection should be implemented to guarantee proper maintenance.

4.1.4 Mosquito Abatement

A primary concern regarding stormwater management is the proliferation of mosquitos in wet areas, including ponds, wetlands, and other BMPs. Although this is a valid concern, mosquito control can be designed into each BMP.

Bioretention: These BMPs are designed to completely drain within approximately 24 hours. The installation of an underdrain will help to guarantee that no standing water will remain long enough for mosquito breeding.

Detention Ponds: Detention ponds can be a source of mosquito problems if water remains stagnant for periods exceeding 5-6 days. For wet detention ponds, it is generally recommended to have a deep pool of water (say, 8 feet or more). When wetland shelving is recommended (as it is in this study), continuous flow should be provided to prevent stagnant water from forming. For dry detention ponds, the entire storage area should completely drain within 24-48 hours.

The State of Virginia has published useful guidance on stormwater management with respect to mosquito control. This document, entitled *Stormwater Management Technical Bulletin No. 8, Vector Control, Mosquitoes & Stormwater Management*, is available at the following website:

http://dcr.virginia.gov/soil_&_water/documents/tecbltn8.pdf

4.1.5 Proposed Storm Sewer System

Figure 4-2 is an example of how BMPs employ storm sewers to direct flows from large wet weather events to detention ponds. As rain gardens are designed to detain and infiltrate the 1-year, 1-hour storm, little to no runoff should enter the storm sewer system unless a rainfall of greater than 1 inch occurs. At that point, the conventional storm sewer system takes over.

Figure 4-2
Proposed Storm Sewer System for Large Wet Weather Events

Storm sewers should to be designed to convey the overflow from each BMP to prevent unwanted flooding near the BMP. Catch basins located within each BMP will act as a regulating weir to control inflow into the sewer system and maintain infiltration at the BMP site. The 1-foot elevation difference between the elevation of the bioretention area and the catch basin inlet provides the local storage and the ponding needed to treat the flows associated with wet weather events.

Figure 4-2 illustrates a general concept of how each BMP is connected through these overflow pipes that connect the drainage network through a series of detention ponds. The storm sewer pipes leaving each site should be designed to carry the <u>*100-year 24-hour peak flows*</u> to the intended detention structure with little to no surcharging to prevent excessive flooding at the BMP sites. Although storm sewers are typically designed for a 10-year storm, the 100-year design is necessary in this case, as the proposed storm sewers act as primary flood conveyance.

The obvious difference between a traditional sewer network and the network associated with the proposed LID design is the overland flow that is encouraged to drain localized areas so that less sewer and fewer inlets are required for equivalent drainage designs.

4.2 STORMWATER DETENTION LOCATIONS

The proposed wet and dry stormwater detention basins for the South Campus Research Park are illustrated in Figure 4-3. The small blue areas dispersed throughout the site are water features that would likely serve primarily as decorative features, as they would likely not provide significant storage volume. The three blue- and green-colored ponds along Windsor Road are the three wet detention ponds proposed for this master plan. These ponds will attenuate flow for even small storm events for the areas within the watershed that do not drain into a BMP. The dry detention basins east of [future] Fourth Street are designed for the large wet weather event flows from the BMPs throughout the expanded Research Park. These ponds are be intended to be disguised as general open space with trees and prairie vegetation, while becoming temporarily inundated with water (generally less than 3-foot depth) during major storm events.

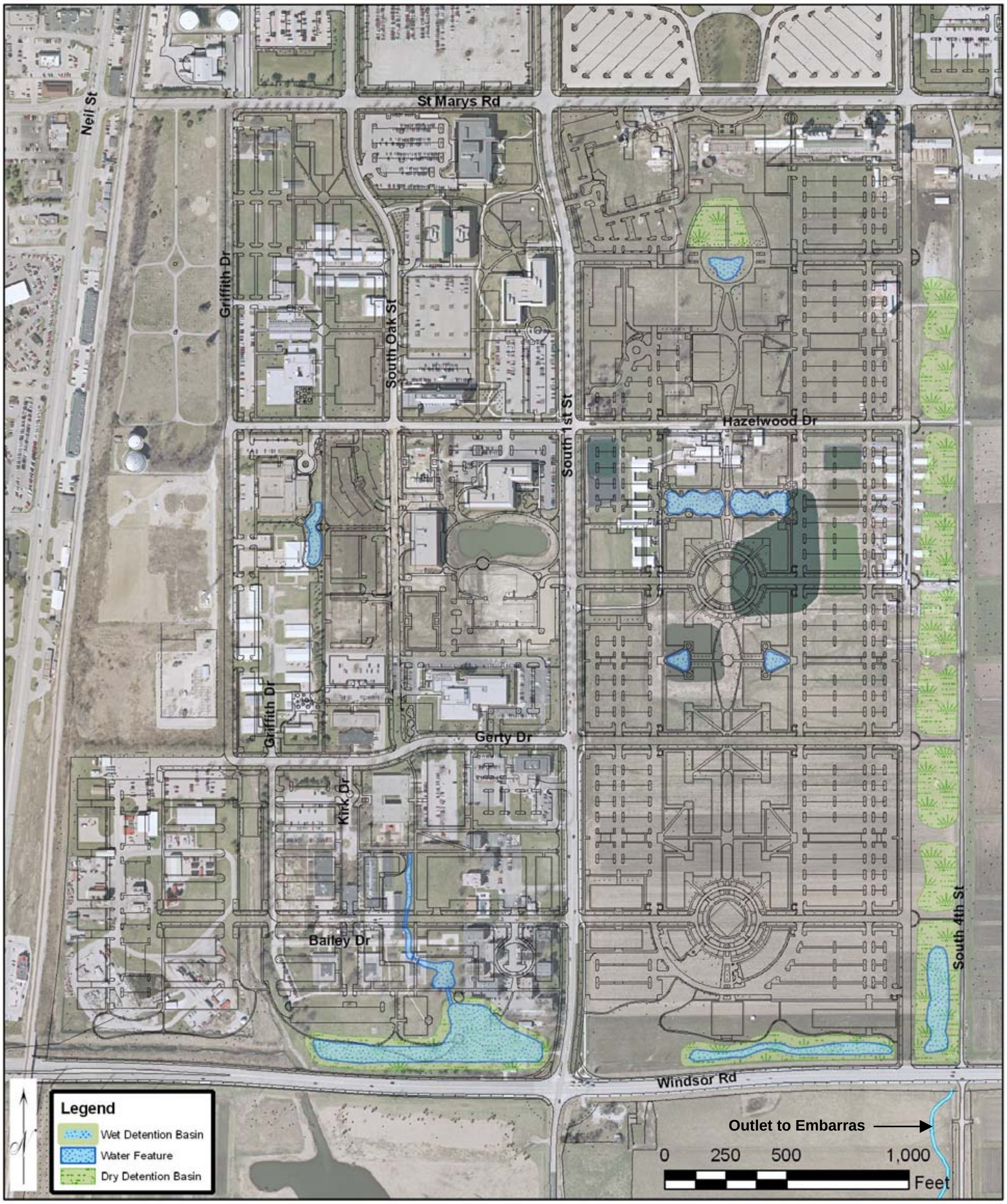


Figure 4-3
Proposed Stormwater Detention Locations

The locations of the water features are arbitrary and most would be designed for aesthetic value and some minor stormwater detention and drainage. These water features would not be large enough to impact the site runoff significantly and there are too few of these ponds to make a significant impact.

The wet detention ponds located along the south edge of the development (along Windsor Road) will serve as the final location for stormwater storage before discharge to the Embarras River. This portion of the site is the most logical area for regional stormwater detention because it is the lowest elevation in the study area. These detention basins will serve to regulate the flow offsite to satisfy stormwater discharge requirements (specifically, to satisfy the City of Champaign).

The eight dry detention ponds along Fourth Street are proposed to be constructed in the designated "green corridor" along Fourth Street. This area will serve as a natural buffer between the Research Park and the proposed golf course. The dry detention ponds will each serve areas to the west of [future] Fourth Street. These ponds will function in series with north basins flowing south into subsequent basins, all the way to Windsor Road. Using these areas as "dry" detention will allow for multi-use of these areas and will minimize the wet detention footprint along Windsor Road. As these ponds will be dry, vegetation (such as trees, shrubs, and native prairie vegetation) can be planted within and along these ponds to increase infiltration and evapotranspiration, as well as providing a pleasing visual amenity.

4.2.1 Detention Pond Sizes and Layout

Figure 4-4 illustrates a plan and profile view of the recommended layout of the eight dry detention ponds to the east and the regional wet detention pond at Windsor Road. The proposed 2-foot contours are shown (upper portion of Figure 4-4) to demonstrate how these ponds can be graded along Fourth Street. *Earthwork in this area will alter the topography so that actual basin sizes and elevations may have to be adjusted to accommodate the design of Fourth Street.*

Figure 4-4 demonstrates that the "step down" pond design allows for shallow detention ponds to be placed along the existing north-to-south slope. This allows for relatively small detention pond footprints and helps to minimize the need for a larger pond downstream.

The dry detention ponds will each accept runoff from individual drainage areas west of Fourth Street (as illustrated in Figure 4-2). The southern-most dry detention pond will discharge into the proposed wet detention pond north of Windsor Road. At this point, flows are regulated prior to discharge to the Embarras River.

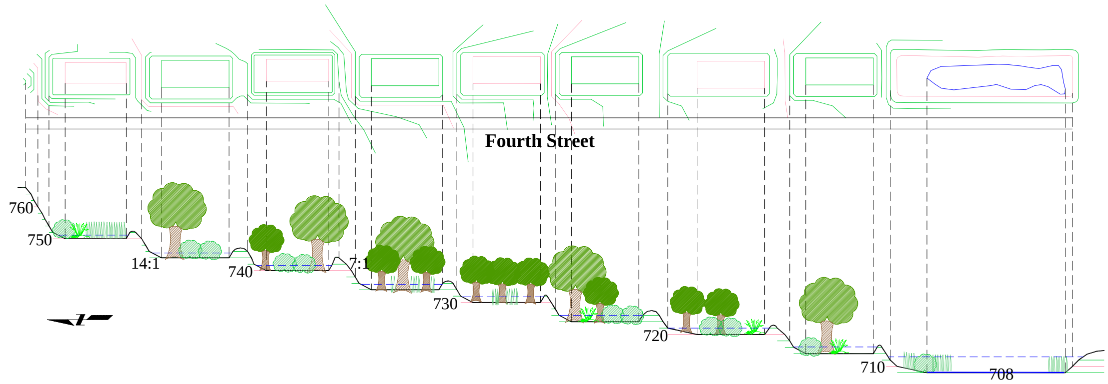


Figure 4-4
Proposed Stormwater Detention Basins

The sizes of the dry detention ponds range from 0.6 to 1.8 acre-feet with footprints between 0.6 ac and 1.1 ac. The calculated ponding depths for the 100-year 24-hour storm range from 1.1 to 2.1 feet, as shown by the blue dashed lines in Figure 4-4. The size and shape of these basins would not be uniform since topography, drainage areas, and development characteristics will dictate the dimensions of these basins. *We recommend that these basins are constructed with natural (irregular) boundaries, as opposed to the rectangular shape shown for volume planning purposes only.*

The outlet of each dry detention pond should be similar to the drop structure shown in Figure 4-5. Each outlet will consist of a drop structure and erosion protection at the downstream end of each pipe. A manhole between each pond (ideally located at the proposed sidewalk) will allow for easy access for periodic maintenance of the outlet pipes. The preliminary design of these basins also allows for a spillway to be located near the drop structure to allow the water to spill into the next basin if the pond fills beyond its design capacity.

The basins are designed with at least 0.5 foot freeboard for the 100-year 24-hour storm before water would overtop spillways. The side slope at the bottom of each basin is approximately 14:1 (horizontal:vertical) that increases to roughly 7:1. These slopes are significantly flatter than traditional pond side slopes, which accomplishes the following goals:

- Allows the pond areas to blend in with the surrounding landscape, making them look less like traditional ponds and more like natural areas
- Reduces the potential for pond slope erosion, which often occurs with steeper slopes
- Encourages pedestrians to use the green space, thereby creating a multi-functional area

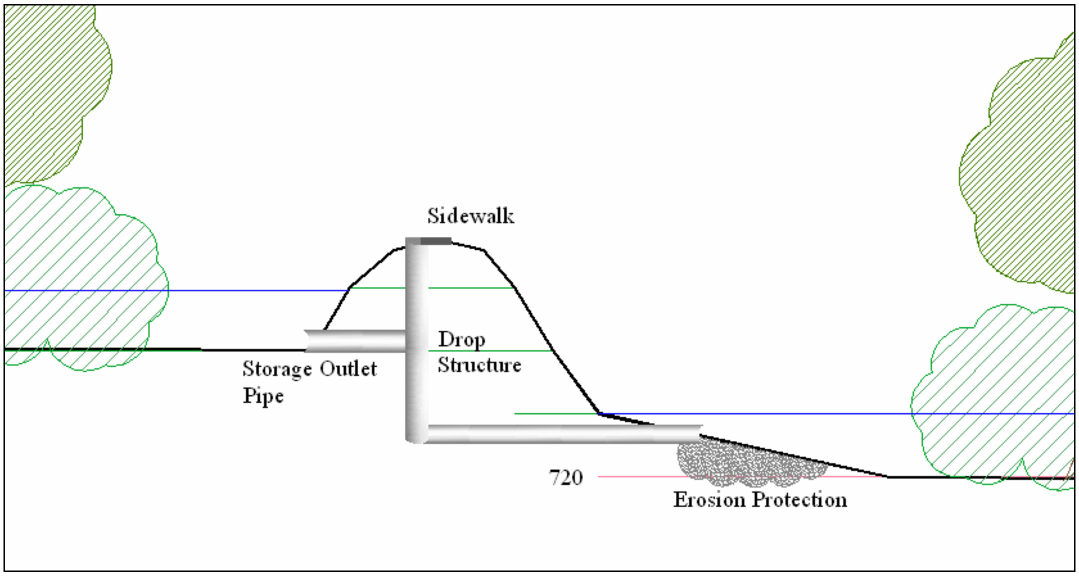


Figure 4-5
Proposed Stormwater Detention Basin Drop Structure

Figure 4-6 illustrates the wet detention basin proposed northwest of the First Street and Windsor Road. This pond should have a total storage volume of approximately 10 acre-feet, with a footprint of about 3.5 acres and a 100-year high water level of approximately 714 (nearly 3 feet above normal pool elevation). This detention pond would collect stormwater runoff from areas west of South First Street that do not discharge to the iCyt pond. This proposed pond would *not* accept flow from the 84-inch north-south trunk sewer or the channel along Windsor Road and the Railroad Tracks.

The 50-acre area proposed to drain to this pond is currently developed; however the South Campus Research Park Master Plan identifies areas to the south that will be redeveloped, which will allow this pond to be installed along Windsor Road. The proposed pond side slopes are 10:1 near the water surface and 6:1 farther up the banks of the pond. These gradual slopes will allow vegetation and possibly a pathway and benches around this pond for added recreational value. The use of 10:1 side slopes also allow for a "wetland fringe" to aid in erosion protection, nutrient uptake, and general improvement in water quality (see Figure 4-8 for a wetland fringe detail).

We recommend that this wet pond be hydraulically separated from the receiving drainage channel (immediately west of the pond) to prevent interaction between floodwaters from other drainage areas. By keeping the pond separate from the channel, the existing channel can remain undisturbed during construction.

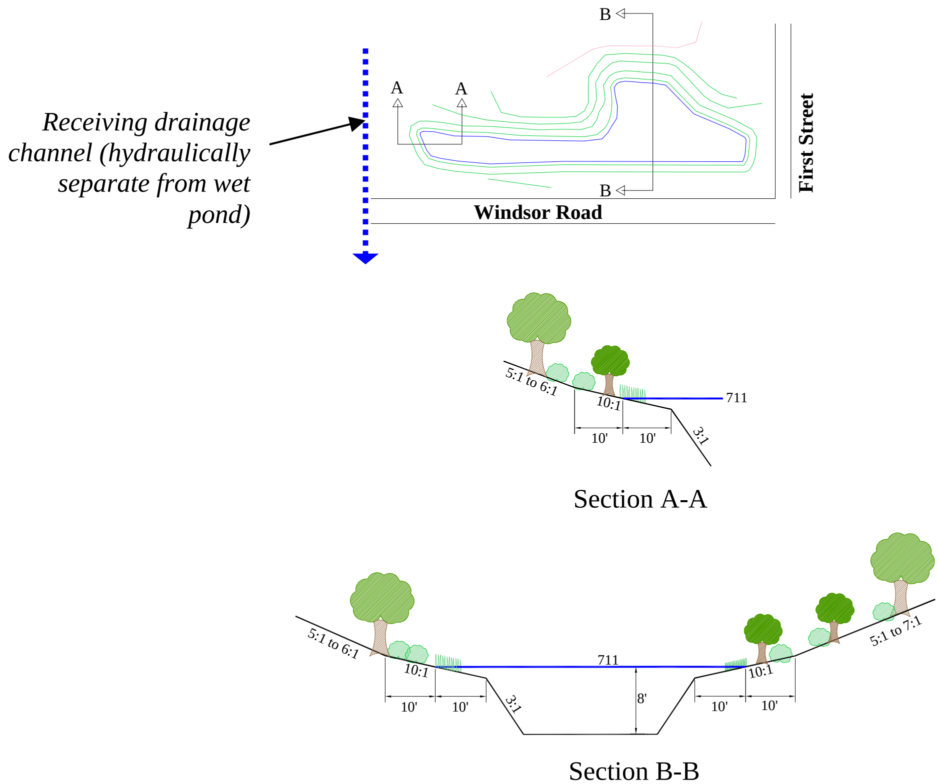
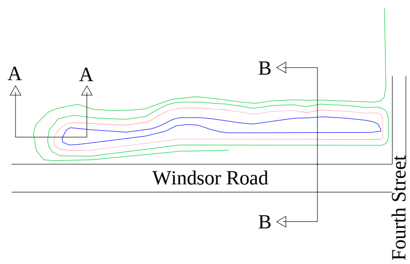


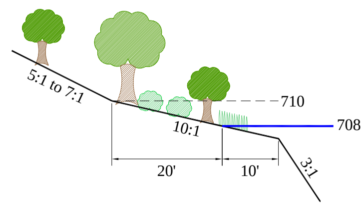
Figure 4-6
Proposed Wet Detention Pond Northwest of Windsor/First Intersection

Figure 4-7 illustrates the wet detention pond between First Street and Fourth Street, north of Windsor Road. This pond accept stormwater runoff from the proposed trunk sewer along South First Street that (which includes the iCyt pond discharge). Although a portion of this watershed currently drains under Windsor Road at First Street, this new flow pattern directs flows east through the regional detention pond before discharging into a meandering channel south of Windsor Road at Fourth Street. This flow pattern would allow greater control of peak flows upon development along South First Street. *Furthermore, this wet detention pond could preclude the construction of the detention basin proposed as part of the new FDC development proposed at the northeast corner of Windsor and First.*

Similar to the wet pond proposed west of South First Street, this detention pond will have 10:1 side slopes near the water surface and 7:1 side slopes at higher elevations. This pond will be connected to the regional detention pond east of Fourth Street directly so that both ponds act as a single pond during wet weather events.

Figure 4-2 provides an overview of all the proposed ponds, showing connectivity and relative sizes/locations.





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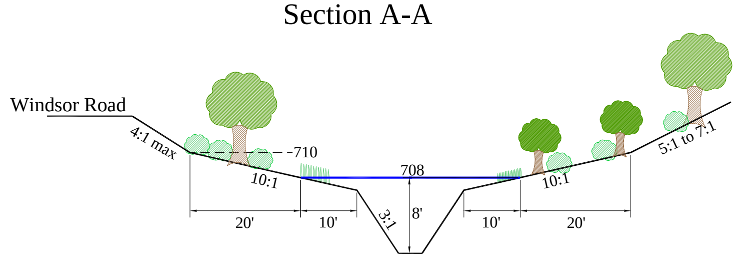

Section B-B

Figure 4-7
Proposed Wet Detention Pond Northwest of Windsor/Fourth Intersection

4.2.2 System Connectivity

Channels, culverts, drop structures, inlets, outlet structures and many other structures will be used to connect the storm sewer network from the BMPs to the Embarras River. Spillways and drop structures will connect the dry detention ponds along the east edge of the study area. Outlet structures, drop structures and spillways will connect the storm sewers and dry ponds to the regional wet detention ponds. The regional detention ponds straddling Fourth Street should be connected using culverts under Fourth Street. The pond immediately northeast of the Windsor/Fourth intersection will contain an outlet structure to regulate peak flows prior to discharge to the Embarras River.

4.2.3 Detention Pond Edge Treatment

Figure 4-8 shows a typical wetland shelf for a detention pond. The 10:1 side slopes near the edge of water promotes the establishment of emergent wetland vegetation. The 10:1 slope on the wetland shelf separates deep water from the shoreline for safety and controls bank erosion. The vegetation on the wetland shelf also serves to filter surface stormwater flow, providing nutrient update and filtering sediment prior to discharge.

This edge treatment is different than traditional detention ponds that have relatively steep slopes and mowed turfgrass down to water. As can be seen in many local developments, traditional detention pond design often leads to severe bank erosion within 5-10 years of development.

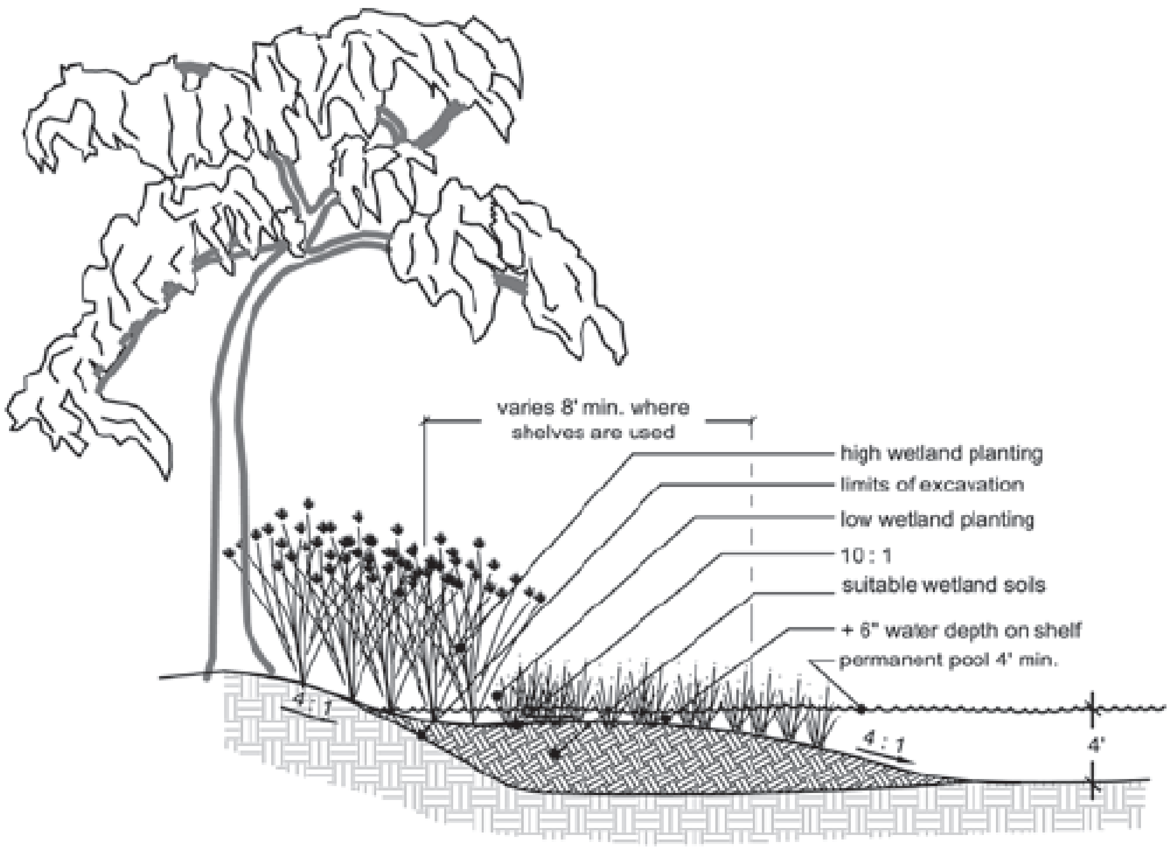

Figure 4-8
Typical Wetland Shelf
(http://crd.dnr.state.ga.us/assets/documents/GGG3B.pdf
Georgia Department of Natural Resources – Coastal Resources Division
Stormwater Management Manual Figure 3.3.2.l)

4.3 OUTLET SIZES AND PATH TO EMBARRAS

The South Campus area drains south under Windsor Road to the Embarras River. The area west of South First Street flows to the existing South First Street Detention Pond (see Figure 2-3).

However, the area east of South First Street flows under Windsor Road and then down road ditches (along First and Fourth Streets) to get to the Embarras River. Under the proposed development, the regional detention ponds will discharge to a point along [future] Fourth Street. Instead of using the existing road ditch to convey site discharge, we recommend a meandering, naturalized channel be constructed south of Windsor Road to add aesthetic appeal to the area and further enhance stormwater quality. This outlet channel should be wider than typical roadside ditches, thereby encouraging lower flow velocities. An adequate easement should be established for this outlet channel to provide for future maintenance and protect it against future encroachment and/or modification. Figure 4-3 illustrates the potential location for this outlet channel.

4.4 IMPACTS OF RECOMMENDATIONS

Figures 4-9 to 4-12 show hydrograph comparisons between three models:

- Existing Conditions Scenario
- Proposed LID Design Scenario
- Traditional Scenario (meeting City's 0.18 cfs/acre requirement)

The *Existing Conditions Scenario* hydrographs were derived from the existing conditions model, based on the site configuration before the hotel and conference center development commenced.

The recommended *LID Design Scenario* hydrographs were developed based on the suggested 5% BMP coverage area for most of the drainage areas identified in the proposed site layout. BMPs were sized for the1-year, 1-hour storm so that surface runoff can be treated by the local BMPs and flows from larger storm events are regulated through downstream detention ponds.

The *Traditional Scenario* includes regional detention ponds (with no BMPs) at the downstream end of the fully developed study area. The hydrograph shown is derived form 250 acres of developed land flowing into regional detention ponds that are designed to regulate the 100-year, 24-hour storm flow to a value lower than or equal to 0.18 cfs/acre (per City of Champaign requirements). The results of these models are discussed on the following pages.

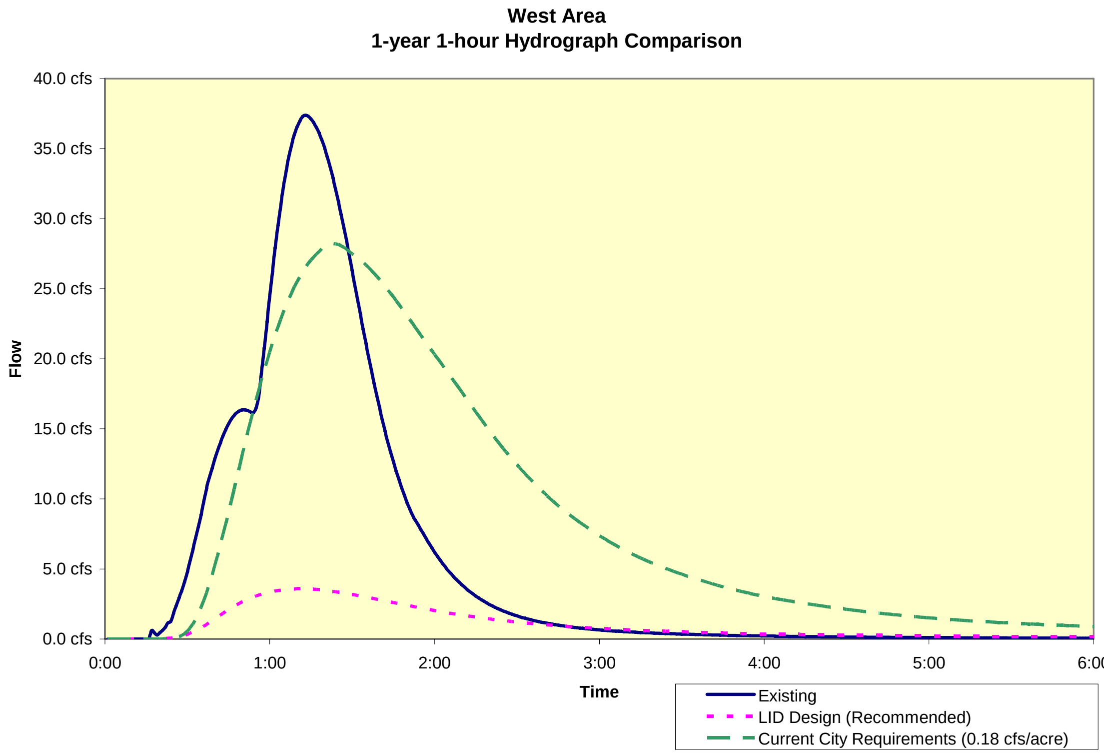

Figure 4-8
West Area: 1-year, 1-hour Hydrograph Comparison

Figure 4-9 illustrates the impact of different design scenarios west of South First Street on the 1-year storm event. This figure demonstrates that the inclusion of BMPs greatly reduces the peak flow and also prevents higher sustained flows after the peak. The important aspect of this figure is the hydrograph shapes, specifically the peak and the width of these curves. The regional detention pond design and the LID design both reduce the peak flows for this storm event for the area west of South First Street. The Traditional Design Scenario (green dashed line) shows a longer duration of flows exceeding 10 cfs than the existing hydrograph. The LID hydrograph reduces the peak flow to below 5 cfs, which eliminates the possibility of long duration high flows for small (frequent) wet weather events. For this size storm event the LID (recommended) design is better with respect to downstream impacts.

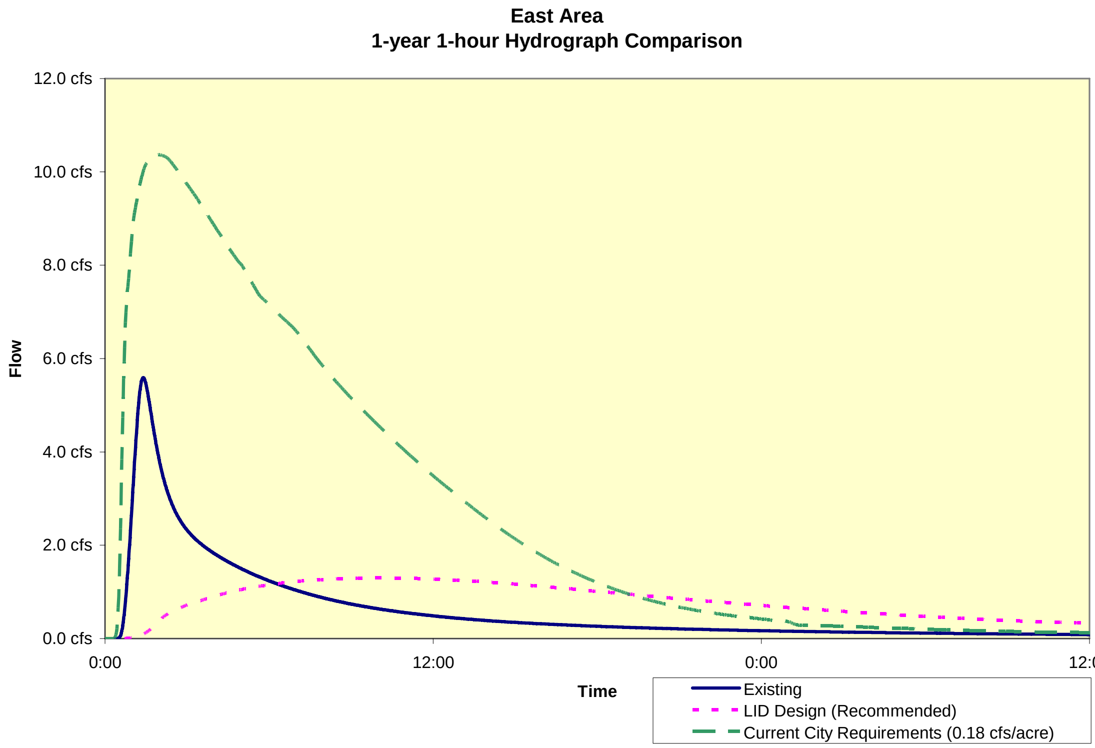

Figure 4-9
East Area: 1-year, 1-hour Hydrograph Comparison

Figure 4-10 illustrates the runoff hydrographs for the 1-year, 1-hour storm event for the area east of First Street (including the iCyt pond drainage area, which is proposed to outlet to the east stormwater management system). These flows are significantly lower that the flow for the west side since this site has yet to be developed. The layout of this site could accommodate either a regional detention pond for the entire area or BMPs scattered throughout the development. The difference with these hydrographs is that the Traditional Design Scenario (designed to meet city specifications) creates a condition where peak flows and longer duration high flows exist. These flows are greater than existing conditions, but the flows are relatively low. The LID (recommended) scenario is the hydrograph with the lowest peak discharge, and maintains flows less than 2 cfs for the duration of this flow event. Figures 4-9 and 4-10 demonstrate that the LID design performs very well during frequent storm events and better than traditional stormwater management practices.

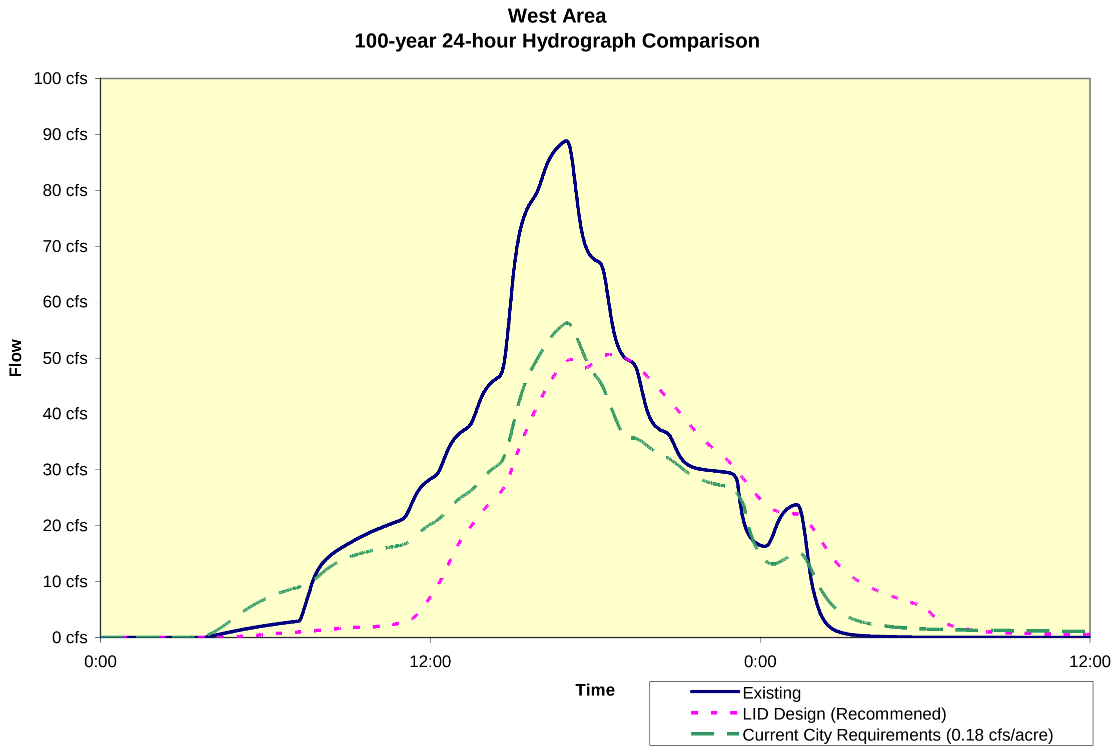

Figure 4-10
West Area: 100-year, 24-hour Hydrograph Comparison

The 100-year, 24-hour hydrographs for the predominantly-developed area west of South First Street (Figure 4-11) show a peak reduction for both the LID design and conventional site design scenarios. The *LID Design Scenario* further reduces the peak and shifts the curve back slightly, but otherwise the two designs produce similar runoff hydrographs for the 100-year storm. The existing and proposed site layout only allows for part of the site to be designed to the 0.18 cfs/acre restriction because of the limited open space available to construct a large regional detention pond. However, as the proposed stormwater management will reduce the impact of peak flows to the Embarras River, this scenario should have a positive impact on area stormwater management (with respect to 100-year flood control).

These hydrographs neglect the flow contribution from drainage areas outside of the study area (areas north of St. Mary's Road that drain to the 84-inch UIUC storm sewer and areas west of Neil Street that drain to the culvert under Windsor Road, just south of the existing fire training facility). We anticipate that these offsite flow contributions should not impact the recommended stormwater management design.

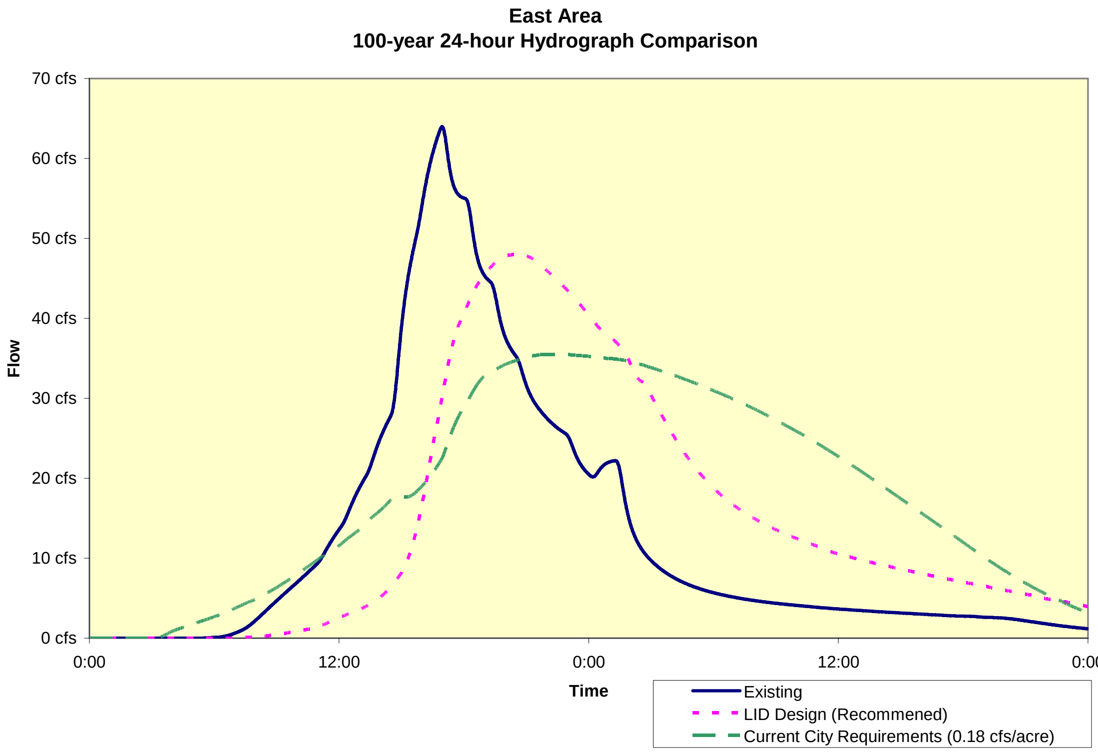

Figure 4-11
East Area: 100-year, 24-hour Hydrograph Comparison

Figure 4-12 summarizes the performance of different design scenarios east of South First Street. These runoff hydrographs show the *LID Design Scenario* 100-year peak flow is higher than the current city requirement of 0.18 cfs/acre, but still lower than the existing conditions. The duration of flows greater than 10 cfs is shorter for the LID design than under the *Traditional Design Scenario*. The flow measured at 15 hours after the peak of these scenarios is 50% lower for the LID design than the *Traditional Design Scenario*. 12 hours after the end of the precipitation event, the *Traditional Design Scenario* would discharge flows of approximately 23 cfs, while the LID design would discharge less than 11 cfs. The LID design has a similarly shaped hydrograph as the existing conditions hydrograph, but the curve is shifted to a later time and has a lower peak. This design shows an improvement over existing conditions, but does not meet the 0.18 cfs/acre discharge limit established by the City of Champaign.

4.4.1 Being Creative *and* Meeting City Requirements

The hydrographs shown in Figures 4-9 to 4-12 demonstrate how LID design can improve hydrologic conditions for both large, infrequent storm events as well as the smaller, more frequent events. The LID design performs very well for the small storm events and improves flow conditions for the large storm events. Most importantly, the modeling effort reveals that post-development peak stormwater runoff can be reduced under the *LID Design Scenario*.

However, the peak flow is not the only concern for drainage networks and channels. Traditionally-designed detention ponds produce long duration high flows that stress channel sideslopes, accelerating erosion. Higher flows for long durations can be just as (if not more) damaging as high peak flows. The LID design reduces the duration of high flows by storing less water at the downstream end of the drainage area. The runoff characteristics resulting from LID design better resemble the existing hydrograph shape and duration.

The traditional approach results in an altered runoff hydrograph that changes the flow regime in the Embarras River. The LID design is a creative approach that enhances water quantity and quality scenarios. The LID design specifically addresses the first inch of rainfall, which often carries the greatest pollutant load. By effectively removing this polluted runoff from the drainage network, cleaner runoff will be discharged into the Embarras River.

Table 4-2 summarizes the total stormwater runoff *volume* for the key design scenarios discussed in this study. For the east drainage area, LID is important to avoid a drastic increase in total runoff volume (with traditional design, runoff volume from the first flush storm would increase by as much as 400% in the east drainage area). For the west drainage area, LID would actually *reduce* runoff volume, given that most of this area is already developed and would benefit from new stormwater controls (that is, the baseline runoff values are higher in the west drainage area).

Table 4-2
Hydrograph Volume Comparison
(all values listed are in acre-feet)

Drainage Area	Storm Event	Existing	LID Design (Recommended)	Current City Requirements (0.18 cfs/ac)
East	100-year, 24-hour	49.7	58.7	71.9
West	100-year, 24-hour	59.0	44.7	46.8
East	1-year, 1-hour	1.9	2.6	8.3
West	1-year, 1-hour	2.8	0.6	4.5

Sharing these results with the City of Champaign should increase the probability of technical buy-in from their engineering staff.

4.4.2 Construction Phasing and Project Prioritization

The recommended construction sequence of the detention ponds and trunk storm sewer along First Street is shown in Figure 4-13 with both primary and secondary construction phasing indicated. This sequence is based on the knowledge of the current construction and plans for development east of First Street, as well as the assumption that development will first occur along the South First Street corridor.

Figure 4-13 shows that the regional detention ponds near Fourth Street and Windsor Road and the meandering channel south of Windsor Road are the highest priority for this site development, as this establishes the primary drainage outlet for the majority of the study area.

Upon establishing the primary drainage outlet, an enlarged trunk storm sewer along First Street needs to be installed before any development along First Street occurs. This trunk sewer will accommodate increased stormwater runoff (resulting from high-intensity storms after development) and convey this runoff to the proposed regional detention pond north of Windsor Road.

The dry detention basins east of Fourth Street can be constructed as development along Fourth Street progresses. These basins would likely be constructed later, as development along this corridor will likely not occur until Fourth Street is extended south of St. Marys Road. Local storm sewers and BMPs can connect to these detention areas as development occurs.

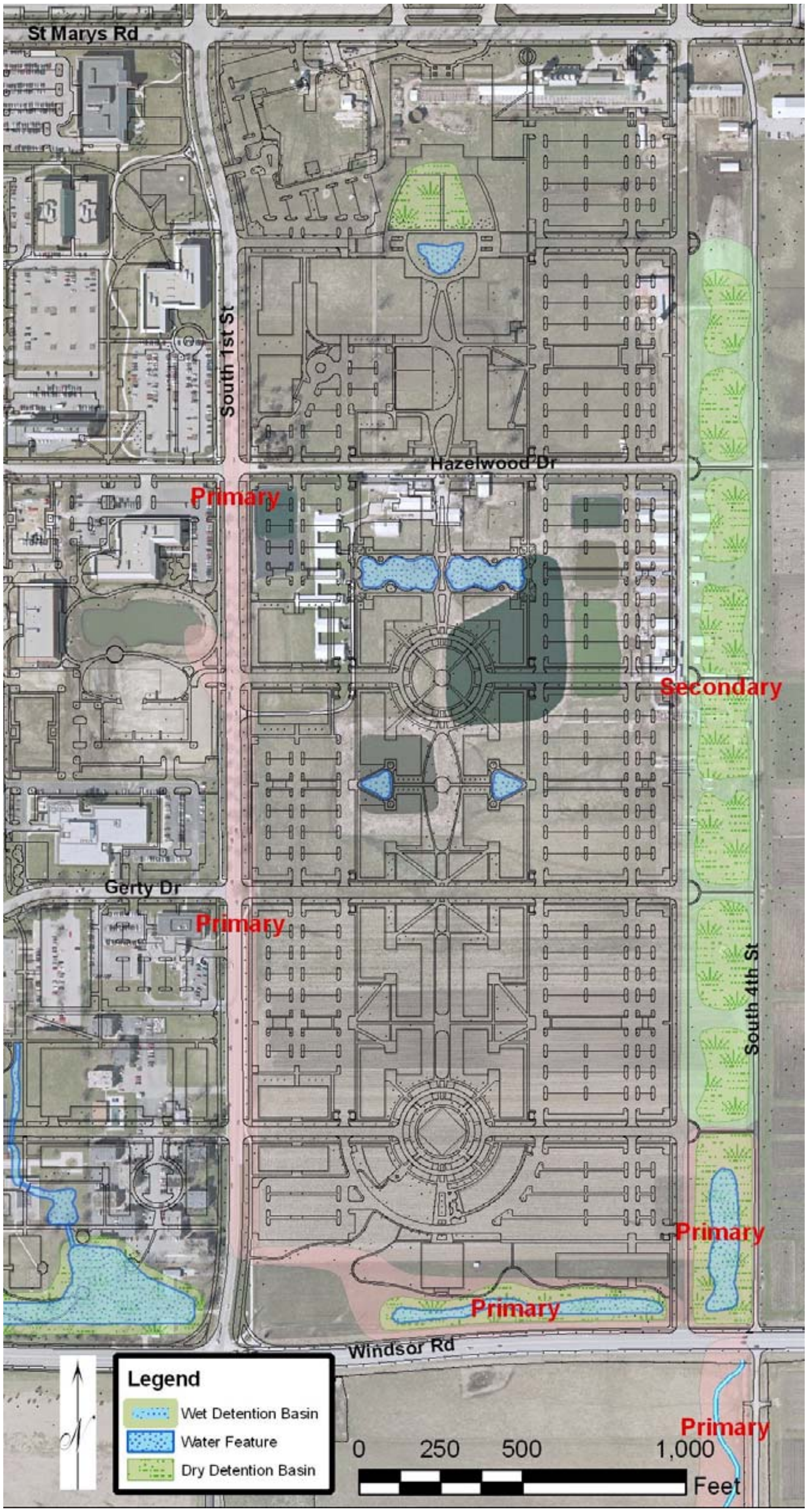

Figure 4-12
Proposed Construction Phasing

Figure 4-14 illustrates the site plan for the hotel and conference center at the corner of St. Marys and South First Street (currently under construction) and the proposed drainage structures associated with this site. The current plan shows a shallow detention area (or rain garden) at the northwest corner of the site which could receive surface runoff from the adjacent parking areas and discharge excess flows into the storm sewer along St. Marys Road.

The remaining site flows to the southeast towards a detention pond situated at the southeast corner of the site. The size and location of this detention structure provides an opportunity for BMP retrofit, as the volume of the detention pond appears to be larger than necessary for the hotel and convention center. We recommend that the northwest fringe of the detention pond be converted to a rain garden, with an overflow berm into the flood storage cell (remaining pond footprint). The storm sewer from the west could flow directly into the rain garden, while the storm sewer for the east parking lot could be redirected into the rain garden as indicated in Figure 4-14.

This BMP would require a 1-foot high berm that would separate the rain garden from the detention area so that large wet weather events would flow over this berm and into the detention storage area. The outlet of the detention basin should have an overflow structure at the southeast corner to provide for appropriate flood conveyance (for emergency overflows). The 6-inch outlet (as designed) is not adequate to serve as an emergency overflow conduit.

The flow from this retrofitted pond would then need to be directed to the dry ponds along Fourth Street via an internal storm sewer system (ideally larger than the 6-inch sewer as designed). Additional excavation of this basin could allow for a wet pond area that could double as a water feature (the Research Park Master Plan identifies a water feature immediately south of this detention pond).

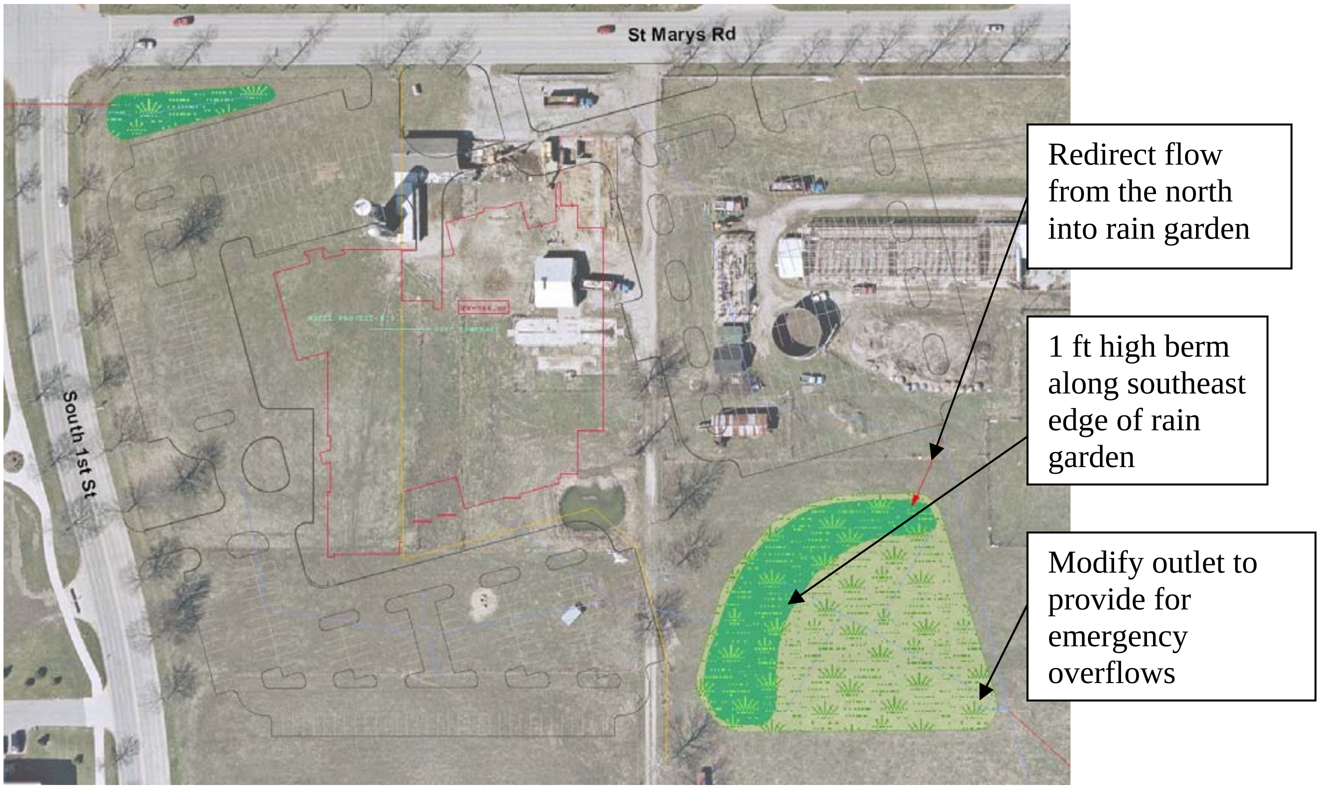

Figure 4-14
Hotel and Convention Center Site

4.4.3 Immediate recommendations for FDC commercial development northeast of the Windsor/First intersection

University staff indicated that a preliminary plan exists for developing the northeast corner of First and Windsor. The developer has proposed a commercial development with conventional stormwater management (a detention pond at the southwest corner of the property).

The proposed detention pond for this development could be eliminated if the regional wet detention ponds straddling Fourth Street and the meandering channel south of Windsor Road were constructed before this site is developed. Instead of constructing a detention pond at the southwest corner of the development, a BMP (or series of BMPs) could be constructed, ultimately discharging to the wet detention pond east of the site. The total footprint of the BMPs would be considerably smaller than the pond as proposed in the preliminary site plan.

Replacement of the South First Street trunk storm sewer should occur before this site is developed, but this step is not as critical as the regional detention ponds and primary outlet channel. If development of this site occurs before a regional detention pond can be constructed as recommended, then an onsite detention pond will be necessary to meet City of Champaign requirements.

4.5 OTHER BEST MANAGEMENT PRACTICES

Although bioretention is the key recommended method of promoting stormwater infiltration for this Master Plan, other options exist to reduce the impact of stormwater runoff.

Although the alternate methods listed below provide stormwater quality benefits, they do *not* replace the need for stormwater detention for a design storm event (i.e. 100-year storm). As such, these practices would still require the use of detention ponds (as does the bioretention recommended in this report).

- ***PROPRIETARY STORMWATER QUALITY STRUCTURES:***
  Bioretention (using rain gardens and bioswales) is not the only way to provide stormwater quality enhancement. Proprietary devices are also available to trap pollutants at the source. These devices are typically contained within an underground structure (such as a vault or manhole) and can intercept the "first flush" volume, separate total suspended solids (TSS) and provide flow bypass for larger (i.e. 10-year) storms. Figure 4-15 includes sample images of available technologies.

Aqua-Swirl™
Stormwater Quality Device

Inlet Filter

Figure 4-15
Structural BMP Options

Note: *The products shown above are proprietary. This does not represent an official endorsement of these specific products, but is meant only to demonstrate the type of structural BMPs available. Multiple vendors provide similar products to those shown above.*

Key advantages of these devices:

- Devices can be installed underground when little to no green space is available.
- When properly maintained, these devices can reduce stormwater pollution.

Key disadvantages of these devices

- Often more expensive than bioretention and other surface BMPs
- Require regular maintenance (i.e. cleanout), sometimes as often as every 3-6 months.
- Some devices require filter replacement. Filter replacement can be labor-intensive and replacement filters are often very expensive.
- Testing data reveal that these devices are typically not as efficient as surface BMPs (i.e. bioretention) in removing stormwater pollutants.
- These devices typically do not provide infiltration. Instead, they focus on sediment and debris removal while sending stormwater runoff downstream to the receiving sewer system.

For the South Campus development / redevelopment, we recommend a focus on "green" solutions (integrating bioretention into available green space). Proprietary stormwater quality devices can be used for individual development areas in which little to no green space is available.

- ***PERMEABLE PAVEMENTS***: Permeable pavements are a common method to promote stormwater infiltration. Although there are no current plans to employ permeable pavements in this Master Plan, they can be considered an alternate BMP if a lack of green space prevents the use of bioretention on a specific site.

Figure 4-16
Permeable Pavements
Image Source: Interlock Paving Systems

Permeable pavements are typically more expensive than conventional concrete or bituminous pavements. Furthermore, they require significant maintenance. Frequent sweeping and vacuuming is necessary to keep the pore spaces free of sediment and allow the pavement to function as designed.

- ***GREEN ROOFS***. Green roofs transform impervious surfaces (rooftops) into pervious surfaces. This reduces stormwater runoff volumes and provides a similar level of treatment provided by bioretention.

  A properly-designed green roof can also provide energy efficiencies for the building it covers (by providing insulation), and often results in additional points for LEED Certification. Water collected in the green roof collection system can be reused for site irrigation, water features within or surrounding a building, or used in the building's cooling system.

Figure 4-17
Green Roof – Chicago City Hall

  University staff indicated that green roofs would likely not be constructed in the project area. If future development plans accommodate the use of green roofs, they could reduce the area needed for bioretention or other BMPs identified in this report.

- ***RAIN BARRELS / CISTERNS.*** This type of BMP is used to collect runoff from rooftops and store it in above-ground tanks. These tanks (often referred to as rain barrels for residential use and cisterns for larger-volume commercial applications) can be used to supplement irrigation water for landscaping and grassed surfaces. Cisterns, which can be integrated into the architectural character of a building, can provide a significant benefit by allowing rain water to be stored and used to water landscaped areas. This also promotes infiltration, as the majority of landscape watering will soak into the soil.

Although this Master Plan makes no specific references to cisterns in the recommendations, a cistern can be used to reduce the area needed for bioretention or other BMPs identified in this report.

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