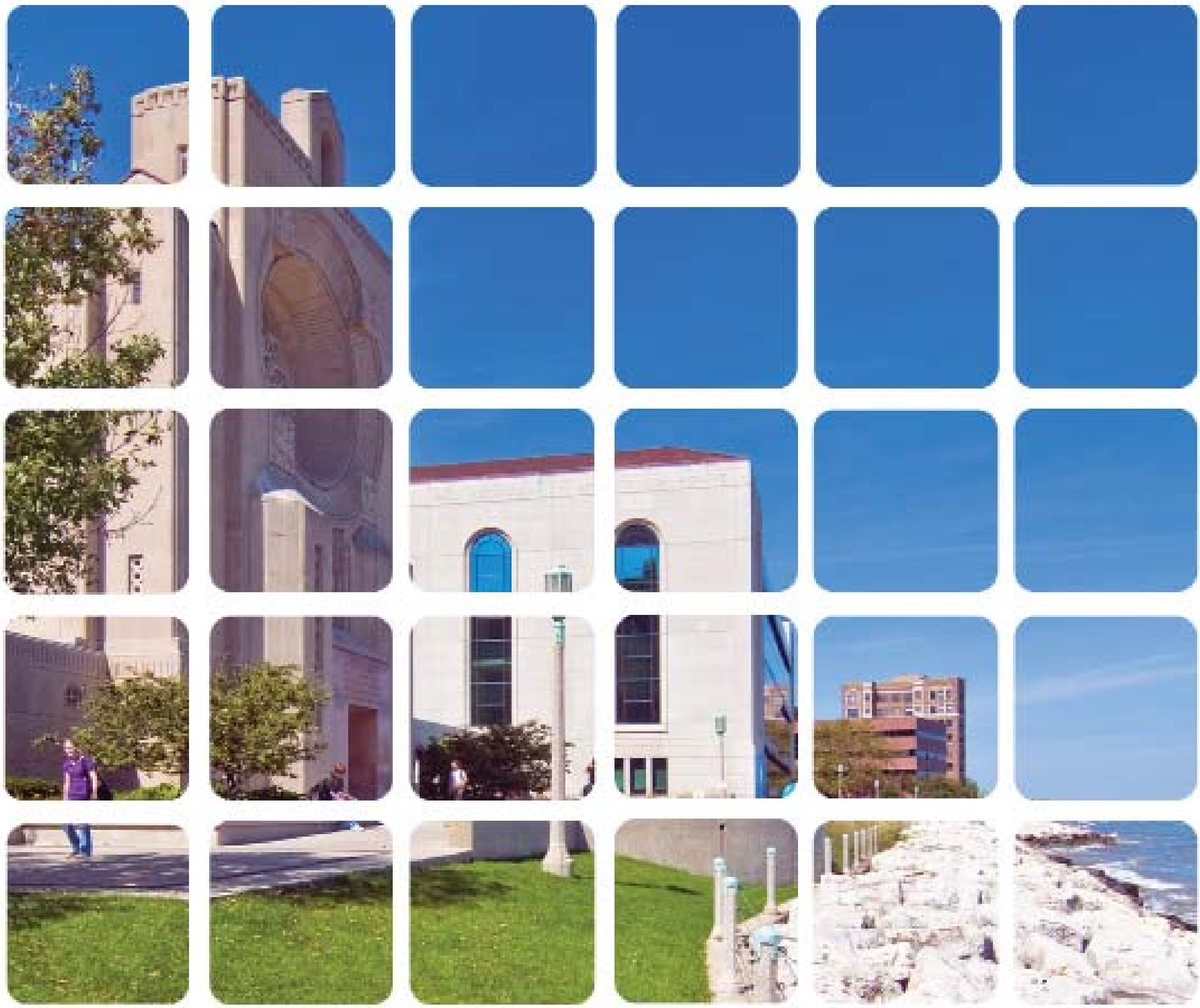
STORMWATER MANAGEMENT MASTER PLAN
LOYOLA UNIVERSITY CHICAGO
LAKE SHORE CAMPUS



LOYOLA
UNIVERSITY CHICAGO

February 6, 2009

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CAMPUS SUMMARY

As Loyola University Chicago (LUC) embarks on several major construction projects on the Lake Shore Campus over the next five years, JJR has developed a Stormwater Management Master Plan to provide a holistic approach to efficiently manage stormwater runoff for the campus.

The area considered for the Lake Shore Campus Stormwater Management Master Plan consisted of approximately 29.09 acres of the campus bounded by W. Loyola Avenue to the north, W. Sheridan Road to the south, N. Sheridan Road and the CTA Red Line tracks to the west, and Lake Michigan to the east. A large portion of the existing facilities on the Lake Shore Campus were constructed prior to when any stormwater management regulations were in effect. However, over the last several years, LUC has completed numerous campus projects involving new building construction, building additions, and general landscape/hardscape improvements. Each of the recently constructed projects have been permitted through various departments of the City of Chicago with most requiring some method of stormwater management on site for either detaining stormwater runoff to reduce peak flows to the existing combined city sewer systems or for treating stormwater runoff to reduce pollutant loads prior to discharging to Lake Michigan. The Stormwater Management Master Plan will serve as a guide to LUC, providing implementation strategies that meet the needs for the studied areas of the Lake Shore Campus resulting in a more cohesive and effective solution rather than designing and constructing individual systems for each new project.

The City of Chicago adopted a new Stormwater Management Ordinance, effective January 1, 2008, that increases the previous stormwater management requirements. The City of Chicago Stormwater Management Ordinance requires both rate control measures to regulate the release of stormwater to a rate allowable based on the capacity of the city's sewer system at the specific project location and volume control measures to ensure that a portion of stormwater runoff from each project is captured, retained, and treated within the site to reduce harmful effects on the hydrologic cycle and to improve the water quality of runoff.

This report studied the existing and proposed conditions within the Lake Shore Campus and provides preliminary estimates for the size of stormwater treatment devices that would be needed to meet both rate and volume control requirements per the City of Chicago's ordinance. JJR analyzed the existing conditions for the campus as of spring 2008. The future proposed conditions were based on the approved Final Framework Plan 2012, prepared by JJR and dated October 2007, as modified by current design plans for three campus improvement projects that JJR is working on in various stages of development: East Quad, Cudahy Faculty Lounge, and the Center for Varsity Athletics. Summaries of the existing and proposed drainage conditions will be presented followed by a discussion of potential stormwater management techniques, called Best Management Practices, that LUC can implement in order to meet the stormwater treatment requirements for the campus.

Fig. 1.0 Lake Shore Campus (JJR)

EXISTING CONDITIONS

The 29.09 acres of campus studied for this report were divided into 11 drainage areas. The drainage areas were determined by evaluating existing survey information and design plans, when available, to classify general drainage patterns and identify where sewers within the campus discharge to either City of Chicago sewers or Lake Michigan. Building roof areas have been assigned to drainage areas as accurately as possible, but for a majority of the older campus buildings, it is indeterminate where roof internal drainage lines or external downspouts are connected to sewers. Inaccuracies in roof drainage assignment should have minimal effects on the future stormwater requirements outlined later in this report, as future requirements are determined by actual disturbed areas, not necessarily all upstream tributary areas. The existing drainage areas are described as follows (see figure 2.2):

Drainage Area 100: Northwest Area to N. Sheridan Road

This area is 3.39 acres and contains the Alumni Gym, Centennial Forum, Mertz Hall, and part of the Gentile Center. This area has two existing sewer outlet connections, one 18-inch and one 12-inch located between Alumni Gym and Centennial Forum, that appear to connect to a 72-inch combined city sewer located in the N. Sheridan Road right-of-way. It is not known if there exists any restrictions on storm sewer connections to the existing sewer outlets or if any existing detention or stormwater treatment devices are provided in this area.

Drainage Area 101: Recreational Sports Field

This area is 1.92 acres and contains the Recreational Sports Field constructed in 2007. This project utilized permeable pavers within the new pedestrian and emergency vehicle pathway system. Approximately 10,450 cubic feet of stormwater detention storage was provided in pipes, manhole structures, and in the aggregate voids of sewer underdrain to meet city stormwater management requirements. This area has two existing outlet control structures that contain City of Chicago 4-inch vortex restrictors that limit the rate of discharge to the existing combined city sewer in the W. Loyola Avenue right-of-way to 0.25 cubic feet per second (cfs) for each device. The western control structure has an 8-inch sewer connection to the existing combined sewer, which is 18 inches at the connection point, and the eastern control structure has an 8-inch sewer connection to the existing combined sewer that is 15 inches at the connection point.

Fig. 2.0 Recreation Sports Field Permeable Pavers (JJR)

Drainage Area 102: Northeast Area to W. Loyola Avenue

This area is 1.63 acres and contains the Crown Center and part of the Cudahy Library. (JJR has assumed that part of the roof drainage of the existing Cudahy Library is connected to the sewer system defined within Drainage Area 102, although this cannot be confirmed by current available topographical surveys.) This area has an existing 10-inch sewer outlet connection to a 15-inch sewer located in the W. Loyola Avenue right-of-way. It is not known if there exists any restrictions on storm sewer connections to the existing sewer outlet or if any existing detention or stormwater treatment devices are provided in this area. Three existing sump pumps are identified in this area on the current topographical surveys that provide discharges for low elevation areas within the campus that cannot drain by gravity to existing sewers. It appears that sump pump “A” provides an outlet for drainage from the lower level entrance to the Crown Center, and possibly some interior sewer outlets. Sump pumps “B” and “C” appear to drain interior sewer outlets for portions of the Cudahy Library.

Drainage Area 103: West Area to W. Sheridan Road

This area is 10.91 acres and contains the Halas Sports Center, Steam Plant, Dumbach Hall, Cudahy Science Hall, Flanner Hall, and portions of Gentile Center and Cudahy Library in addition to the Parking Garage and the Halas Athletic Field and Track. This area has two existing sewer outlet connections, one 12-inch and one 24-inch, that connect to an 81-inch combined city sewer located in the W. Sheridan Road right-of-way at the N. Winthrop Avenue intersection. It is not known if there exists any restrictions on storm sewer connections to the existing sewer outlets or if any existing detention or stormwater treatment devices are provided in this area.

Drainage Area 104: East Pump Station

This area is 3.02 acres and contains the Jesuit Residence Hall and Information Commons. This area is the lowest point on the Lake Shore Campus, approximately elevation 7.00 City of Chicago Datum (CCD). The drainage from this area is restricted to 0.89 cfs per the existing outlet pump capacity, and stormwater detention storage is provided in pipes and manhole structures. The pump discharges to a 15-inch sewer, which ultimately discharges to the existing 81-inch combined city sewer located in the W. Sheridan Road right-of-way.

Drainage Area 105: Pre-treatment Area of Information Commons

This area is 0.64 acres and contains landscape and hardscape areas around the Information Commons building, constructed in 2007, that discharge to Lake Michigan. Per ordinance requirements in effect at the time of this project, detention was not required if the project site directly discharged to Lake Michigan, but stormwater quality measures were required. The runoff from this area is directed to a CDS® Pre-treatment Manhole, Model PMSU20_15. The CDS® unit uses patented Continuous Deflective Separation technology that effectively removes sediments, oil and floatables from stormwater runoff prior to discharging to Lake Michigan.

Drainage Area 106: Northern Shoreline of Lake Michigan

This area is 1.27 acres and contains the newly constructed Information Commons campus building as well as areas adjacent to the shoreline protection system. Per ordinance requirements in effect at the time of this project, building roof drainage was allowed to be directly discharged to Lake Michigan without any treatment. Additionally, a portion of the Information Commons roof was constructed with a green roof system. The remaining landscape and hardscape areas adjacent to the shoreline revetment wall within this drainage area sheet flow directly into the lake.

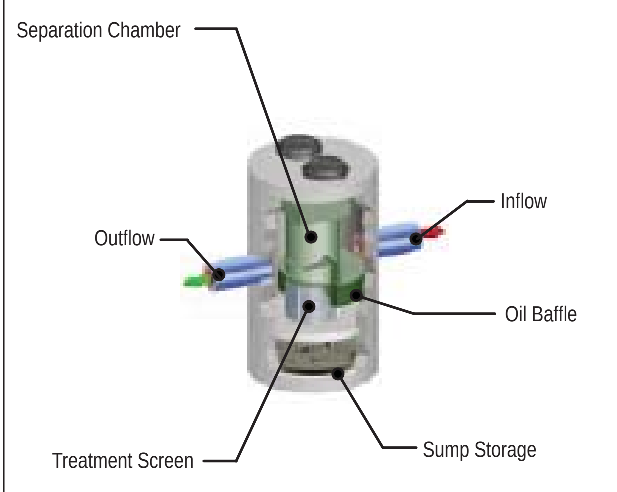


Fig. 2.1 CDS® Filter (Contech Constructions Products, Inc. www.contech-cpi.com/stormwater/13)

Drainage Area 107: Quinlan Life Sciences Center

This area is 1.08 acres and contains the Quinlan Life Sciences Center. This project was constructed in 2004 and has three outlet control structures, each with City of Chicago 3-inch vortex restrictors that restrict the flow to 0.15 cfs each. A portion of the building roof was constructed with a green roof system. The majority of this site area, which includes the building and associated walks and landscape areas, is directed to at-grade detention ponds, and the outlet control structure ties into an 18-inch sewer that connects to the 81-inch city sewer located in the W. Sheridan Road right-of-way at the N. Kenmore Avenue intersection. The other two control structures restrict the runoff rate from the small areas near the Quinlan Life Sciences Center loading dock and the Damen Hall loading dock. Both of these control structures discharge to combined sewers within the campus that connect to the 81-inch city sewer located in the W. Sheridan Road right-of-way at the N. Winthrop Avenue intersection.

Drainage Area 108: Southeast Area to W. Sheridan Road

This area is 3.59 acres and contains the Mundelein Center, Damen Hall and the Madonna Della Strada Chapel. This area has two existing sewer outlet connections, one 12-inch and one 18-inch, that connect to an 81-inch combined city sewer located in the W. Sheridan Road right-of-way at that N. Kenmore Avenue intersection. It is not known if there exists any restrictions on storm sewer connections to the existing sewer outlets or if any existing detention or stormwater treatment devices are provided in this area.

Drainage Area 109: W. Sheridan Road Courtyard

This area is 0.67 acres and contains the courtyard that is located between Piper Hall, Coffey Hall, the Mundelein Center and W. Sheridan Road. This courtyard was constructed in 2006, and storm runoff is directed to a surface infiltration pond located adjacent to the Lake Michigan shoreline on the north side of Coffey Hall. The total storage volume required was 3,562 cubic feet for detention requirements including 363 cubic feet for water quality requirements. A total of 4,013 cubic feet were provided within the infiltration pond as well as in pipe and structure storage. The infiltration pond does not have a direct outlet; rather, runoff is designed to infiltrate into the existing soils and, if necessary, the pond will overflow over the shoreline revetment wall into Lake Michigan.

Drainage Area 110: Southern Shoreline of Lake Michigan

This area is 0.97 acres and contains Coffey Hall, Piper Hall, and the plaza and gardens around Piper Hall. These areas either drain to an infiltration pond located south of Piper Hall (which is just outside the area limits of this analysis) or sheet flow directly into Lake Michigan. Like the infiltration pond in Drainage Area 109, the infiltration pond does not have a direct outlet and will overflow to Lake Michigan in emergency situations.

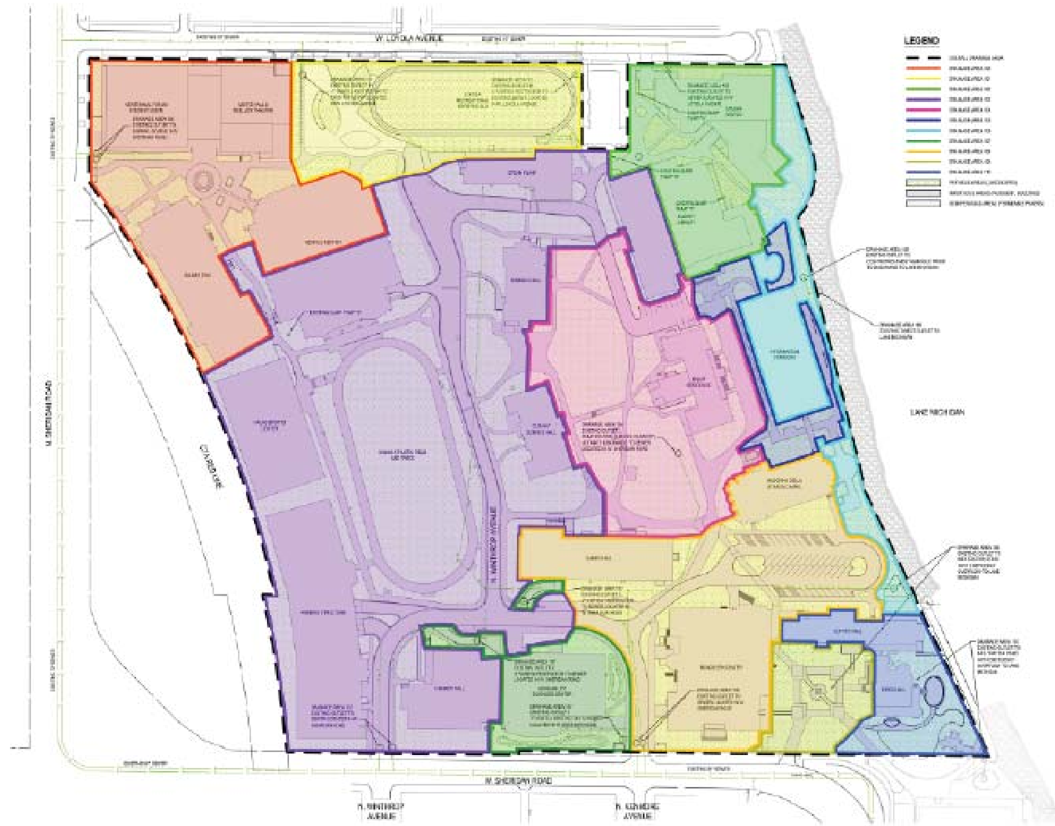


Fig. 2.2 Existing Drainage Area Map - Lake Shore Campus (See Appendix A) (JJR)

Existing Drainage Area Calculations
Lake Shore Campus

Drainage Area	Area (Sq. Ft.)	Area (Acres)	Impervious Area (Acres)	Permeable Pavers (Acres)	Pervious Area (Acres)	Avg. C Value
100-Northwest Area	147461	3.39	2.69	0.00	0.70	0.81
101-Recreational Sports Field	83812	1.92	0.35	0.28	1.29	0.49
102-Northeast Area	70989	1.63	1.32	0.00	0.31	0.82
103-West Area	475254	10.91	7.28	0.00	3.63	0.72
104-East Pump Station	131628	3.02	1.16	0.00	1.86	0.53
105-Pre-treatment Area	27867	0.64	0.31	0.00	0.33	0.59
106-Northern Shoreline	55226	1.27	0.72	0.00	0.55	0.66
107-Quinlan Life Sciences Center	47179	1.08	0.70	0.00	0.38	0.71
108-Southeast Area	156163	3.59	3.09	0.00	0.50	0.86
109-Sheridan Road Courtyard	29313	0.67	0.22	0.00	0.45	0.50
110-Southern Shoreline	42375	0.97	0.57	0.00	0.40	0.67
TOTAL	**1267267**	**29.09**	**18.41**	**0.28**	**10.40**	**0.71**

Impervious C = 0.95

Permeable Pavers C = 0.95*

Pervious C = 0.27

Fig. 2.3 Existing Drainage Area Table - Lake Shore Campus (JJR)

NOTES

The runoff coefficient, C, describes the ability of a surface to absorb stormwater. A runoff coefficient of 0.95 means that a surface can only absorb approximately 5% of rainwater that falls onto the surface and the remaining 95% of rainwater becomes surface stormwater runoff. Surfaces with high runoff coefficients, like pavement and buildings, are described as impervious, whereas surfaces with low runoff coefficients, like landscaped areas, are described as pervious because they have a higher capacity to absorb runoff.

* The permeable paver surfaces have been assigned a high runoff coefficient (the same as impervious surfaces) as a conservative calculation. The City of Chicago Stormwater Management Ordinance allows for flexible use of the assigned runoff coefficient for permeable pavements depending on how the surface is chosen to be used for runoff treatment. Each future drainage area will be evaluated on a case by case basis during engineering design to determine the best solution for assigning runoff coefficients to each area.

PROPOSED CONDITIONS

The future proposed conditions were based on the approved Final Framework Plan 2012, prepared by JJR and dated October 2007 (see figure 3.9), as modified by current design plans for three campus improvement projects that JJR is working on in various stages of development: East Quad, Cudahy Faculty Lounge, and the Center for Varsity Athletics. JJR reviewed each of the 11 existing drainage areas for changes in their composition that would affect drainage characteristic changes (addition or removal of campus buildings as well as hardscape changes). Based on assumptions of future grading changes within the campus due to new building and/or hardscape construction projects, slight modifications were made to the size of some of the 11 drainage areas determined when analyzing the existing conditions. JJR recognizes that two intermediate steps have either been permitted or are currently being permitted for stormwater management solutions for the Cudahy Faculty Lounge, Center for Varsity Athletics, and East Quad projects; however, the proposed conditions analysis will consider the entire campus area per the Final Framework Plan 2012 and will note the stormwater devices provided by each of the projects.

Screening-level computer modeling of the quantity of existing and proposed stormwater runoff from specific drainage areas that changed was completed using Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2008, Version 6.052 by Autodesk, Inc. An analysis of the overall proposed conditions for the 29.09 acres of campus studied indicates that the final constructed condition in 2012 will actually result in a very small amount of less impervious coverage of the campus. In other words, the surface area of newly constructed buildings and pathways will be slightly less than the existing pavement, walks, and buildings. Thus, the overall quantity of stormwater runoff and the peak rate of stormwater discharge will be slightly less in the proposed 2012 condition than in the existing condition (see figure 3.0).

The City of Chicago (City) Stormwater Management Ordinance, however, states that any project, defined as any construction activity, excavation, or grading, that:

- disturbs a land area or substantially contiguous land areas of 15,000 or more square feet in aggregate, or
- creates an at-grade impervious surface of 7,500 or more substantially contiguous square feet, or
- results in any discharge of stormwater into any waters or separate sewer system

is a regulated development and must meet the applicable design requirements of the ordinance. Regulated projects that discharge to combined sewer systems must meet both rate and volume control measures, whereas regulated projects that discharge to Lake Michigan are only required to meet volume control measures. For each drainage area determined to be a regulated project, preliminarily estimates of the size of stormwater management devices necessary to meet the City's ordinance requirements are provided in this analysis. The proposed drainage areas are summarized as follows (see figure 3.7):

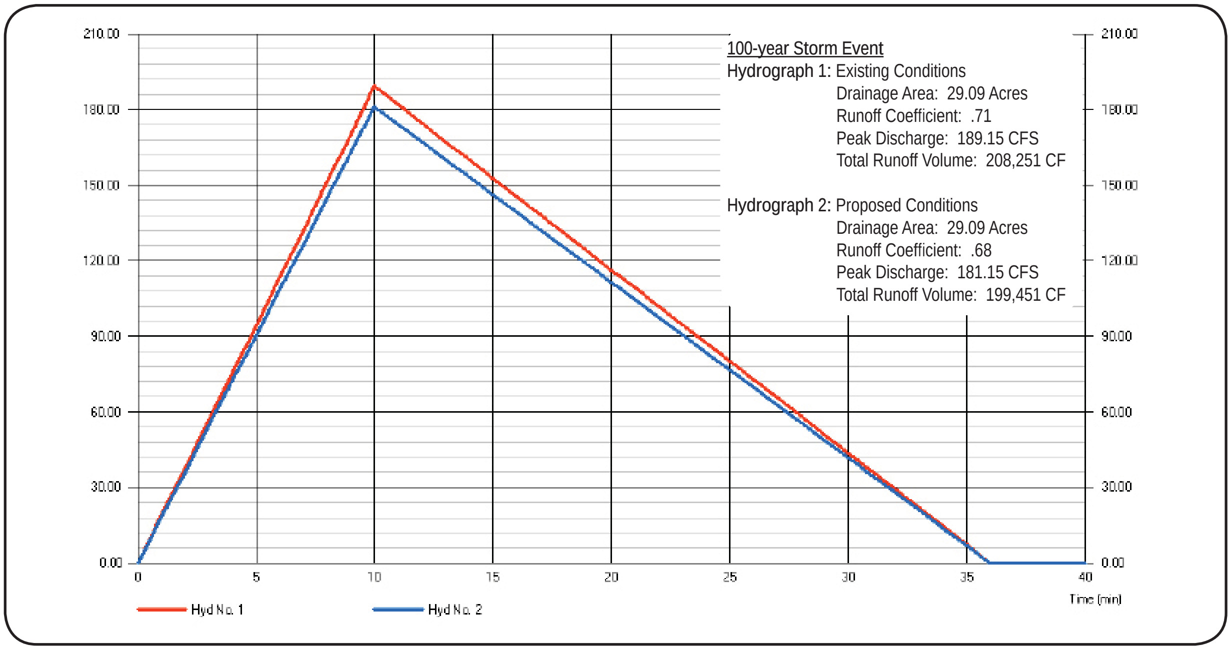


Fig. 3.0 Overall Campus Hydrographs 1 & 2 - Lake Shore Campus (JJR)

Proposed Drainage Area 100: Northwest Area to N. Sheridan Road

This area has no characteristic changes based on the Final Framework Plan 2012. However, if construction activities occur in this area that require stormwater management control based on the City's ordinance, both rate and volume control requirements will need to be met.

Proposed Drainage Area 101: Recreational Sports Field

Based on the design development documents prepared by JJR for the Center for Varsity Athletics project dated April 10, 2008, a small portion of the existing drainage area will be rerouted to the south due to grading changes. Overall peak runoff rates and discharge volumes to the existing outlet control structures that discharge to W. Loyola Avenue will be less than originally permitted (see figure 3.1); therefore, the originally designed detention system should not require any modifications.

Proposed Drainage Area 102: Northeast Area to W. Loyola Avenue

This area has no characteristic changes based on the Final Framework Plan 2012. However, if construction activities occur in this area that require stormwater management control based on the City's ordinance, both rate and volume control requirements will need to be met if the existing sewer outlet connection is used. JJR recommends that any construction projects located in this area take advantage of the direct access to outlet stormwater runoff to Lake Michigan. If stormwater runoff is directed to Lake Michigan rather than the city sewer in the W. Loyola Avenue right-of-way, only volume control requirements will need to be addressed to meet the City's ordinance. Discharging to Lake Michigan will require additional permitting and approvals (including Chicago Department of Transportation Harbor Permit, City of Chicago Department of Environment, United States Army Corps of Engineers, United States Fish and Wildlife Service, Illinois Environmental Protection Agency, Illinois Department of Natural Resources, and Metropolitan Water Reclamation District of Greater Chicago); however, several benefits exist for pursuing this option. First, rate control stormwater management requirements per the City's ordinance are not required. This will significantly reduce the volume of stormwater treatment that would be required. Secondly, by removing the storm system from the city sewer system, the possibilities for sewer backups into the campus sewer systems are eliminated. Lastly, depending on the actual parameters and grading of construction/redevelopment, several, if not all, of the three existing sump pumps could possibly be eliminated if they serve as existing storm discharge outlets only. (If the existing sump pumps currently serve to discharge sanitary sewer from the buildings, then they will likely have to be maintained.)

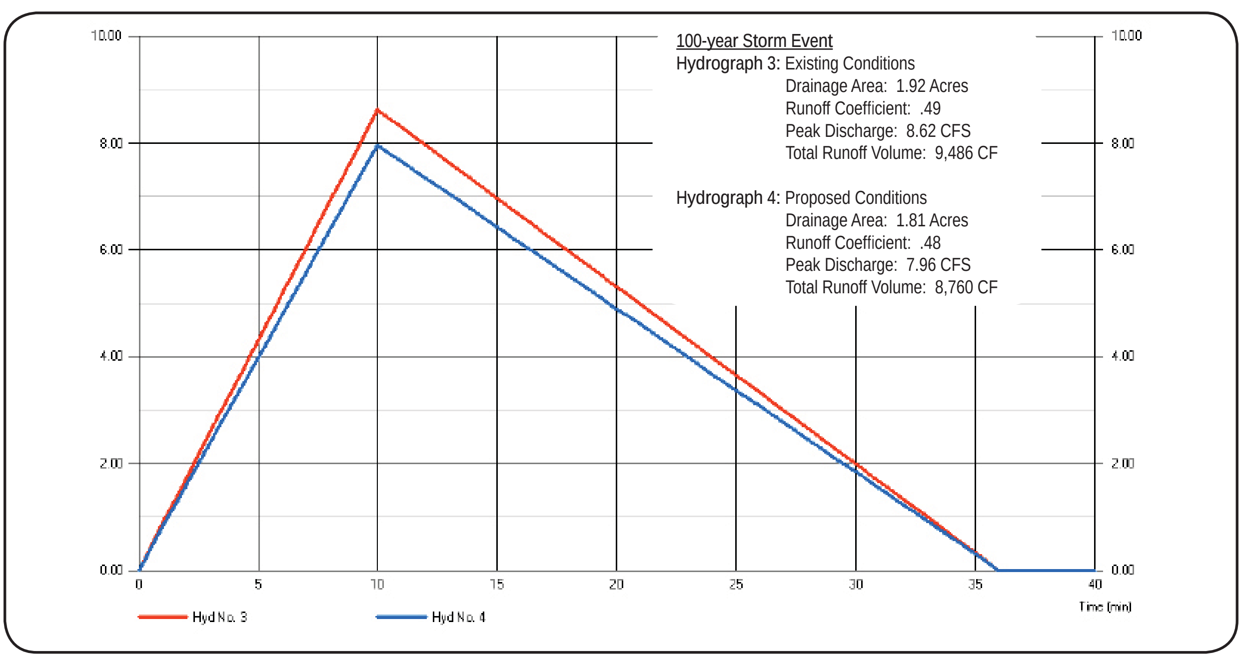


Fig. 3.1 Drainage Area 101: Hydrographs 3 & 4 - Lake Shore Campus (JJR)

Proposed Drainage Area 103: West Area to W. Sheridan Road

Future development slated to occur in this area includes construction of the Cudahy Faculty Lounge, the Center for Varsity Athletics, and the Halas Addition and Tower buildings; removal of Halas Athletic Field and Track and the portion of N. Winthrop Avenue within the campus; construction of a permanent bus station along the campus loop road; and development of the West Quad and associated site work around Cuneo Hall.

The proposed redevelopment of this area will result in negligible increase in peak runoff rates and discharge volumes than per the existing conditions (see figure 3.2). Stormwater management controls will be necessary for this area to meet the City's ordinance requirements.

The overall tributary area for the preliminary analysis of this subsection is 11.07 acres; however, JJR estimates that approximately 6.32 acres of this area will be disturbed for future construction projects. Preliminary calculations based on an assumed allowable release rate of 0.25 cfs per acre indicate that a total of 33,000 cubic feet of detention storage would be required to meet the rate control requirements of the City's ordinance if the outlet connection is to the city's combined sewer system. JJR designed a StormTrap® underground detention system to meet the detention storage requirements for the Cudahy Faculty Lounge and the Center for Varsity Athletics projects—approximately 2.38 acres. This project was permitted by the City's Department of Water Management under the previous ordinance, and the StormTrap® was constructed in June/July 2008 (see figures 3.3 and 3.4). The StormTrap® system provides approximately 16,500 cubic feet of detention storage. The outlet control structure for this system discharges to an existing 18-inch sewer near N. Winthrop Avenue that ultimately discharges to the 81-inch combined city sewer in the W. Sheridan Road right-of-way at the N. Winthrop Avenue intersection. The StormTrap® system constructed in 2008 would provide about half of the total volume needed for the ultimate build-out of this area, so an additional 16,500 cubic feet of storage volume would be required. However, it appears that it would be possible to direct some of the runoff from this area directly to Lake Michigan. If this is possible, then rate control management is not required for the areas tributary to Lake Michigan.

Regardless of discharging to a city combined sewer or to Lake Michigan, approximately 6,000 cubic feet of volume control stormwater management treatment devices would be required. With the continuation of using permeable pavers for the main campus pathway system, approximately 2,000 cubic feet of the volume control treatment storage would be provided in the void space of the drainage aggregate subbase. Thus, JJR estimates that an additional 4,000 cubic feet of volume control storage area would be required.

JJR recommends utilizing treatment options that allow for natural infiltration of stormwater to meet both rate and volume control requirements. An underground stone aggregate bed, surface infiltration trenches, or a rain garden could be designed within the West Quad to provide the required treatment volumes.

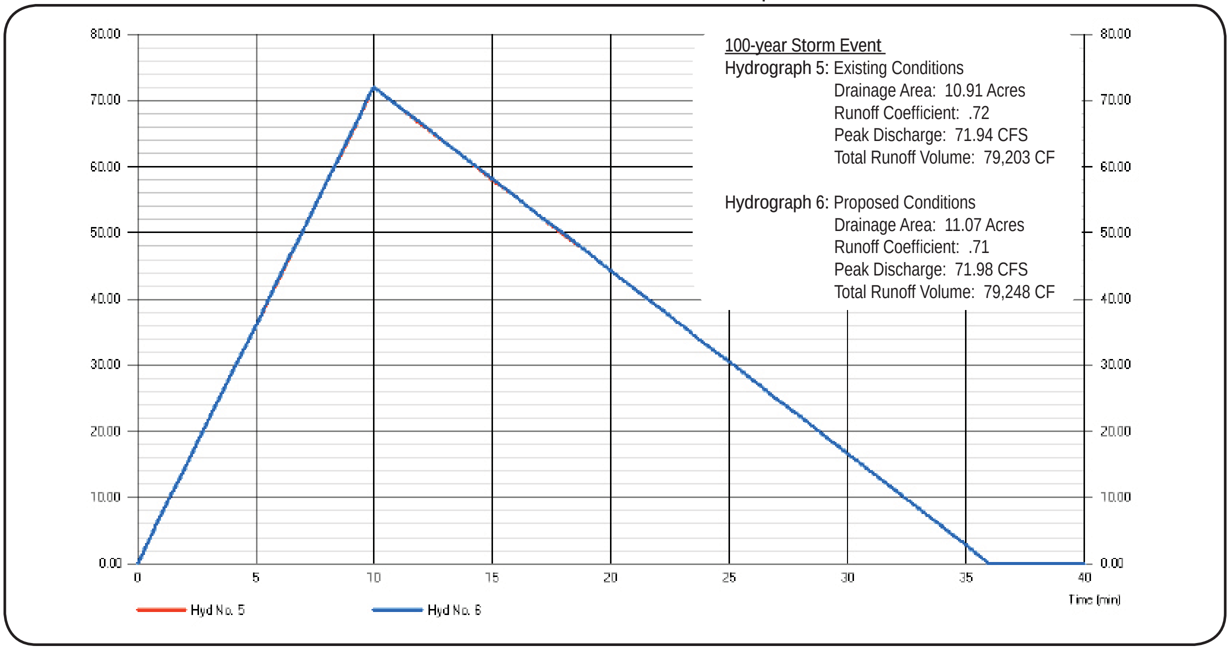


Fig. 3.2 Drainage Area 103: Hydrographs 5 & 6 - Lake Shore Campus (JJR)

Fig. 3.3 StormTrap® - Lake Shore Campus, June 25, 2008 (JJR)

Fig. 3.4 StormTrap® - Lake Shore Campus, June 25, 2008 (JJR)

Proposed Drainage Area 104: East Quad Project

The future development of this area was designed by JJR in 2008 and construction began in August 2008. This area includes the demolition of the Jesuit Residence Hall and construction of the East Quad. The East Quad was designed per the City's new Stormwater Management Ordinance for both rate and volume control. Rate control detention volume storage required for the project was approximately 8,500 cubic feet and was provided in an underground stone aggregate infiltration bed in the middle of the lawn quad area, approximately 5,700 cubic feet, and in the aggregate base section of the permeable pavers used throughout the project for the campus pathway system, approximately 3,000 cubic feet. A control structure with a 4-inch diameter orifice has been designed that will restrict the runoff rate from the area to the existing discharge rate of 0.89 cfs (existing pump capacity) in order to not cause an increase in discharge rate to the city sewer system. For this project, volume control requirements are met by reducing the imperviousness of the site by 15 percent, which was accomplished by the demolition of the Jesuit Residence Hall and removal of asphalt parking and driveways.

Future demolition of Damen Hall and consequent construction of Cuneo Hall will result in slight modifications to the drainage area characteristics that are tributary to the East Quad detention system; however, it is anticipated that most of the new improvement areas will be routed to the south to their own stormwater management system (see Proposed Drainage Area 108) and thus new modifications would not be required to the current East Quad detention system.

Additionally, it may be possible in the future to reroute the outlet sewer from the underground infiltration bed to discharge to Lake Michigan. Currently, the outlet sewer connects to a 15-inch sewer that ultimately connects to the 81-inch combined city sewer located in the W. Sheridan Road right-of-way. Due to relocation of campus utilities for the construction of Cuneo Hall, the option of disconnecting this outlet storm sewer from the public combined sewer system to avoid possible sewer backups and rerouting the storm runoff to discharge to Lake Michigan should be evaluated.

Proposed Drainage Area 105: Pre-treatment Area of Information Commons

Due to the East Quad construction, minor changes occur to the drainage areas tributary to the existing CDS® Pre-treatment Manhole. Overall peak runoff rates and discharge volumes will be less than originally permitted (see figure 3.5); therefore, the originally designed treatment system should not require any modifications.

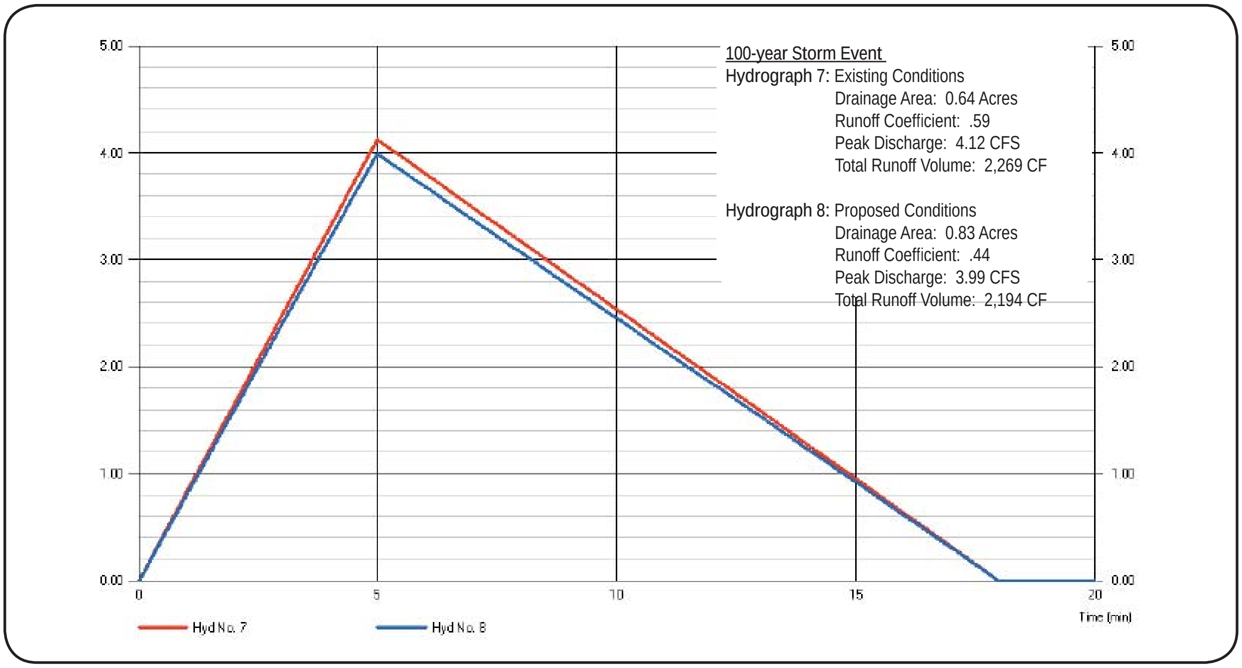


Fig. 3.5 Drainage Area 105: Hydrographs 7 & 8 - Lake Shore Campus (JJR)

Proposed Drainage Area 106: Northern Shoreline of Lake Michigan

A small southern portion of this area, approximately 0.18 acres, will be disturbed for construction of the Chapel Wedding Garden, so this area will be combined with Proposed Drainage Area 108 to provide required stormwater management control requirements.

A small event plaza is proposed at the existing east entrance to Cudahy Library. Construction of this plaza will require meeting volume control requirements per the City's ordinance prior to discharging to Lake Michigan, but only an estimated 100 cubic feet of treatment volume storage is required. Additionally, any construction within 40 feet of the Base Flood Elevation of a Chicago waterway requires obtaining a CDOT Harbor Permit and other regulatory agency approvals mentioned previously. JJR estimates that construction of this plaza will disturb areas within 40 feet of the Lake Michigan revetment wall and thus the Base Flood Elevation of Lake Michigan.

Proposed Drainage Area 107: Quinlan Life Sciences Center

With the future demolition of Damen Hall and consequent construction of Cuneo Hall, existing subarea #3 (the runoff from the existing Damen Hall loading dock) and its vortex restrictor will be eliminated. This drainage area will be combined with Proposed Drainage Area 103. No other characteristic changes are proposed to the existing Life Sciences area; therefore, the remaining originally designed treatment system should not require any modifications.

Proposed Drainage Area 108: Southeast Area to W. Sheridan Road

Future development slated to occur in this area includes the demolition of Damen Hall and the surface parking lot located between Madonna Della Strada Chapel and Coffey Hall, and the construction of Cuneo Hall and the Chapel Wedding Garden.

The proposed redevelopment of this area will actually result in slightly lower peak runoff rates and discharge volumes than per the existing conditions (see figure 3.6). However, stormwater management controls will be necessary for this area to meet the City's ordinance requirements. JJR recommends that all runoff from all disturbed areas be routed to Lake Michigan, thus eliminating the need for rate control stormwater management requirements.

The overall tributary area for the preliminary analysis of this subsection is 4.02 acres; however, JJR estimates that approximately 2.29 acres of this area will be disturbed for future construction projects (excluding the roof area of Cuneo Hall). Preliminary calculations indicate that approximately 2,000 cubic feet of volume control storage would be required. The runoff from the new roof area of Cuneo Hall can be directly discharged to Lake Michigan without any detention or treatment requirements. With the continuation of using permeable pavers for the main campus pathway system, approximately half (1,000 cubic feet) of the volume control treatment storage will be provided in the void space of the drainage aggregate subbase; however, JJR estimates that an additional 1,000 cubic feet of volume control storage area will be required.

JJR recommends utilizing treatment options that allow for natural infiltration of stormwater to meet both rate and volume control requirements. An underground stone aggregate bed, surface infiltration trenches, or a rain garden could be designed within the Chapel Wedding Garden to provide the required volume treatment.

Proposed Drainage Area 109: Sheridan Road Courtyard

This area has no characteristic changes based on the Final Framework Plan 2012 for its tributary area; however, the existing stormwater management control device, the infiltration pond north of Coffey Hall, could be affected by the construction the Chapel Wedding Garden. Thus, the storage volume provided by the existing system, approximately 3,600 cubic feet, will need to be provided in addition to requirements for Proposed Drainage Area 108. Based on the new ordinance that only requires volume control measures for projects discharging to waters, it may be possible to eliminate the detention volume storage originally required (3,562 cubic feet), but the water quality treatment storage of 363 cubic feet would still have to be provided. This requirement can be clarified with the City during the future design of the Chapel Wedding Garden area.

Proposed Drainage Area 110: Southern Shoreline of Lake Michigan

This area has no characteristic changes based on the Final Framework Plan 2012. However, if construction activities occur in this area that require stormwater management control based on the City's ordinance, both rate and volume control requirements will need to be met if connecting to the combined city sewer, or only volume requirements will need to be met if discharging to Lake Michigan (recommended).

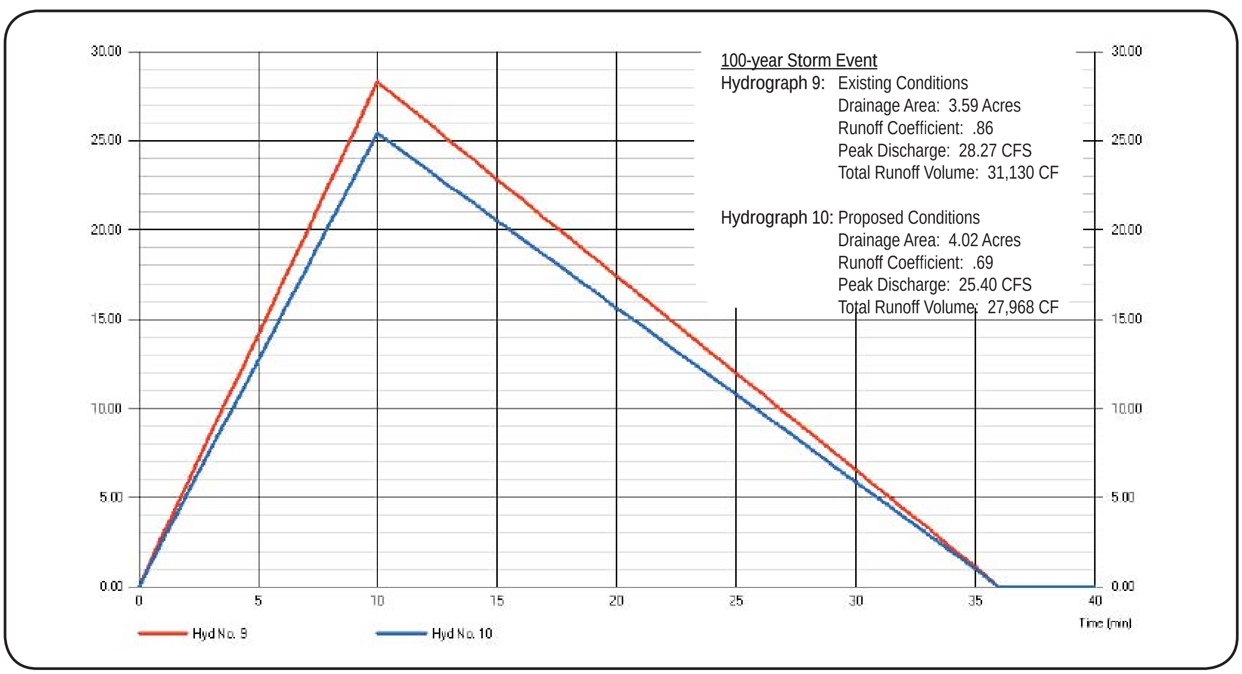


Fig. 3.6 Drainage Area 108: Hydrographs 9 & 10 - Lake Shore Campus (JJR)

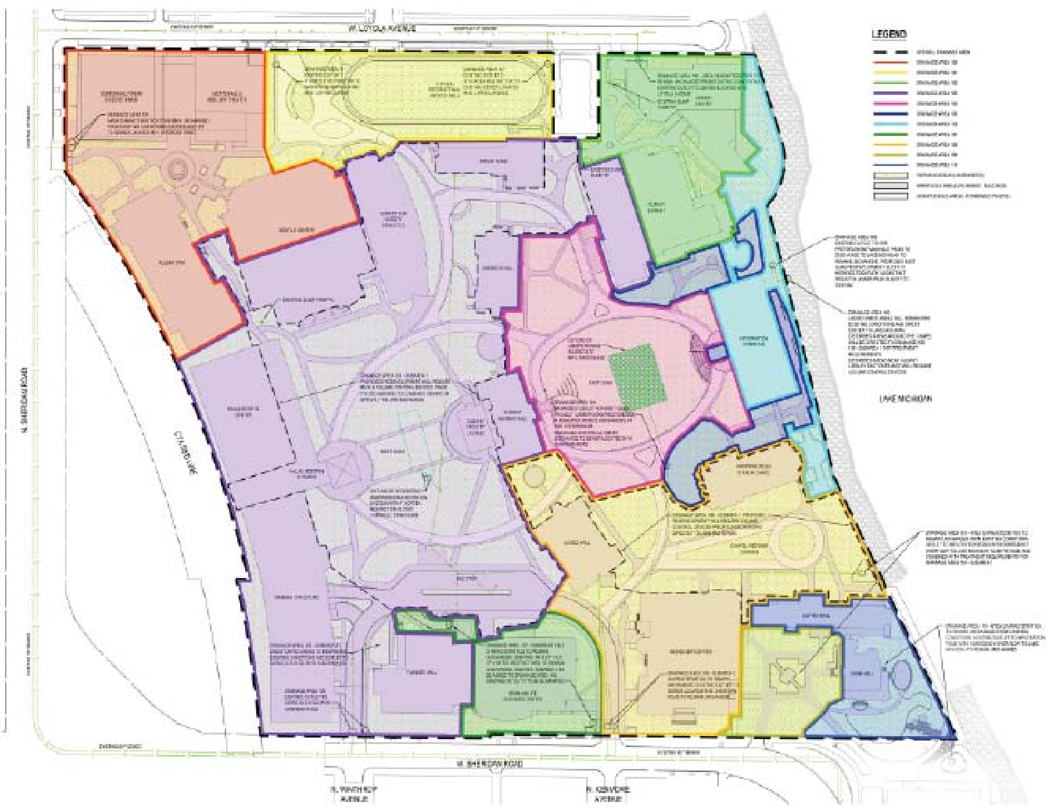


Fig. 3.7 Proposed Drainage Area Map - Lake Shore Campus (see Appendix B) (JJR)

Proposed Drainage Area Calculations
Loyola University

Drainage Area	Area (Sq. Ft.)	Area (Acres)	Impervious Area (Acres)	Permeable Pavers (Acres)	Pervious Area (Acres)	Avg. C Value
100-Northwest Area	147461	3.39	2.69	0.00	0.70	0.81
101-Recreational Sports Field	78990	1.81	0.25	0.30	1.26	0.48
102-Northeast Area	70989	1.63	1.32	0.00	0.31	0.82
103-West Area	482360	11.07	6.72	0.49	3.86	0.71
104-East Quad Project	112199	2.58	0.33	0.38	1.87	0.46
105-Pre-treatment Area	36056	0.83	0.21	0.00	0.62	0.44
106-Northern Shoreline	47602	1.09	0.73	0.00	0.36	0.73
107-Quinlan Life Sciences Center	44838	1.03	0.70	0.00	0.33	0.73
108-Southeast Area	175084	4.02	2.07	0.39	1.56	0.69
109-Sheridan Road Courtyard	29313	0.67	0.22	0.00	0.45	0.50
110-Southern Shoreline	42375	0.97	0.57	0.00	0.40	0.67
TOTAL	**1267267**	**29.09**	**15.81**	**1.56**	**11.72**	**0.68**

Proposed Subdrainage Areas

Subdrainage Area	Area (Sq. Ft.)	Area (Acres)	Impervious Area (Acres)	Permeable Pavers (Acres)	Pervious Area (Acres)	Avg. C Value
103-Subarea 1	275286	6.32	2.67	0.49	3.16	0.61
108-Subarea 1	99859	2.29	0.61	0.36	1.32	0.56

Impervious C = **0.95**

Permeable Pavers C = **0.95***

Pervious C = **0.27**

Fig. 3.8 Proposed Drainage Area Table - Lake Shore Campus (JJR)

NOTES

* The permeable paver surfaces have been assigned a high runoff coefficient (the same as impervious surfaces) as a conservative calculation. The City of Chicago Stormwater Management Ordinance allows for flexible use of the assigned runoff coefficient for permeable pavements depending on how the surface is chosen to be used for runoff treatment. Each future drainage area will be evaluated on a case by case basis during engineering design to determine the best solution for assigning runoff coefficients for each area.

Fig. 3.9 Final Framework Plan 2012 - Lake Shore Campus (JJR)

Proposed Drainage Area Summary

As noted in the individual drainage area summaries, there is potential for several of the redeveloped areas to be routed to discharge to Lake Michigan. By discharging to Lake Michigan, rate control measures (typical detention devices) are no longer required per City ordinance; only volume control measures (typical water quality treatment devices) are needed. This will reduce the overall size of stormwater management facilities that are required within the campus.

In addition, discharging stormwater runoff to Lake Michigan provides environmental benefits as further described in the next section of this report by returning water to the natural hydrologic cycle as well as reducing the amount of discharge into the public sewer system.

The overall increase in runoff volume that could potentially be directed to Lake Michigan (and thus removed from the public sewer system) is 59,665 cubic feet for a 100-year storm event and 19,746 cubic feet for a 1-year storm event. Additionally, the peak discharges to the public sewer system are significantly reduced by directing runoff to Lake Michigan: a 54.19 cfs reduction for a 100-year storm event and a 17.94 cfs reduction for a 1-year storm event (see figure 3.10).

It is recommended that as much runoff be directed to Lake Michigan as possible during campus redevelopment projects in order to benefit the environment as well as benefit LUC in reduced infrastructure costs.

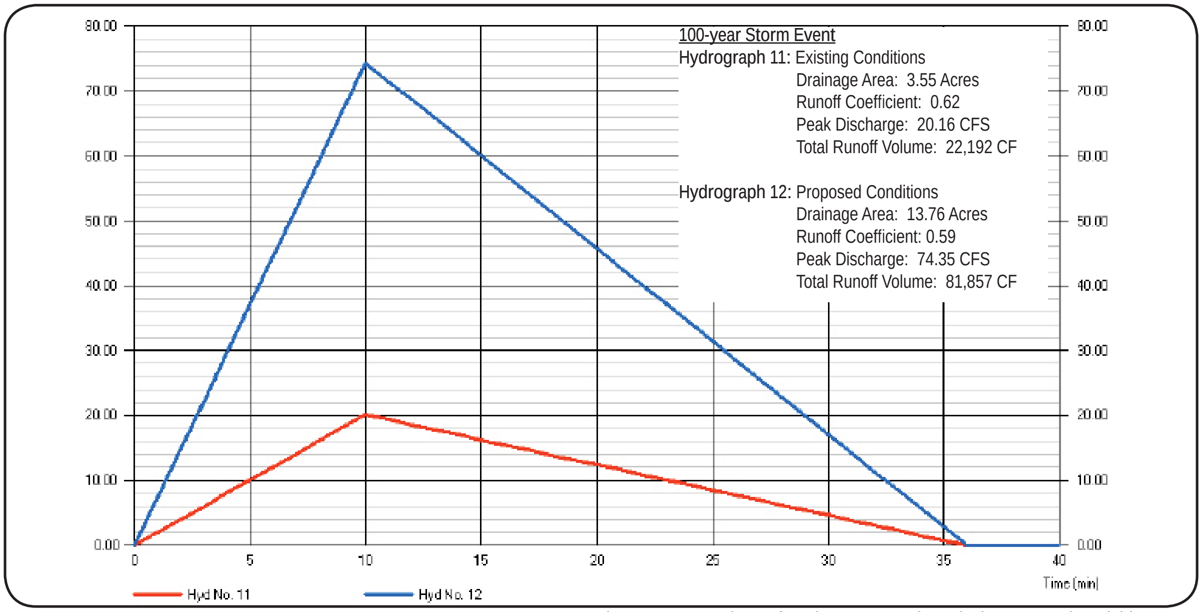


Fig. 3.10 Comparison of Drainage Areas that Discharge to Lake Michigan (JJR)


Fig. 3.11 Map of Benefits to Directing Runoff to Lake Michigan (See Appendix D)

BEST MANAGEMENT PRACTICES

Best Management Practices (BMPs) are defined as methods that have been determined to be the most effective, practical means of preventing or reducing pollution from non-point sources, such as stormwater runoff. Stormwater BMPs are designed to temporarily store or treat stormwater runoff in order to mitigate flooding and reduce pollutant loads and can be attractive site amenities when incorporated into an overall landscape design.

In a dense, urban environment, such as LUC's Lake Shore Campus, the quantity of stormwater runoff can be much higher and the quality of stormwater runoff can be much lower than less dense environments due to increased impervious surfaces (roads, walkways, buildings, etc.) and higher concentration of pollutants from vehicular and human uses. By collecting stormwater runoff in catch basins and directing to sewers, the natural hydrologic process is impacted. In an undeveloped site, rainwater will infiltrate into the natural soils providing groundwater recharge and act as a water source for plants and trees, which leads to transpiration, while excess rainwater will run off and collect in natural depressions that feed the natural evaporation process. BMPs incorporate design practices that limit the impact on the natural processes of groundwater recharge and evapotranspiration.

In addition to preserving the natural hydrologic cycle, BMPs help alleviate the amount of discharge to public sewers. Being located in a large older city, like Chicago, the public sewer system is typically a combined system that includes stormwater runoff as well as sanitary sewer discharges. This significantly increases the risk for sewer backups or overflows during heavy rain events as the sewers are inundated with stormwater and the sewer mains and treatment plants cannot keep pace with the higher inflow of wastewater. Managing stormwater within a project site by use of BMPs reduces the amount of runoff directed to city sewers, reducing the potential for sewer backups. BMPs also function to reduce pollutant loads in stormwater runoff by allowing for suspended sediment to settle out of the water, thus creating a cleaner discharge to receiving waters or sewers.

Most of the BMPs used for stormwater management require some rate of infiltration into existing soils. According to the Chicago Soils Map and various geotechnical investigations performed for campus building projects, the existing soils throughout the Lake Shore Campus are predominately SM (silty sand, sand-silt mixture) to SP (poorly graded sand, gravelly sand, little or no fines) for at least the upper 10 feet of the strata. In order to confirm the soil type and verify the suitability of using infiltration BMPs on the campus, JJR performed two infiltration tests on July 22, 2008, in accordance with procedures outlined in the City's ordinance, within the center lawn quad area of the East Quad project. The results at the two infiltration test locations were 3.35 inches/hour and 8.24 inches/hour. The results indicate that existing soils on campus are highly infiltrative and suitable for design of infiltration BMPs.

While these results indicate the existing soils are generally conducive to infiltration within the campus, the City's ordinance requires soil borings and infiltration tests be performed at, or very near, the location of future infiltration devices in order to verify specific soil conditions at each location.

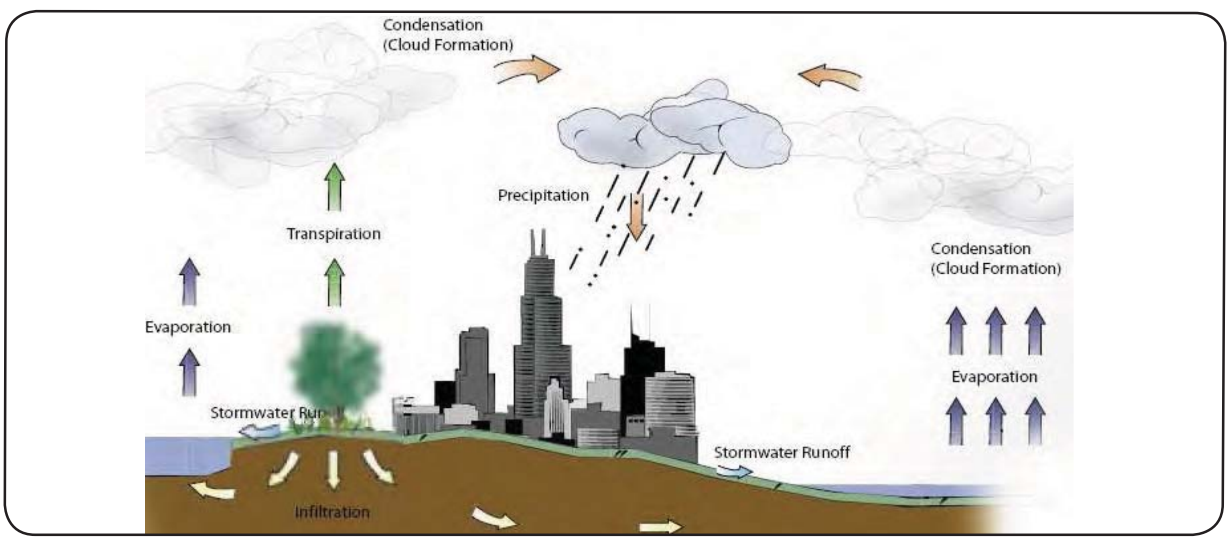


Fig. 4.0 Hydrologic Cycle (City of Chicago Stormwater Management Ordinance Manual, February 2008 www.cityofchicago.org)

fig. 4.1 Test Site 1 (JJR)

fig. 4.2 Test Site 2 (JJR)

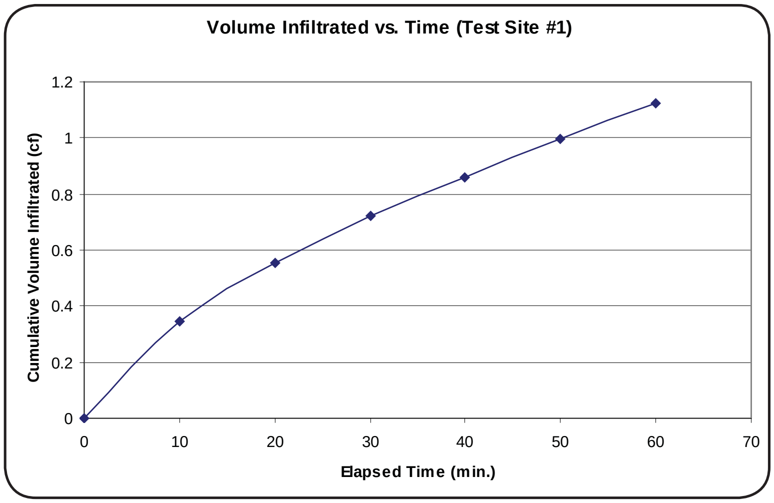


Fig. 4.3 Test Site 1 Infiltration Rate Graph (JJR)

Infiltration Rate, K=3.35 inches/hour

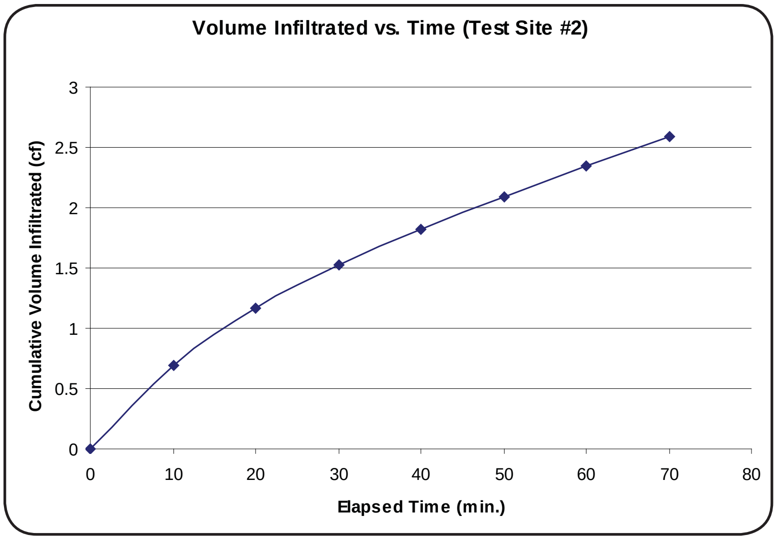


Fig. 4.4 Test Site 2 Infiltration Rate Graph (JJR)

Infiltration Rate, K=8.24 inches/hour

Chicago Stormwater Maintenance Ordinance Manual
Volume Control

Figure 3-2 Chicago Soils Map

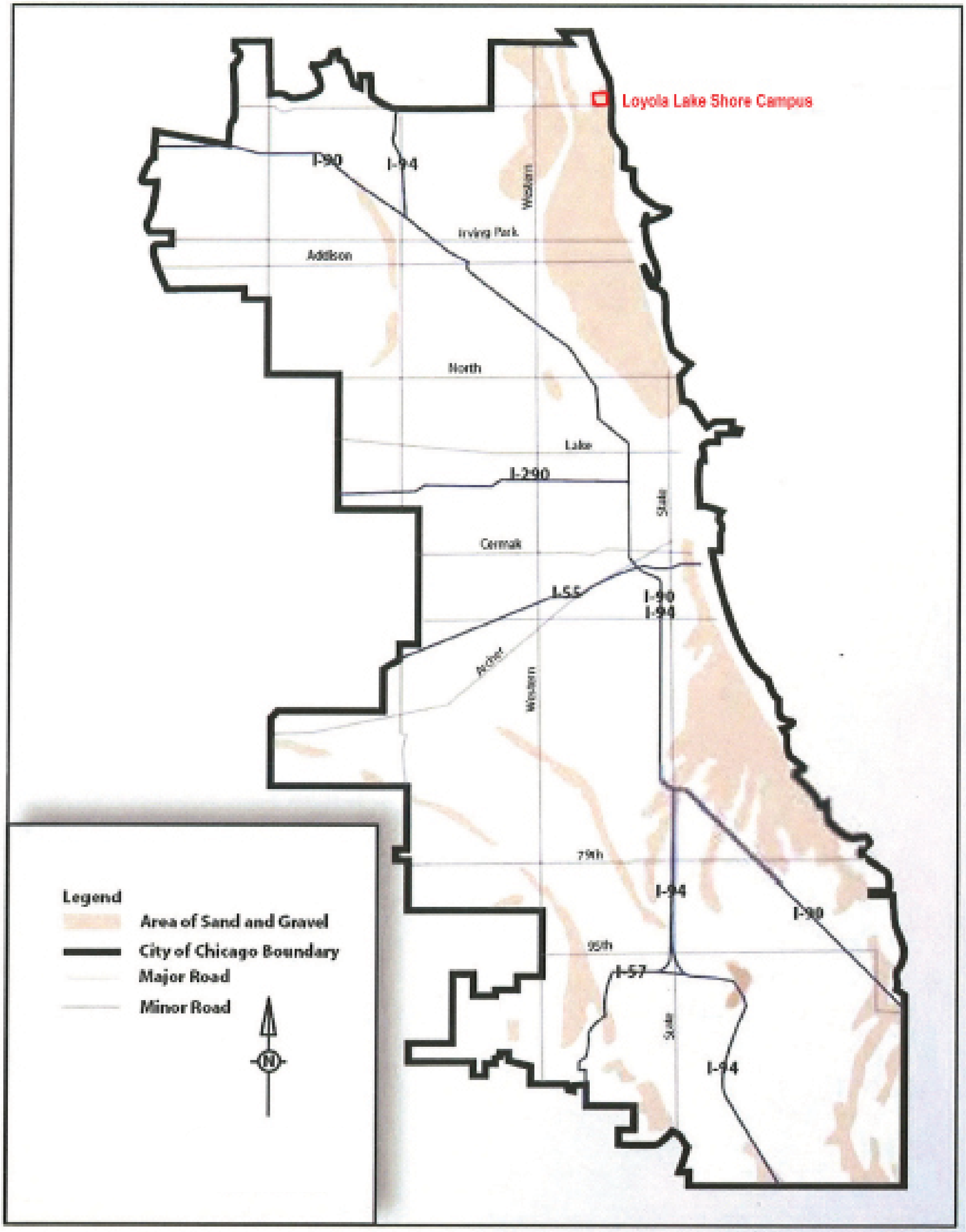


Fig. 4.5 Chicago Soils Map (City of Chicago Stormwater Management Ordinance Manual, February 2008 www.cityofchicago.org)

Potential BMPs to Implement on the Lake Shore Campus

Natural Landscaping

JJR routinely incorporates natural landscaping using native species into our site designs, and have done so on recent projects for LUC including the Cudahy Faculty Lounge, Center for Varsity Athletics, Information Commons, and East Quad. Native species typically develop deeper, more extensive root systems and therefore promote higher water absorption rates and provide increased soil erosion protection. Typically, natural landscapes require less irrigation and less maintenance than conventional landscapes, since they are suited to the existing environment. While natural landscaping does not specifically apply to meeting either rate or volume control requirements, if designed appropriately, it can be considered as a more pervious surface than conventional landscaping that results in a lower runoff coefficient for the site and thus can reduce the overall amount of stormwater management treatment storage volume required. Natural landscaping is a sound standard practice and is an easily implemented BMP that does not have significant cost differences from conventional landscaping.

Rain Gardens

A rain garden is a bioinfiltration system that consists of shallow, landscaped depressions that increases the absorption of stormwater runoff into the soil. Rain gardens typically have a deep soil medium that allows infiltration, and they are designed to treat small, more frequent rain events. Rain gardens are also effective at removing pollutants as stormwater runoff is infiltrated and can be designed using a variety of shrubs, grasses, and perennials to create the desired aesthetic on the campus.

The Chapel Wedding Garden provides an ideal location where a rain garden could be incorporated into the campus. A rain garden in this location could create a beautiful environment as students, faculty, and visitors lead up to the chapel entrance and is one option for meeting the volume control requirements that are needed for redevelopment for Proposed Drainage Area 108. A rain garden could also be considered for the West Quad development.

It should be noted that rain gardens are inherently different from above-ground detention ponds. Rain gardens are designed to treat the small, frequent rain events, and runoff will only pond for short durations (typically, 12 inches is the maximum storage depth and the runoff infiltrates within several hours). Rain gardens can be designed with an overflow for larger rain events to bypass the rain garden and avoid undesirable ponding. Rain gardens could be used to meet volume control requirements.

Fig. 4.6 Renderings of Rain Garden Proposed in Battle Creek, MI (JJR)

Fig. 4.7 Renderings of Rain Garden Proposed in Battle Creek, MI (JJR)

Typical costs for rain gardens can range from $10-$40 per square foot depending on the size, soil depth, and density of plantings. Maintenance practices should include annual inspections for soil erosion, sediment buildup, and regular plant maintenance. Excess sediment should be removed as necessary to allow for continued infiltration within the rain garden.

Fig. 4.8 Rain Garden Located in Portland, OR
(Portland Stormwater Management Manual, Revisions, September 1, 2004, www.portlandonline.com/bes)

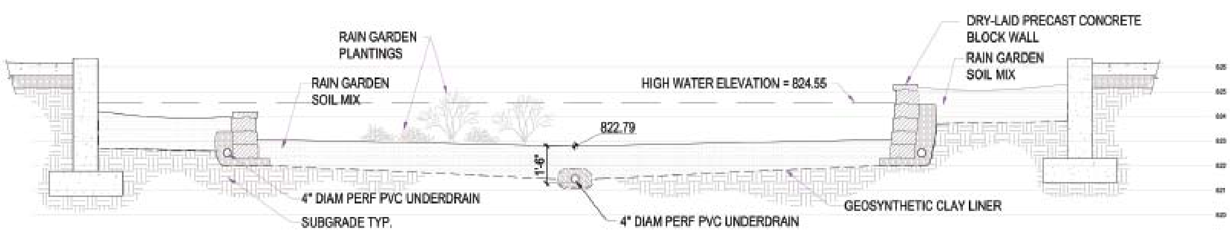


Fig. 4.9 Construction Detail of Rain Garden Proposed in Battle Creek, MI (JJR)

Pervious Pavement

With native sandy, permeable soils, LUC's Lake Shore Campus is an ideal location to implement pervious pavements, as stormwater runoff will naturally be absorbed into the soils, thus providing groundwater recharge. Pervious pavements could be used to meet both rate and volume control requirements by providing storage volume in the voids of the drainage aggregate subbase. There are several types of pervious pavements: permeable pavers, porous concrete, and porous asphalt.

LUC has already incorporated the use of permeable pavers with the construction of the Recreational Sports Field. The selected permeable pavers are constructed with open joints that are filled with drainage aggregate that allows stormwater to infiltrate directly into the subbase drainage aggregate rather than sheet-flowing across a hard surface to catch basins like a traditional paved roadway. LUC has indicated that permeable pavers will be used for the main pathway systems throughout the campus as the redevelopment continues to meet the Final Framework Plan 2012.

Implementation of porous concrete and porous asphalt could also be possible at other areas within the campus. Porous concrete and asphalt are designed with larger void spaces within their pavement structure to allow for storm runoff to directly infiltrate through their surfaces. Porous pavements are ideal for areas with low volume vehicular traffic and overflow parking areas.

Construction costs for permeable pavers can range from $10-$15 per square foot including the aggregate base. Construction costs for porous concrete can typically be 25 percent more than traditional concrete, and costs for porous asphalt about 15 percent more than traditional asphalt, with further additional costs usually incurred for thicker subbase aggregate drainage layers as well. While costs of pervious pavements are typically higher than traditional pavements, other infrastructure costs can be significantly reduced because of less storm sewer pipe and structures that are needed.

Fig. 4.10 Permeable Pavers Installed at Recreational Sports Field, August 2007 (JJR)

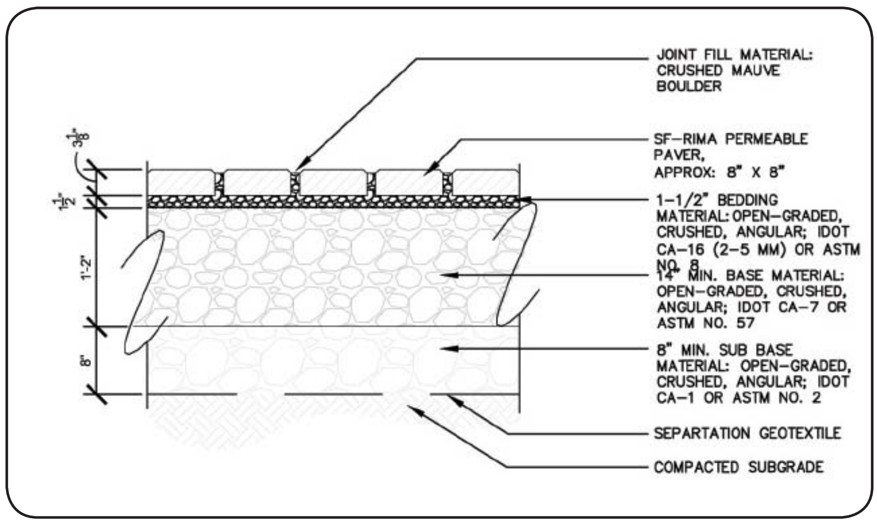


Fig. 4.11 Permeable Paver Construction Detail (JJR)

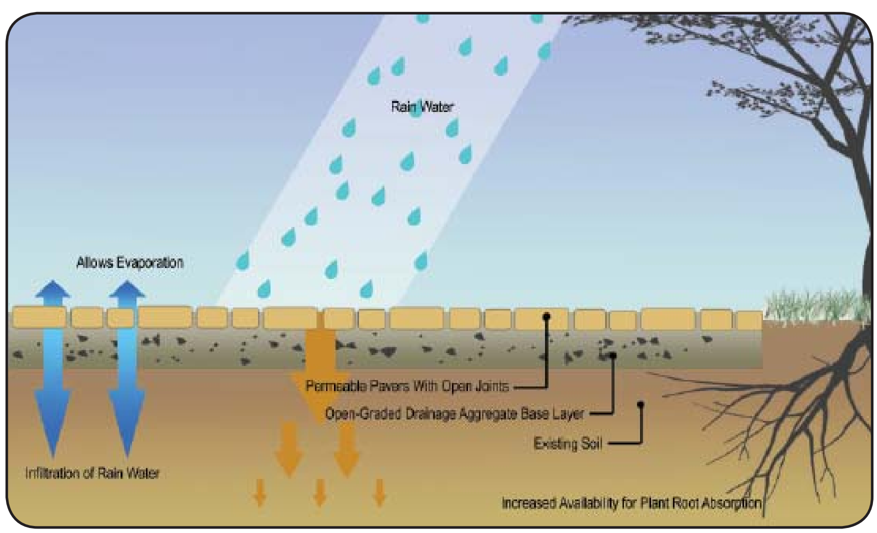


Fig. 4.12 Infiltration Illustration (JJR)

Pervious pavement should be inspected annually to ensure that the joints or pavement surfaces have not become clogged. If necessary, vacuuming of the joint material or pavement surfaces should be performed. Snow removal costs can be reduced as compared to traditional pavements because early and late small snow events can typically melt and drain into the subbase during daylight hours. For regular snow maintenance, plow blades should be set slightly higher than normal to not dislodge any individual pavers or catch any pavement joints. Sand should never be used for surface treatment, as it will clog the open joints. Nontoxic, organic deicers should be used when necessary.

Fig. 4.13 Porous Concrete Bike Parking - Under Construction at University of Michigan (JJR)

Fig. 4.15 Porous Concrete Cross-Section (perviouspavement.org)

Fig. 4.14 Porous Asphalt Example (perviouspavement.org)

Fig. 4.16 Porous Concrete and Traditional Concrete (Michigan Dept. of Environmental Quality)

Infiltration Beds or Trenches

Similar to the benefits of permeable pavers, infiltration trenches can be incorporated into the grading and stormwater design for future projects that would promote infiltration of stormwater. Stone infiltration trenches adjacent to the main pathways could function to eliminate the need for traditional catch basins and storm sewer installation. Infiltration trenches would function to effectively remove pollutants from stormwater runoff and provide groundwater recharge.

Below-grade stone aggregate infiltration beds, such as those designed for the East Quad project, can also be used to meet the storage and treatment requirement for future projects. Infiltration trenches and beds could be used to meet both rate and volume control requirements by providing storage volume in the voids of the drainage aggregate.

While stone infiltration devices and underground chamber storage devices are both effective and viable stormwater management solutions, the East Quad detention system is a more environmentally sustainable solution than the StormTrap® system constructed for the Cudahy Faculty Lounge and Center for Varsity Athletics for several reasons. The East Quad system is infiltrative, which allows for storm runoff to infiltrate into the naturally sandy soils that exist on the Lake Shore Campus and return to the natural hydrologic cycle by recharging groundwater rather than directing it to the city sewer system. Depending on the specific site design constraints, including available surface area for treatment devices, depth to groundwater, depth to existing sewer or lake outlet elevation, and the existing soil conditions, infiltration devices may not be feasible. Thus, under certain conditions, underground chamber storage devices, like the StormTrap® system, can be a more desirable and effective underground detention option. JJR recommends that, whenever feasible, infiltration devices be incorporated into the stormwater management solutions; however, each site must be evaluated to determine the most effective solution.

Aggregate infiltration devices can range from $10-$30 per cubic foot depending on the size and depth of the system. Underground detention systems using concrete chambers can range from $8-$15 per cubic foot of storage provided.

All aggregate infiltration systems should be wrapped in geotextile to prevent soil migration into the system. For systems that have sewer discharges into them, pre-treatment devices should be installed just upstream of the inlet to prevent sediment from entering the storage medium. Pre-treatment devices can be as simple as catch basins with sumps and/or half traps on their outlets to more complex devices like the CDS® unit installed for Information Commons. As with permeable pavement, other infrastructure costs can be reduced by installing infiltration technologies in lieu of extensive storm sewer systems.

Annual maintenance inspections should be performed to inspect for sediment buildup. Flushing the aggregate may be performed, or replacement of at-grade aggregate may be necessary.

Fig. 4.17 Infiltration Trench Incorporated Into Landscape (JJR)

Fig. 4.18 At-Grade Infiltration Basin in Portland, OR (JJR)

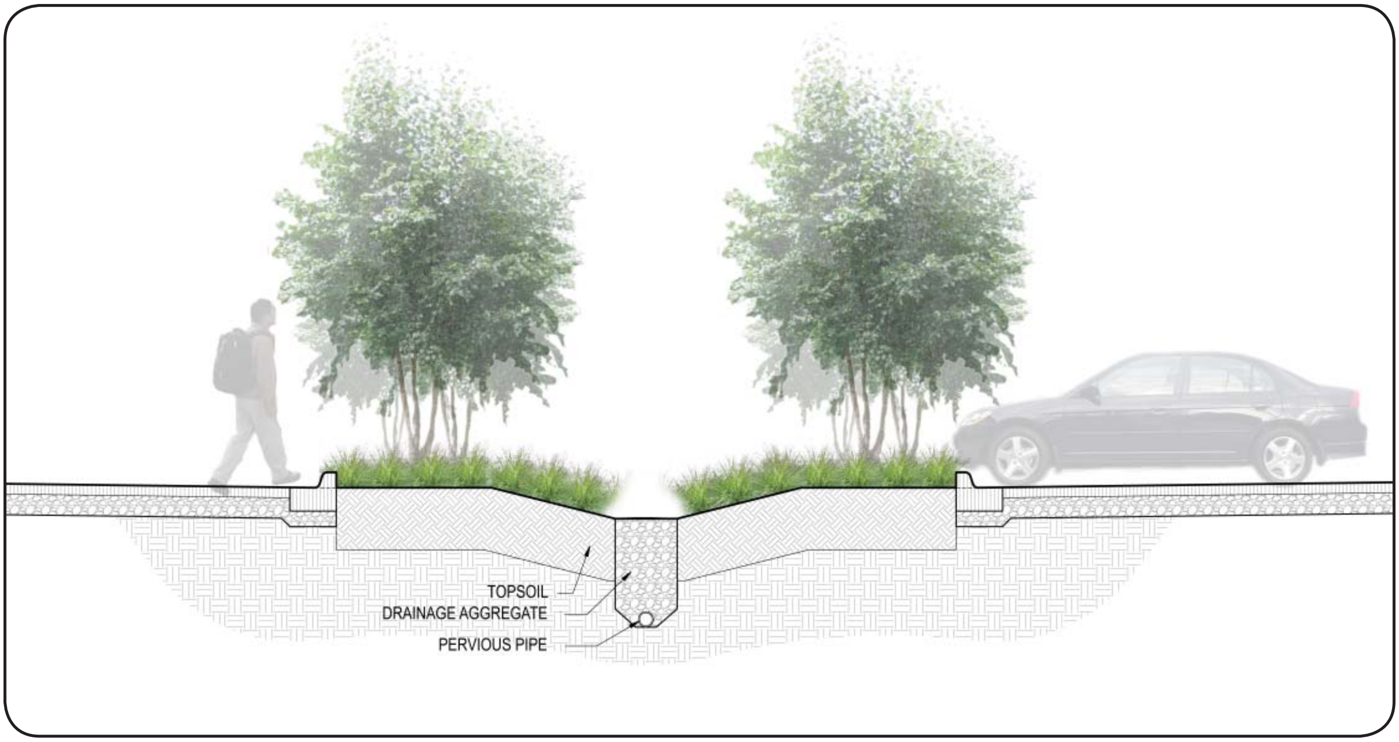


Fig. 4.19 Typical Infiltration Trench (JJR)

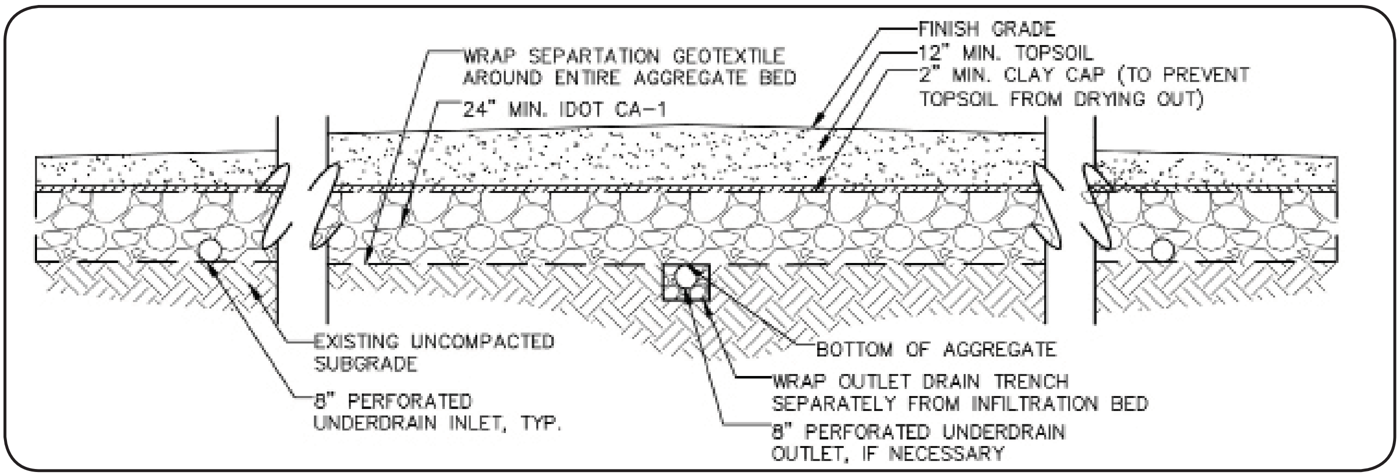


Fig. 4.20 Construction Detail of Aggregate Infiltration Bed at East Quad (JJR)

Planter Boxes or Rain Cisterns

For any dense, urban project site, a key contributor to impervious surfaces is a building roof. Runoff from roof drainage can be treated several ways:

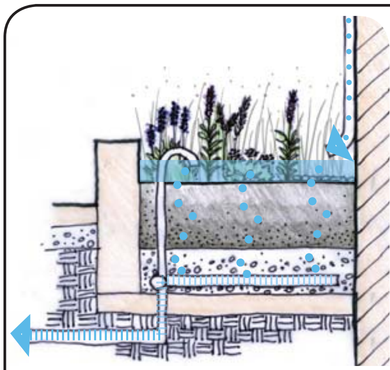
- Roof downspouts can be designed to discharge at grade on splash blocks to disperse the runoff to sheet flow across lawn areas and allow for infiltration into the landscape.
- Roof downspouts can be discharged to flow-through planters that look like traditional planter boxes around buildings, except they are designed to detain and treat stormwater runoff. Flow-through planters are typically designed to treat small, frequent rain events and have an overflow that allows for bypass of runoff during heavy rain events, similar to rain gardens. A wide variety of plantings can be incorporated into flow-through planter boxes to obtain the desired aesthetic. Flow-through planters could be used to meet the volume control requirements.
- Roof downspouts can be directed rain cisterns, which are large containers that store water for re-use for irrigation. The re-use of stormwater for irrigation reduces the demand on potable water. Depending on the future design of the West Quad, if runoff can be directed to Lake Michigan as discussed earlier, it may be possible to use the existing StormTrap® system, with modifications, as a supply source for irrigation.

The various roof runoff treatment options can be incorporated into new buildings as well as modifications to existing buildings. Campus buildings that have gutter downspouts directly connected to the underground sewer system can be modified to have the downspout discharge at grade per one of the options noted previously. The City's ordinance encourages the disconnection of roof downspouts from the sewer system when feasible.

Costs for planter boxes would typically be slightly higher than traditional foundation plantings due to the specific soil media, underdrain system, and walls. Plant maintenance would be typical, but the planter would need annual inspection for sediment accumulation and possible removal. Planter boxes may also require extra watering during extremely dry periods.

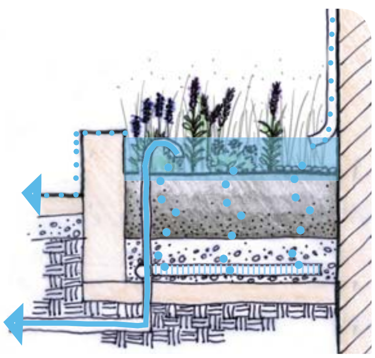
Fig. 4.21 Flow-Through Planter Box in Portland, OR (JJR)

Fig. 4.22 Flow-Through Planter Box in Portland, OR (JJR)



Summer Rain Event

*The reservoir acts as a holding area until the water is able to move through the planter.
*Water is absorbed, slowed, and cleaned by the plant and soil media.
*It is collected in the drain layer and transported out of the system at a reduced and delayed rate.



Large Rain Event

*When the 100-year event is reached, the water level in the reservoir will rise to the point where water will flow into the stand pipe and be directed to the infiltration/storage pipe.
*If it continues to rain at a rate that can not be handled by the city's storm system, the water will overflow the planter wall to the roof or street drain.

Fig. 4.23 Stormwater Planter Flow Diagrams (JJR)

Fig. 4.25 Flow-Through Planter Box in Portland, OR
(Portland Stormwater Management Manual, Revisions, September 1, 2004, www.portlandonline.com/bes)

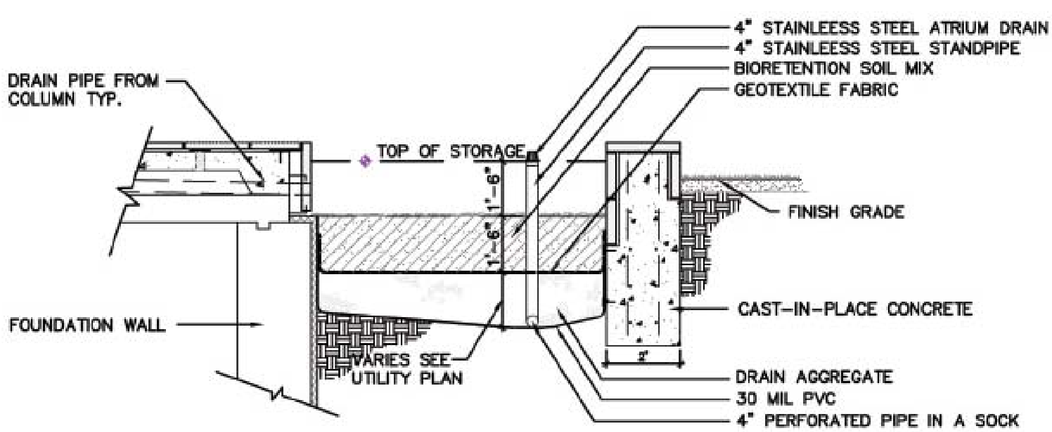


Fig. 4.24 Typical Construction Detail of Flow-Through Planter (JJR)

Green Roofs

Rather than treating roof runoff on the ground, it can be designed to be maintained on the roof itself via green roofs. Green roofs are landscaped areas installed on top of buildings that function to retain and treat water within the soil depth and can significantly reduce the overall runoff volume of stormwater from a building's roof. Recent studies indicate that 50-70 percent of the rain that falls on a green roof will never leave, mimicking the natural hydrologic process. Energy cost savings can also be provided by green roofs by reducing temperatures on the roof, thus reducing energy costs for cooling as well as providing insulation in the winter months to reduce heating costs. Studies have also shown that green roofs can provide protection to the roof itself, increasing the overall life span of the roof.

LUC has already recognized the benefits available by incorporating green roofs, as both the Information Commons and the Life Sciences buildings incorporate green roofs for some portion of the building. Green roofs function to reduce the imperviousness of the site and thus aid in reducing overall treatment storage requirements. The City's ordinance does allow for buildings adjacent to Lake Michigan to directly discharge roof runoff to the lake without treatment. For future buildings or additions that are located further within the campus interior that cannot discharge to Lake Michigan, green roofs are a recommended component for minimizing the City's stormwater management treatment requirements.

Average prices for green roofs in the Midwest are approximately $18-$25 per square foot. As mentioned previously, long-term cost savings can be achieved by reducing heating and cooling costs as well as roof maintenance costs. Typical green roofs require minimal maintenance involving annual inspection of the roof membrane, drainage paths, and plant material. Weed removal and occasional watering may be required for certain green roofs during the first few years until the root system and plant material is established.

Green Roofs have been used in Europe for over 25 years to control runoff volume, improve air and water quality, and promote energy conservation. Green roofs are particularly effective in highly impervious conditions such as cities and other urbanized areas in controlling runoff at the source. In the Midwest, green roofs are becoming more commonly used.

Fig. 4.26 Conventional Green Roof
(Portland Stormwater Management Manual, Revisions, September 1, 2004, www.portlandonline.com/bes)

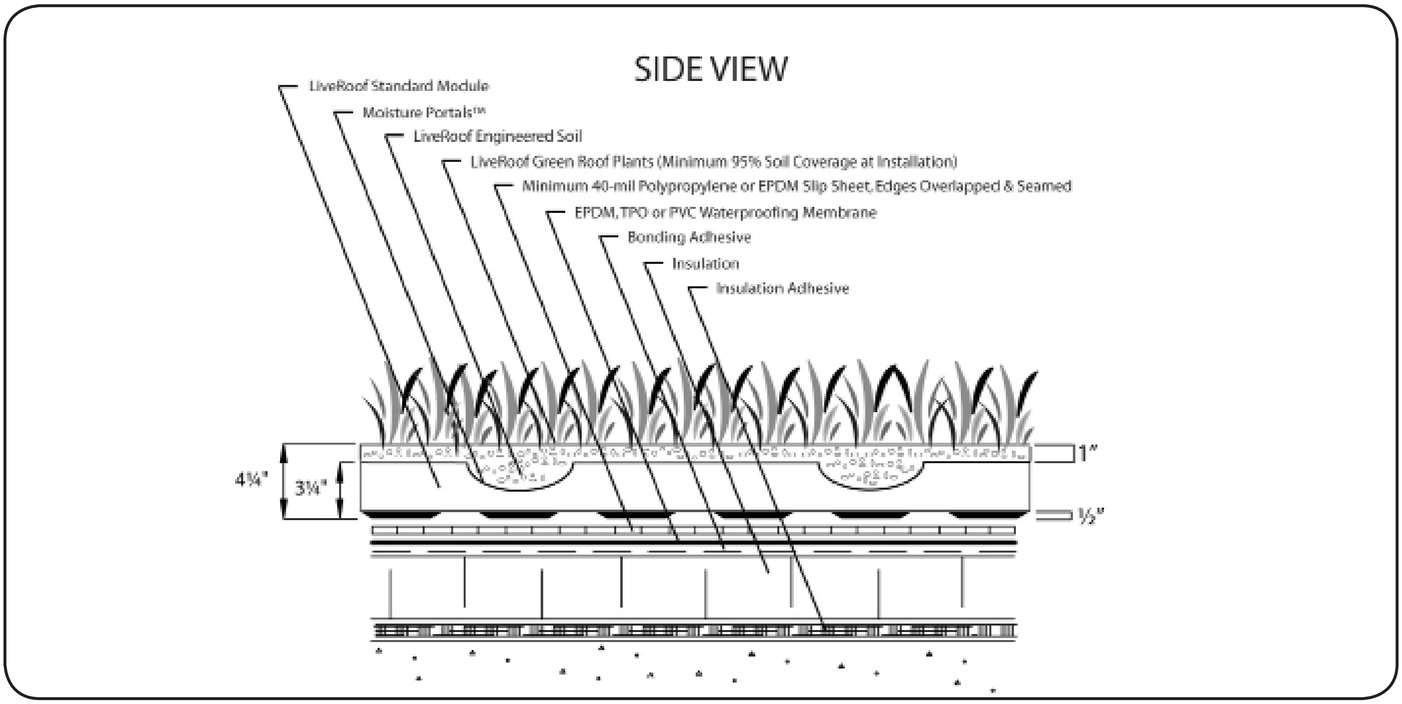


Fig. 4.27 Typical Green Roof Construction Detail (LiveRoof, LLC www.liveroof.com)

Fig. 4.28 Extensive Green Roof (LiveRoof, LLC www.liveroof.com)

CONCLUSION

LUC has the opportunity to incorporate several BMPs at strategic locations throughout the Lake Shore Campus in order to meet the future stormwater management requirements due to expected campus redevelopment. Specifically, the future West Quad and Chapel Wedding Garden are areas with significant proposed redevelopment and would be ideal areas to construct stormwater management devices that could treat the majority of the areas considered for this study.

Due to the predominately sandy soils that exist within the site, infiltration techniques, such as permeable pavers, rain gardens and aggregate infiltration systems, can be incorporated as part of the stormwater management system. Additionally, being located adjacent to Lake Michigan provides a direct connection to a water body, rather than the city sewer system. These benefits are two-fold. First, the BMPs outlined in this report help to restore the natural hydrologic cycle and remove pollutants from stormwater, thus reducing harmful impacts on the environment. Second, disconnecting the campus storm system from the city's combined sewer system eliminates the potential for sewer backups within the campus and reduces the flow in the city system that is sent to treatment plants.

Stormwater BMPs can be incorporated into the overall university sustainability initiative that includes such areas as new building construction, facility maintenance, energy efficiency and waste management practices. Depending on the specific application, the BMPs outlined in this report can be applied to achieve various credits towards achieving Leadership in Energy and Environmental Design (LEED®) certification for new construction. The LEED® system is a national certification established by the U.S. Green Building Council that recognizes building design that utilizes environmentally sustainable practices. Credits for design of stormwater management systems could be achieved in the Sustainable Sites, Water Efficiency and Materials & Resources categories of the outlined criteria.

The Stormwater Management Master Plan can be used as an educational sustainability tool throughout the campus. Wayfinding graphics could be incorporated when BMPs are implemented at specific campus locations to raise awareness of the benefits of the stormwater practices that have been adopted.

Overall, the incorporation of stormwater BMPs within the Lake Shore Campus will aid in boosting LUC's image as an environmentally conscious entity.

Appendices

Appendix A 11x17 trifold

Appendix B 11x17 trifold

Appendix C 11x17 trifold

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