UWM as a Zero-Discharge Zone:

A stormwater masterplan for the UWM Campus

An interdisciplinary faculty/ student research project funded by the Milwaukee Metropolitan Sewerage District as part of the 2020 Facilities Planning Process. Additional funding provided by UWM Community Design Solutions.

Associate Professor James Wasley
Principle Investigator

Contents

INTERDISCIPLINARY RESEARCH TEAM

ARCHITECTURE
James Wasley, PI
Associate Professor
Celia Liu
Assistant Professor

CIVIL ENGINEERING
Hector Bravo
Associate Professor
Libby Locke
Graduate Student

BIOLOGICAL SCIENCES
Tim Ehlinger
Associate Professor
John Berges
Assistant Professor

GEOSCIENCES
Robert Graziano
Laboratory Mgr./Instruct. Support

VISUAL ART
Steve Pevnick
Professor

ARCHITECTURE AND URBAN PLANNING STUDENT RESEARCH, DESIGN AND PRODUCTION TEAM

Jennifer Ott
Shaun Kelly
Michael Kautzer
Anne Gustavson
Melissa Guarin
Greg Johnson
Bethany Madsen
Andrew Manto

Executive Summary

The health of our waters is increasingly dependent on our handling of stormwater. This is true both locally and globally, making stormwater research a significant component of the search for a sustainable future.

'UWM as a Zero-Discharge Zone' addresses this charge through two interrelated projects- a broad investigation of stormwater on the UWM campus and a developed demonstration project proposal.

'UWM as a Zero-Discharge Zone: A Stormwater Masterplan' *investigates recreating the stormwater retention and filtration capacities of Milwaukee's pre-settlement landscape on our densely built-out campus - proving the extreme-case potential of the campus to meet a peak discharge rate of 0.5cfs/acre for a 100 year storm event, and to prevent over 11 acre-feet of water from entering the combined sewer system in that same situation.*

The Pavilion Gateway *project details the transformation of 2.8 acres of impervious surfaces on campus to this same 'zero-discharge' standard, and the transformation of the service zone of campus into a rich interpretive landscape and a new 'front door' to the campus for people arriving through the Pavilion parking ramp.*

Both projects are inherently interdisciplinary, involving primarily the departments of Architecture, Civil Engineering, and Biological Sciences. The second has also involved partnerships with the local design and engineering professional community. Both have constituencies locally and potentials for funding and application regionally, nationally and globally.

Equally importantly from our perspective, both projects engage the aesthetic and pedagogical dimensions of Stormwater. Our intent is to demonstrate that the campus would be both more aesthetically engaging and more useful as a teaching and research environment if such strategies were to be put in place.

Our ultimate goal is to make UWM an international leader in the 'green campus' movement; a living laboratory in the art and science of environmental sustainability. In giving form to the physical potentials of the campus, 'UWM as a Zero-Discharge Zone and the Pavilion Gateway projects provide the first step.

A series of 'next steps' are outlined in the pending Research Growth Initiative Grant Proposal of the same name; a second phase of design research aimed at synthesizing strategies for maximal effect and affordability, the initiation of a campus-wide stormwater policy discussion, and the continued development of the physical and intellectual infrastructure of interdisciplinary stormwater research and education.

UWM Campus 2002
Image c. 1997-2003 *AirPhoto* USA
courtesy of the UWM AGS Collection

"Cooperative, compatible, sustaiable development is an essential goal of campus planning, and the university has a responsibility to provide leadership to achieve this goal."

University of Wisconsin System
Campus Physical Planning Principles
September 2001

Introduction

The 'UWM as a Zero-Discharge Zone' project is actually two intertwined partnerships between the University and the Milwaukee Metropolitan Sewerage District (MMSD).

The first partnership is an interdisciplinary faculty/ student research project to create a physical masterplan for stormwater management on the UWM campus. The stated goal of this masterplan is to recreate a run-off rate and volume comparable to what would have existed on this land in its pre-settlement state; hence the 'Zero-Discharge' title.

The second partnership involves developing architectural and engineering plans to implement three demonstration projects exploring stormwater best management practices for parking lots. Lots 16 to the south of Curtain Hall and Lot 18 to the south of the Power Plant are on the UWM Campus. The third project, known as Lot XL, is intended to produce a minimally invasive prototype design applicable to the UWM remote lots and other such large surface area lots.

Like the first partnership, the '**Focus on Parking**' partnership involves several disciplines on campus. It also involves partnerships with local professionals: the architectural office of Engberg Anderson Design Partnership and the engineering firm Arnold and O'Sheridan. The primary research product of the project is a set of design drawings and cost estimates that will be made available to the Division of State Facilities for consideration as actual demonstration projects.

STORMWATER AS AN IMMEDIATE ISSUE

Stormwater management has become a pressing problem for southeast Wisconsin, as it has globally. In the natural landscape of this region, rain water and snow melt move slowly across the forest floor or deep rooted prairie, percolating into the ground before reappearing in streams and rivers.

In a developed area, by contrast, stormwater is deflected from entering the ground by impervious surfaces such as concrete and asphalt, and is instead collected and directed downstream. This concentration disrupts natural flow patterns, causing erosion, sedementation, altered temperature regimes and other degredations to habitat, water quality and aquafir recharge rates.

To compound these problems, the hard surfaces of the man-made environment also collect chemical pollutants such as motor oil and biological contaminants such as gull droppings. Where these are washed directly into waterways rather than degraded by time and biological activity, they also become water quality concerns.

Taken together, these water quality concerns outline one agenda for stormwater research and demonstration at UWM. The cutting edge of this research deals with the science, engineering and design of ecologically grounded 'green' alternatives to conventional stormwater conveyence and treatment. These strategies seek to recreate the many functions of the natural landscape in concentrated forms that can be woven seamlessly into densely populated human settings.

In long-developed areas such as Milwaukee, collected stormwater was historically combined into a single sewer with the City's sanitary waste stream. This leads to a different set of problems concerning quantity rather than rate and quality. In the worst case, large storms overwhelm the storage capacity of the combined system, causing discharges of mixed stormwater and effluent to be discharged directly into area waterways. Milwaukee's deep tunnels have been built to prevent such discharges by providing additional storage capacity, but significant storm events still cause between 2 and 3 overflows per year.

To eliminate such overflows it is potentially far more cost effective to reduce the scale of the problem by keeping stormwater out of the sewer system through ecological management practices than it is to add storage and/or treatment capacity. Achieving the goal of 'zero-discharge' from the UWM campus through 'green' best management practices would represent the elimination or mitigation of over 60 acres of impervious surfaces, all while creating a far richer and more experientially engaging natural environment for the campus.

In Milwaukee, as in many cities, the question of storage capacity is also complicated by continued development. Suburban sprawl within a sewer system's catchment area makes the appropriate capacity for the system a moving target. The ongoing spread of impervious surfaces stresses both the rigidly constructed components of the system and the capacity of the system as a whole. As a research agenda for UWM, this fact brings Urban Planning into the tent along with architecture, engineering and the biological sciences.

At the same time, there is a much more immediate stormwater capacity problem that the MMSD, the City of Milwaukee and the Village of Shorewood have incentive to solve. Edgewood avenue, which forms the northern border of the UWM campus, is a low point in the local landscape and the location of interceptor sewer lines. For whatever reason, certain pipes under Edgewood have capacity problems, and as a result there is a significant localized flooding problem in the Village of Shorewood that UWM has a potentially important role to play in solving.

In fact, the ideas proposed in these studies would not be the first large scale stormwater management projects on the UWM campus. The construction of the East Tower of Sandburg Hall and now of the Klotche Pavilion have both involved adding large underground storage pipes to decrease the peak discharge rate of the storm pipes that drain the northern portion of campus to Edgewood Avenue.

THE LARGER GOAL OF 'GREENING THE CAMPUS'

While these two partnerships are directed at envisioning implementable stormwater management practices for pragmatic ends, both the MMSD and the faculty involved see a second and equally significant reason for this work in the role that the campus could play as an educational vehicle for stormwater awareness. The University has the unique ability to innovate, to experiment and to produce research on the performance of various stormwater strategies. The University also has the unique ability to educate future generations, and what better way to do that than by example?

The idea that the University should be a 'learning laboratory' for a more sustainable future is being expressed across the globe as 'the Green Campus Movement.' The goal of the researchers behind this current project is to use the inherently interdisciplin

ary issue of stormwater management to forward the green campus movement on the UWM campus. Our goal is to create an identity for the campus as a leader in solving urban ecological issues both in principle and in practice, where students would find themselves immersed in the topics of their studies in every aspect of their daily lives.

RANGE OF ACTIVITIES

While the primary products of these two partnerships are the masterplanning studies and the design documents sampled in this overview document, many other activities have been supported in the name of building a base of awareness and interdisciplinary connections around the issue of stormwater management.

Masters of Civil Engineering student Libby Locke has been supported in her graduate thesis work of creating a SWMM (stormwater management model) simulation of the hydrology of the storm sewer systems on and around the UWM campus. This model now stands as the primary analytical tool for evaluating alternative storm-

Milwaukee Mayor Tom Barrett and MMSD Director Kevin Schafer opening the 'Waterscapes' symposium, April 28, 2005.

Design Charrette participants, 'Waterscapes' symposium, April 28, 2005.

Biological Sciences faculty Tim Ehlinger and other participants, Focus on Parking design charrette, May __ 2005.

UW System Architect Maura Donnally, Focus on Parking design charrette, May __ 2005.

UC Davis Professor Emeritus Rob Thayer

Ecotone students weeding the SARUP Prairie project water strategies on campus.

Biological sciences students and faculty have developed protocols for direct water quality impact sampling of campus surfaces such as roofs, walks and drives.

Architecture and Visual Art students have been challenged to design art and architectural installations that both solve stormwater management challenges and express the poetic aspects of rain and rainwater celebrated rather than swept out of sight.

A public stormwater design symposium, 'Waterscapes: Planning, Designing and Building with Water," has been held featuring as a keynote speaker the preeminent German artist and landscape architect Herbert Dreiseitl. This symposium was attended by over 100 participants, including many City and State officials as well as the local professional community. A brief design charrette had participants designing a future for the UWM campus on the assumption that Hartford Avenue will be closed to vehicular traffic once Columbia Hospital becomes part of the Campus.

A second intensive design charrette was held to generate and evaluate ideas for the Parking Lot Demonstration Project partnership. This event was also attended by over 80 City and State officials and area professionals.

Two other visiting stormwater design experts have been brought to UWM to critique student work and lecture for the community: UC Davis Emeritus Professor of Landscape Architecture Rob Thayer and architect Rich Franko of Mithun Architects, Designers and Planners of Portland, Oregon.

The student environmental group Ecotone has been sponsored in their work to create both rain garden and green roof demonstration sites on the UWM campus.

The UWM Environmental Forum has been sponsored in joining the National Wildlife Federation's 'Campus Ecology Program,' with stormwater management being one of three projects committed to as a campus community.

And much more....


SARUP Prairie Project
ecotone

MASTERPLANNING STUDY OVERVIEW

As embodied by the stormwater systems engineered into the existing UWM campus and the surrounding community, the conventional approach to dealing with precipitation in the urban environment has been to drain it away from the inhabited landscape as quickly as possible. Water has been seen as a nuisance if not a hazard, which in a heavily used pedestrian environment it can often be. As a result, the campus has been laced with a network of drain lines that are incredibly diverse and fine grained. Wherever a surface collects water a drain line reaches out. The branching pattern of pipes to collect and remove water mirrors in inverse the tangled branches of trees in a forest.

Pitched roofs are the clear case. Each roof drains to its eaves, where gutters invariably collect the water into downspouts that disappear into the ground. Even small areas of roof on the older buildings on campus have elaborate gutter systems, because to allow the water gathered by the roof to pour uncontrolled off of the eave would create hazards for those below. Even if this is not the case, allowing falling water to splash or be blown back against the building will eventually damage the structure. Water must be controlled.

What we think of as ‘flat’ roofs are more accurately referred to as ‘low-slope roofs,’ because they invariably do have some pitch to move water in a particular direction. Often they have regular patterns of drains so that their surfaces resemble quilts; water is drained away and is collected into the outermost branches of the storm system before ever hitting the ground.

Likewise, the sidewalks of campus are sloped to drain to the landscape wherever space and grade allows, and are peppered with small drains to collect and spirit water away where the landscape can’t accept it. Parking lots and other vehicular hardscapes create large collection areas, and so are also studded with noticeable drains.

Finally, even the open landscape itself is drained in many places on campus by area drains. These drains are intended to preserve open grass areas that would otherwise be wisely designed with plants tolerant of occasional standing water. The open grass areas of campus in this way are best conceived of as engineered recreational environments. Just as the soccer field is underlaid by an elaborate irrigation and drainage system, the lawns around the Sandburg Towers are artificially wicked dry after a rain.

The upshot of this ‘hard pipe engineering’ approach to stormwater is that water that would naturally percolate into the open landscape is gathered together into a rush that overwhelms the capacity of any pipe. In Milwaukee, where storm and sanitary sewers are combined, this surge often even overwhelms the system as a whole.

For the residents living along Edgewood Avenue at the base of our northern catchment, this means that given a large enough cloud burst over this small area of town, the collector pipes running in the street will back up, if only for a short while. Regardless of how short that period is, if the trunk lines cannot accept water being collected by the branches uphill, combined storm and sewer water backs up into the basements of those at the lower elevations.

To some degree, this fact that the landscape is impervious and engineered to drain quickly is true of the entire City. There are several points that make the UWM Campus unique in our local context, however. The first is that the campus is relatively densely developed. While the Northeast block of campus, which includes the Downer Woods, is a little over 36% impervious surfaces (roofs, pedestrian and vehicular surfaces), the Southeast block is 78% impervious and the Southwest block is 68% impervious. The typical residential block in the neighborhood for comparison is comprised of between 20% and 30% impervious surfaces.

The second distinction is that the storm sewers on the UWM campus are separated from the sanitary sewer lines until they spill into the combined sewers running down the bordering streets. This distinction is critical, as it opens up many opportunities to capture stormwater and retain it on site that would not otherwise exist.

The final distinction is that UWM is an singular institution with the ability to effect change at a scale that the surrounding neighborhood can’t match, as well as many overlapping institutional reasons to do so.

THE STRATEGY OF THE MASTER-PLANNING STUDY

In general terms, the alternative to engineering the built environment to drain water away quickly is to design it to *detain* it for a period of time to diffuse the surge of water moving through the system or to *retain* it indefinitely, until it is infiltrated into the ground or evaporated into the atmosphere. Through many different individual strategies applied to different situations, the resulting goal is to design an environment that has a greater capacity to absorb and store water, and is more functionally and aesthetically geared towards the transitory presence of water. Rather that seeing the campus environment as a stone that sheds water and is quickly dry, the goal is to see it as a forest or prairie, both of which have evolved to function like a sponge and capture water.

The strategy of this study is to take the view of the rain cloud overhead, and systematically study every horizontal surface individually for potentials to capture water. The goal is to leave the water as diffusely scattered across the surface of the campus as possible, recognizing that no single storage feature can possibly contain the run-off from the entire campus. Where hard pipe engineering seeks to gather water together for efficiency's sake, 'soft' or ecologically informed design seeks to mimic the distributed and multi-tiered behavior of the natural landscape.

Working with gravity from the top of the campus down, the categories of surfaces studied are:

Internally Drained Roofs- 'Flat' or low-slope roofs drained directly into the storm system. These roofs are evaluated with respect to the application of 'Green Roofs' or engineered vegetated roof systems; the single Best Management Practice (BMP) appropriate for the situation.

Externally Drained Roofs- Pitched roofs drained to gutters and downspouts that are accessible for potential diversion into the landscape. These roofs are evaluated with respect to the BMP of downspout disconnection to rain gardens. This basic strategy has many permutations, but all are tied to the physical area around the downspout being disconnected.

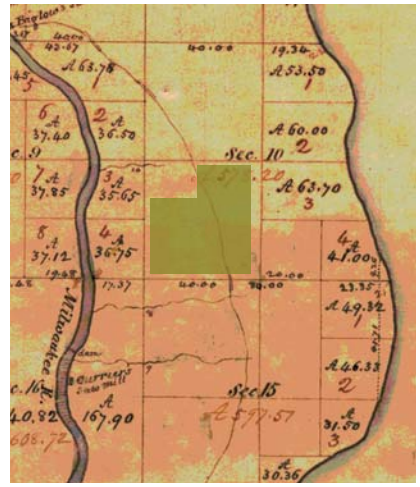
Pedestrian Hardscape- Sidewalks, plazas, and other impermeable surfaces designed for people. Here the variety of BMP's suggested multiplies and in systematically studying each surface individually, we actually seek to innovate new approaches.

Vehicular Hardscape- Parking lots and the driveways, loading docks and other service surfaces designed for vehicular use. These areas are evaluated first with respect to the capacity of the surrounding landscape. Are there areas adjacent and down-slope from the hardscape where runoff can be diverted to features analogous to rain gardens? They are also evaluated with respect to the use of pervious paving materials, which have the potential to create significant storage capacities, but do so without creating any aesthetic or ecological benefit locally and so are treated as a secondary solution.

Landscape- Everything that is not covered with an impervious surface, from the highly engineered soccer field to the Downer Woods.

THE GOAL OF ZERO-DISCHARGE

As stated in it's title, the conceptual goal of this project is to achieve a 'zero-discharge' state for the UWM campus. While this sounds like an unambiguous target, the reality is much



UWM superimposed on an early map of the East Side. Note the visible lines of drainage on both the Northern and Southern borders. The northern border is Edgwood Avenue, which marks the separation of Milwaukee and Shorewood as a low spot in the local topography.

Storm Sewer Tree, Catchment 6. This storm sewer line drains Lapham Hall and the Chemistry buildings, with the Engleman Soccer field at the furthest extent. This is one of the largest trunk lines on campus, as indicated by the thickness of the red line. The yellow line at Kenwood Avenue is the combined storm and sanitary sewer of the City.

more complex.

This study's guiding purpose is to bracket the limits of the definition of 'zero-discharge' and it's physical implications for the campus, not provide an exhaustive engineering or financial optimization analysis. As a design-based study, our goal is prove the physical potential for the campus to transform itself to meet the most aggressive possible stormwater management goals.

Intuitively, the ecologically inspired definition of this state would be to have the campus approximate the hydrological and ecological function of the landscape that existed on this site before settlement; to return the campus to the stormwater hungry Oak clearing or forest that it likely was. Interestingly for such an urbanized campus, the Downer Woods offers a glimpse into that world. With successful restoration, the Downer Woods actually offers the pedagogical opportunity to demonstrate the physical benchmark for the campus' transformation to a stormwater celebrating urban landscape.

From an engineering and policy perspective, the definition of 'zero-discharge' is the allowable peak rate of stormwater entering the sewer system for various defined storm events. We have focused in this analysis and presentation on the maximal 100 year storm event, with it's proscribed discharge rate of 0.5 cubic feet per second per acre drained (cfs/acre). While this focus has the advantage of defining the most challenging target, it does have disadvantages. Most significantly, looking only at the 100 year scenario undervalues the performance of most BMP's, which are designed to optimize performance during much more frequent storms. Both the green roof study and rain garden study suffer from this, and would appear to have an even larger impact in reducing peak discharge rates if we were presenting 2 and 10 year modeling results.

This is confirmed by the fact that the engineering report for the Village of Shorewood on the results of this study will be written using 10 year event results rather than 100 year results. Paraphrasing Mustafa Emir of Bonestroo Rosene Anderlik & Associates, "everyone understands that there will be flooding in a 100 year event. What they can't accept is that there is flooding more frequently."

THE SWMM MODEL

As part of this interdisciplinary project, Masters of Engineering student Elizabeth (Libby) Locke has worked with primary advisor Hector Bravo and P.I. Wasley to create a computer model of stormwater runoff on campus. This model serves as the primary predictive tool for the masterplan, offering a powerful tool that will continue to evolve as it is used to evaluate specific proposals and aspects of the campus.

As her Thesis work, Libby completed the model and it's validation against water flow data collected over the (unfortunately dry) summer of 2005. Both the MMSD and Sigma Environmental Services deserve special thanks for providing monitoring equipment to make this validation possible.

Also covered in the Thesis document are initial analysis of two BMP strategies- the use of green roofs for internally drained low-slope roofs, and the use of downspout disconnections to rain gardens on externally drained roofs. But while the Thesis document offers the most thorough cross validation of the SWMM results with other methods for sizing BMPs, this specific modeling has been superseded by other simulations in this report, as described below.

DEFINING THE EXTENT OF THE SWMM MODEL

A second complexity of the Zero-Discharge goal and its presentation here is that it has been our intention to be as expansive as possible, but have at the same time struggled to frame the impact of the design proposals clearly. As a result of the desire to be expansive, the SWMM model includes Columbia Hospital, adding approximately 13 acres of highly impervious area to the model. To reconcile the SWMM model with the flow data available for validation, the model also includes the residential blocks between Columbia and Edgewood Avenue and all of the streets bounding this entire area.

The net result is that the initial modeling conducted for Libby's Thesis charts the impact of BMP's on campus against an area that is significantly larger than the campus, thereby diluting their apparent effectiveness. For this reason, the summary modeling results presented here have been redone to examine only the area of the campus, graphically representing the impact of various design scenarios against the land area available for their implementation. For simplicity's sake, this area has been defined to include the Downer Woods, though one could also argue that it should be excluded from the base area of campus because as a State Protected Natural Area it is also unavailable for stormwater storage for the campus as a whole. Our goal, in fact, is to insure that stormwater from campus is not allowed to further degrade the woods.

Though it is excluded from the SWMM modeling displayed here, we have made attempts to document Columbia Hospital and the Zelazo center in terms of the applicability of BMPs. These observations are included in the Appendices that document the various surfaces of the campus.

THE NORTH/ SOUTH DIVIDE

The third complexity that frames the Zero-Discharge study is that we have sought to inventory and create a vision of the entire UWM campus, while at the same time acknowledging the MMSD's primary interest in the northern side of campus draining to Edgewood Avenue. This watershed division is consequently a primary category of the analysis- 62 acres of the campus happens to drain north, while 37 acres drains south. That 62 acres is 48% impervious, while the south draining acreage is 73% impervious. These differences echo throughout the masterplan.

This imperative to divide the campus by watersheds rather than street addresses highlights the underlying structure of the SWMM model, which also aligns with an ecological orientation to questions of design. As identified by Libby, the campus is divided into 21 catchment areas; small drainage basins reflecting the underground architecture of storm drains and pipes that shadow but are not necessarily the same as the topographic basins of the visible landscape.

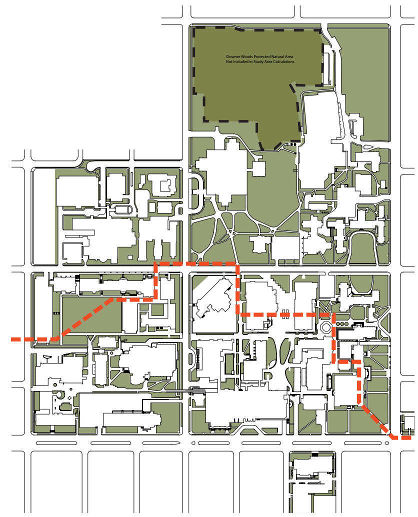
While the identification of these individual catchment areas is not particularly significant in framing design questions, the division between the northern and southern drainages is. For example, the Golda Meir Library drains primarily to catchment 14 on the north but also to catchment 11 on the south. This suggests that it might very well be possible to reroute existing storm lines within the basement of the building to direct the entire building south, which would have a significant impact on the peak flow rate to Edgewood Avenue.

This is the type of novel strategy that our analysis has sought to uncover. (Though this particular example has in the end not been given significant attention because it does not meet a second objective of keeping stormwater above grade where it can be ecologically useful. See storm-pipe daylighting).

Given the focus on Edgewood Avenue, the final SWMM studies presented here model only the northern drainage.

In summary: While the SWMM model and other aspects of the Masterplan inventory reach beyond the campus to Columbia and beyond, the SWMM studies that we are presenting here to illustrate the application of the masterplanning strategy are modeling the northern drainage of the campus area only, and only for the 100 year storm event. All of this is to emphasize the point that this study seeks to bracket

North draining Campus**:**
62 Acres/
48% Impervious



South draining Campus**:**
37 Acres/
73% Impervious

the problem and create a visionary framework for it's solution. It is the first step of many.

TARGET VALUES FOR BMP STRATEGY MODELING

With the goal of capturing stormwater at every opportunity, the basic approach of the masterplan is to identify BMPs for each surface and to apply them uniformly, evaluating the overall impact of doing so for each surface individually and in combination.

Each surface (internally drained roofs, for example) is catalogued into one of three categories; priority, secondary, and not suited for capture. In general, priority applications are those that have multiple benefits in terms of issues such as stormwater management, ecological enhancement, timing in terms of known campus maintenance projects, aesthetic impact and symbolic value. Secondary surfaces

CAMPUS SURFACE INVENTORY (s.f.)

	North	South	Total	Notes
Internal	423,018	520,130	943,148	
Sloped	116,786	0	116,786	
Pedestrian	556,283	469,825	1,026,108	
Vehicle	195,143	190,852	385,995	
Landscape	1,410,461	413,953	1,824,414	Downer Woods is 33% of the North Basin
Total	**2,701,691**	**1,594,760**	**4,296,451**	
Total Acres	**62**	**37**	**99**	
Impervious%	**48%**	**73%**		

TARGET DESIGN VALUES FOR BMP STRATEGY MODELING

STRATEGY	VARIATION ON STRATEGY	PRIORITY IMPLEMENTATION TARGET	FULL IMPLEMENTATION TARGET	NOTES
Green Roof	Extensive (4”) green roof	40% of internally drained roofs to green roof	80% of internally drained roofs to green roof	Actual values of __% and ___% modeled based on campus roof assessment, as shown.
Downspout Disconnect	Garden 10% roof area (MMSD standard)	40% of externally drained roof area disconnected	80% of externally drained roof area disconnected	Actual values of __% and ___% modeled based on campus roof assessment, as shown.
Pedestrian Hardscape	Multiple strategies	20% reduction in hardscape going to drains	80% reduction in hardscape going to drains	Targets modeled. Actual values of __% and ___% established post-model based on campus vehicular hardscape assessment.
Vehicular Hardscape	Bio-retention 5% paving area (MMSD standard)	20% reduction in hardscape going to drains	80% reduction in hardscape going to drains	Targets modeled. Actual values of __% and ___% established post-model based on campus vehicular hardscape assessment.
Storm Pipe Daylighting	Multiple strategies			No SWMM modeling- design to meet unmet demand after applying all other strategies

may share many of these features but are not as high ranking. Together, Priority and Secondary Implementation equal Full Implementation, which in our initial assessment represents the maximum feasible extend that capture is possible.

Through an iterative process of evaluation, the masterplan arrives at a series of target values for each surface: Internally and Externally Drained Roofs have a priority implementation target of 40% of roof surfaces captured, and a Full implementation target of 80%. Pedestrian and Vehicular Hardscape have priority implementation targets of 20% and full implementation targets of 80%.

STORM PIPE DAYLIGHTING

The final strategy constituting the masterplan study is the idea of 'daylighting' water that has already entered the drainage system. This seemingly exotic strategy is actually rich in potential applications, as evidenced by its use in several instances in the Pavilion Gateway Demonstration Project.

In terms of modeling compliance with the zero-discharge goal, capturing water that has already entered the system turns out to be the only viable way to capture enough water. Rather than setting a goal of daylighting 10% or 20% percent of water that has entered the system, the target for this final strategy is defined as the amount of water necessary to make up the difference between the flow rates and volumes resulting from the priority or full implementation of all other strategies, and the 0.5 cfs/acre 100 year zero-discharge target.

SUMMARY RESULTS OF THE SWMM SIMULATIONS

According to Libby's SWMM simulation of the northern drainage, the simultaneous application of all priority BMP's (40% of internally drained roofs retrofitted with the minimum weight green roof technologies, 40% of the external downspouts disconnected and redirected to rain gardens, 20% of both pedestrian and vehicular hardscape drained to bio-retention features or converted to pervious paving materials) result in a 24% reduction in the total volume of water entering the Edgewood Avenue pipes, with close to a 20% reduction in the peak flow rate.

The full implementation of these strategies in the northern drainage results in a 54% reduction in total volume and a 44% reduction in peak.

Finally, construction of the Pavilion Gateway Demonstration Project and the Sandburg Commons Green Roof Project together result in a total volume reduction of 10%, with a peak reduction of over 7%.

Looking graphically at the difference between the SWMM plots of the priority and full scenarios and the 0.5 cfs/acre target, these results establish target volumes for storm-pipe daylighting and retention of roughly 80,000 cubic feet for the northern drainage under the Priority Implementation scenario, and 20,000 cubic feet under the Full Implementation scenario. These targets have yet to be tested in detail, but it would appear that the excess volume of water leaving campus under the Full Implementation scenario is easily captured by the diverse strategies documented in the masterplan.

CONCLUSIONS AND NEXT STEPS

As a first step, this study clearly demonstrates the physical potential for the UWM campus to meet the most stringent of stormwater management goals. Whether this 100 year/ zero-discharge goal is the appropriate goal is certainly both an engineering and a policy question that now needs to be addressed.

At the same time, every individual strategy mapped out here has some positive benefit. All are potentially demonstration projects and real contributions to solving the flooding problems of Edgewood Avenue. The masterplan is, in fact, a catalog of possible next projects for the faculty, students and administration to pursue. The Pavilion Gateway and Sandburg Commons Green Roof projects in particular are shown to offer substantial benefits to Edgewood Avenue, as well as offering fantastic pedagogical and research opportunities.

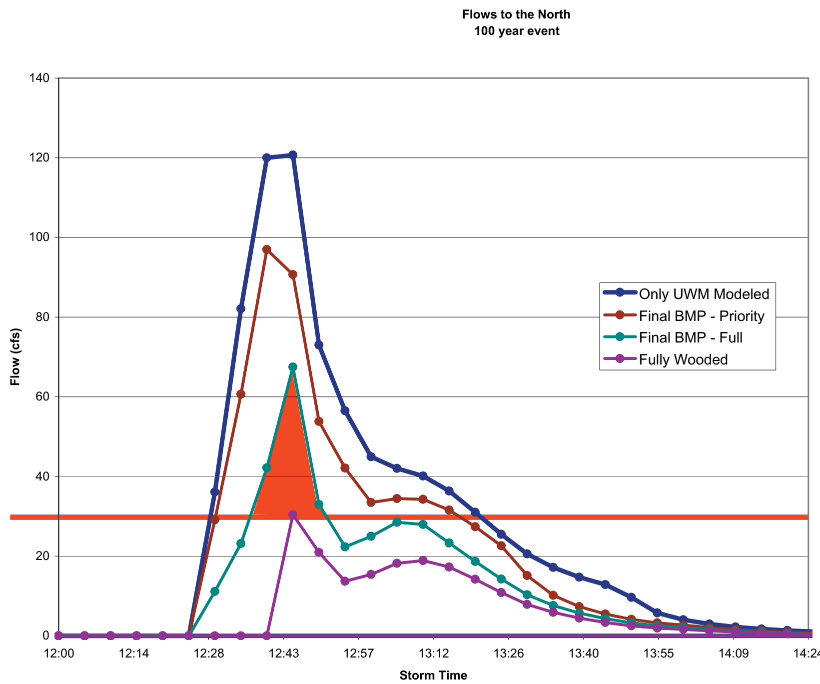
These demonstration projects as a whole are predicted to reduce peak flow by 9 cfs. in a 100 year event. For comparison, we estimate that the existing stormwater detention pipe installed to the north of Sandburg Commons reduces peak flow by 3.6 cfs.

As a final observation, the fact that the Pavilion Gateway Demonstration Project has been developed in tandem with this masterplan has been a great advantage, Rather than being hampered by the lack of a clearly defined masterplan, the detailed investigation of the Pavilion Gateway project has informed the masterplan in several specific instances. One example of this would be that the idea of roof capture through storm pipe daylighting was generated first in the Pavilion Gateway, and then developed as a conceptual category in the Masterplan.

The most important insight to come out of this parallel work, however, is that the systematic layering of separate strategies undertaken in the masterplan provides an important inventory, but doesn't capture the larger potentials of individual situations. In other words, the generic designs suggested by the masterplan can't replace detailed design investigations of individual spaces on campus. The masterplan could not predict the Pavilion Gateway.

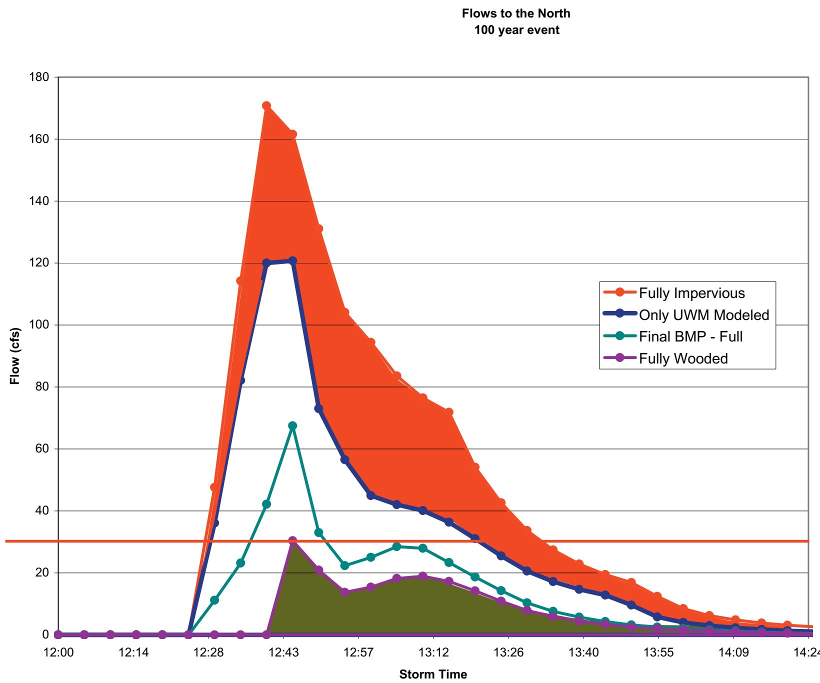
Not only are the individual strategies complex enough to warrant closer scrutiny than they can be given at the level of the masterplan, but the real potentials for innovation and impact lie in their interrelationships, and in the unexpected and novel design opportunities of individual situations.

One clear candidate for future design exploration illustrates how attention to 'place' based design opportunities can potentially trump the masterplan's evaluation of individual surfaces and BMPs. This is the idea, explored in the public design charrette, that Hartford Avenue could be closed between Downer and Maryland, and the land reintegrated into the campus. While the 51,000 s.f. road bed represents a respectable area to capture, it is the possibilities of recasting everything around it in unthought of ways that offers the pay-off. Creating a rain garden scaled to Golda Meir's 130,000 roof alone would completely transform the discharge profile of the campus, not to mention its institutional identity.



Water to be Captured by Daylighting
The various plots represent the rate at which stormwater is entering the north sewer system at Edgewood Avenue for 1.) the existing conditions of the northern drainage, 2.) the cumulative total of all PRIORITY BMPs, and 3.) the cumulative total of the FULL BMPs. The bottom most plot 4.) represents the limiting condition in which the entire northern drainage is returned to forest.

The red line at 32 cfs represents the targeted zero-discharge rate of 0.5 cfs/ acre over the 64 acre drainage. The area shaded between this threshold and the plot of the FULL BMP implementation represents the volume of stormwater to be captured by daylighting in order to meet the zero-discharge goal. This retained water would either be dissipated or released at the 0.5 cfs/acre rate.

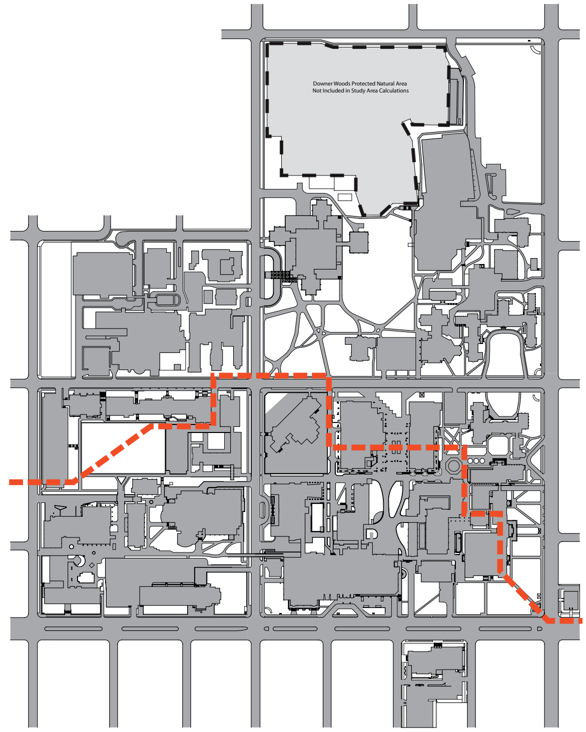


Bracketing the Northern Drainage. Here, the plot described above has had an additional upper limit added. This top most plot represents the profile of the drainage at the limiting condition of being completely impervious.

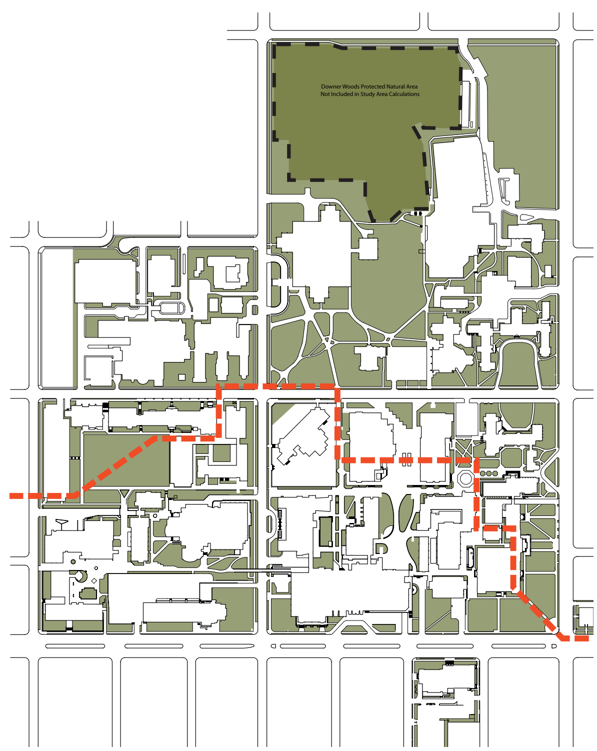
The bottom most plot represents the opposite limiting condition in which the entire area is returned to forest. In the white space between these extremes lies the existing situation and the space of action for the masterplan.

Impervious Surfaces Inventory Overview

As indicated by the dashed red line, he Campus is divided between two drainage basins. The Northern half of campus drains to Edgewood Avenue and is of particular interest to the MMSD for it’s potential to reduce localized flooding in Shorewood.

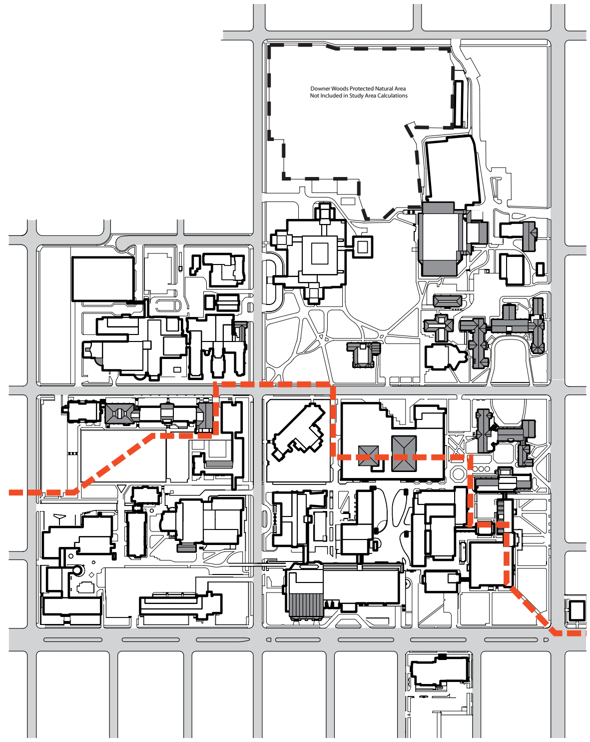


Impervious Surfaces
Approx. **61 acres- 53%** of the total Campus area (excluding Downer Woods)

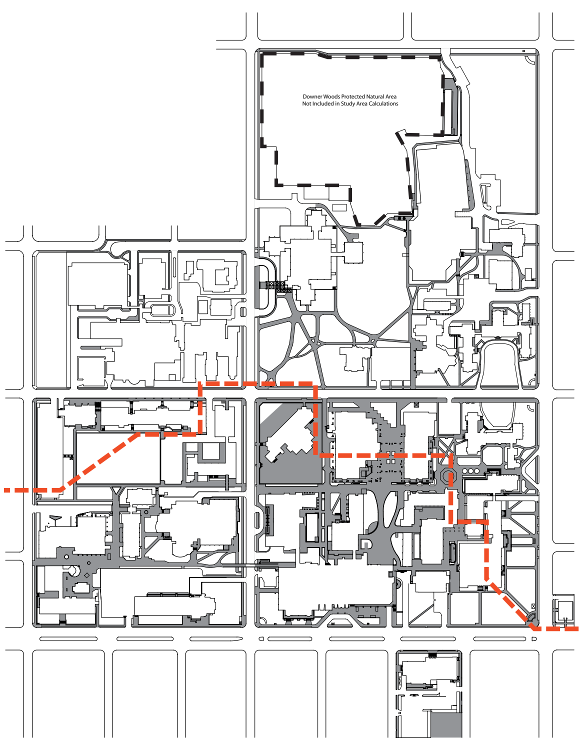


Pervious Surfaces
Approx. **54 acres- 47%** of the total Campus area (excluding Downer Woods)

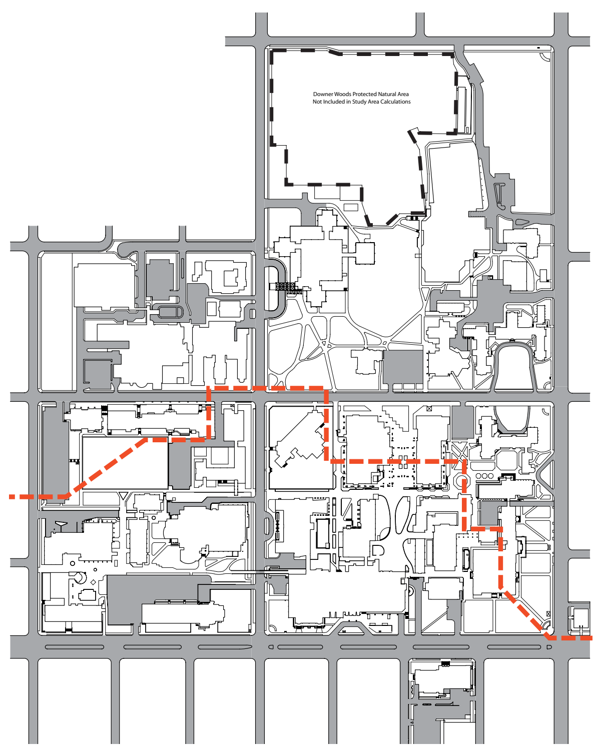
Internally Drained Roofs
Approx. **23 acres- 20%** of the total Campus area
Potential candidates for Green Roofs



Externally Drained Roofs
Approx. **7 acres- 6%** of the total Campus area
(all within the critical Northern Drainage)
Potential candidates for downspout disconnections to rain gardens.



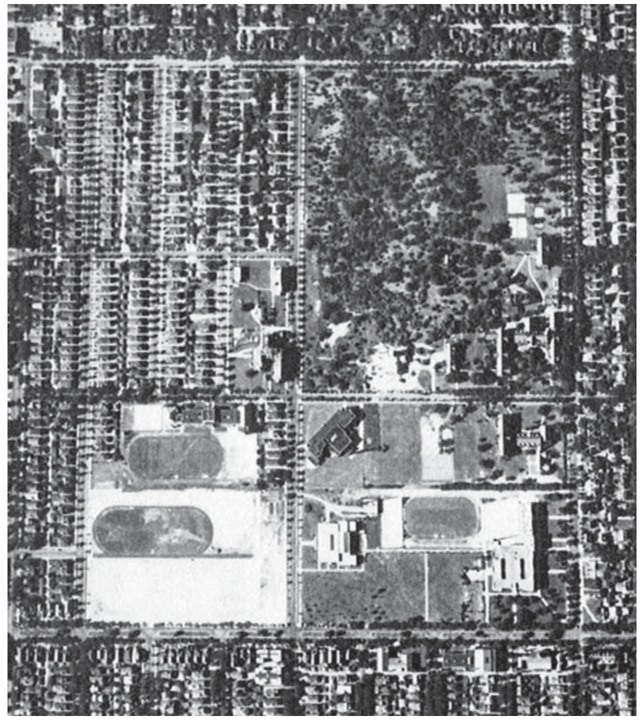
Pedestrian Hardscape
Approx. **20 acres- 17%** of the total Campus area
Potential candidates for various stormwater diversion to landscape and permeable paving strategies



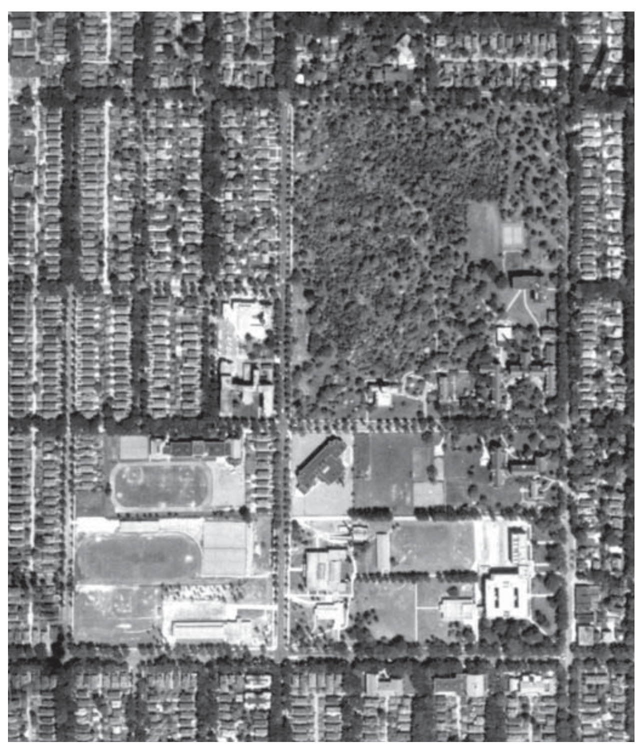
Vehicular Hardscape
Approx. **11 acres- 10%** of the total Campus area
Potential candidates for various stormwater diversion to landscape and permeable paving strategies

Campus Development History

Areal Photography: 1937, 1956 courtesy of DigitalAir Photos, UWM AGS Collection. 1963, 1967, 1980, 2000 Courtesy of SEWRPC, UWM AGS Collection.



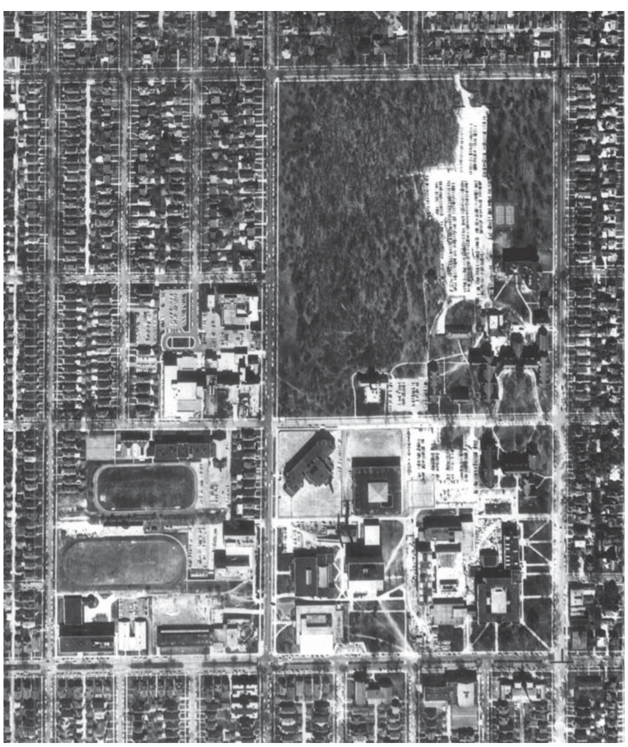
1937



1956

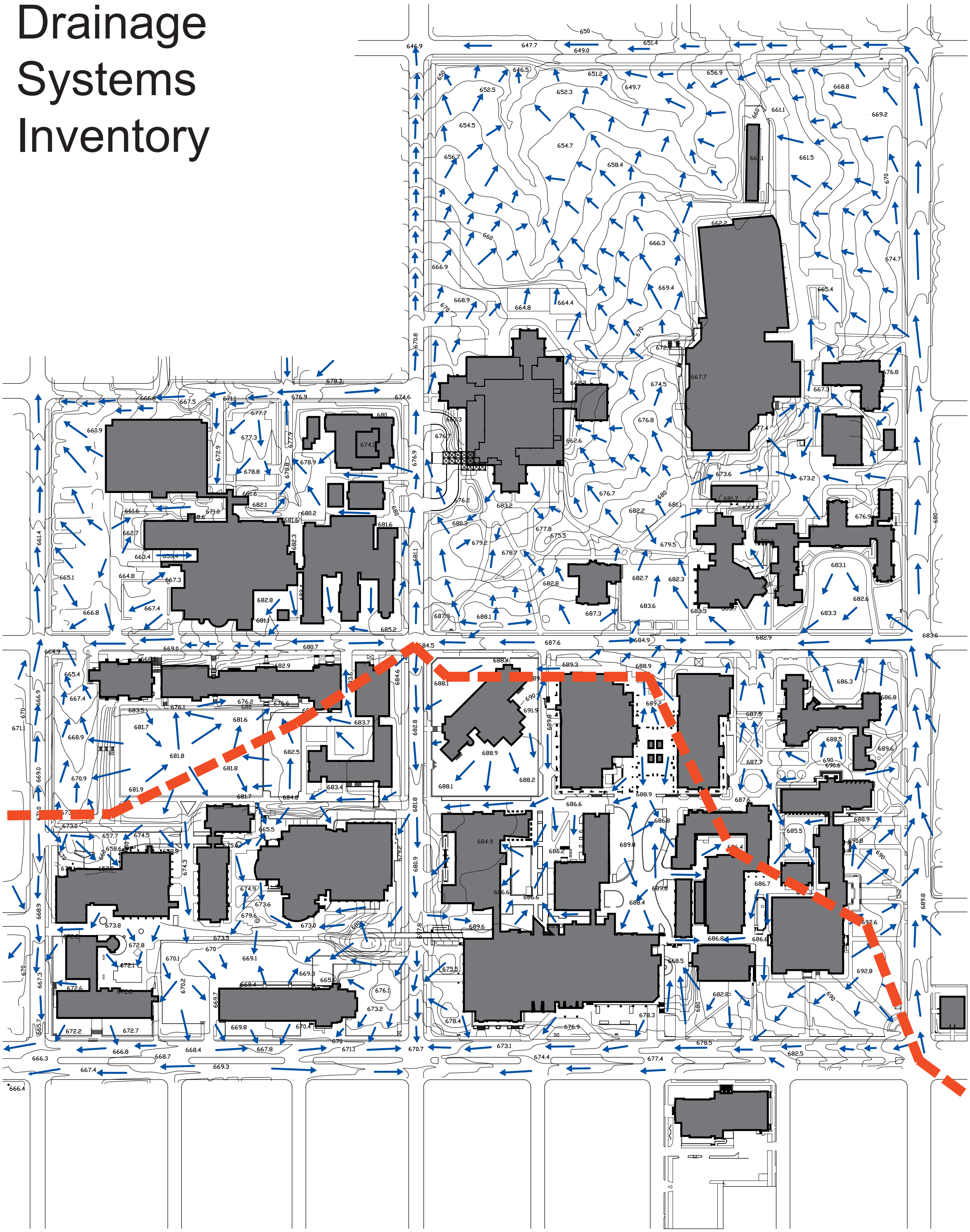

1963


1980

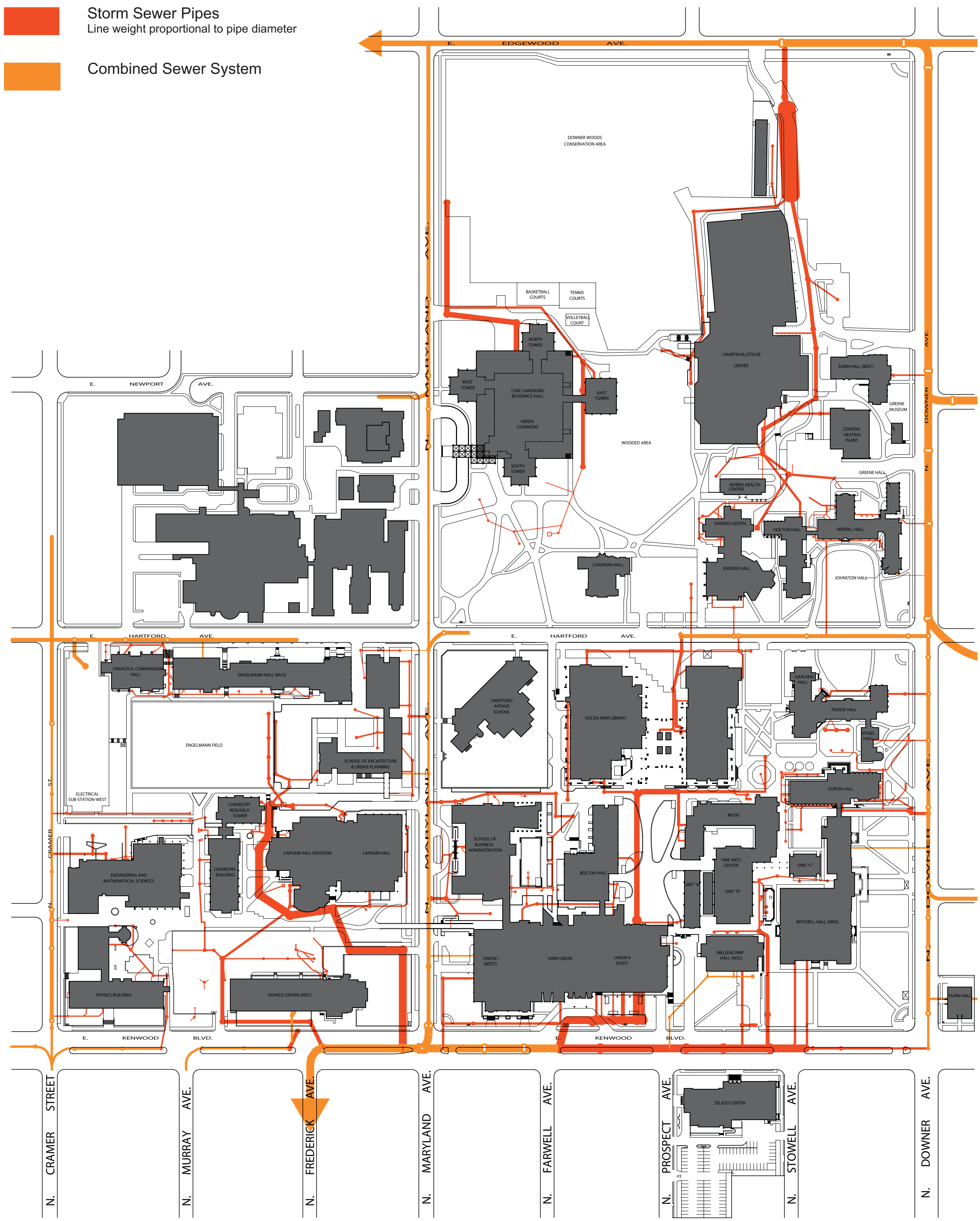

1967


2000

Drainage Systems Inventory



SURFACE DRAINAGE DIRECTIONS BY ELEVATION



CAMPUS STORM SEWER DRAINAGE TREES

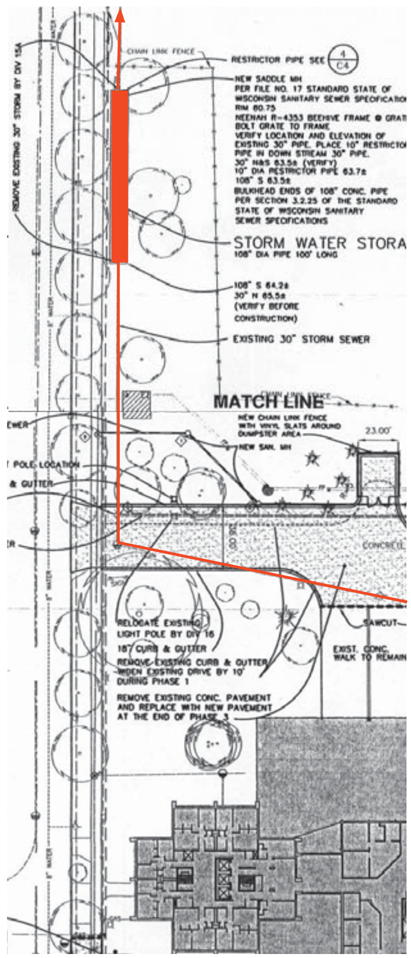
Existing Stormwater Infrastructure

Sandburg East Stormwater Storage Pipe + Pavilion Stormwater Storage Pipe

The recent construction of both the Sandburg East Tower and the Pavilion on the north side of campus have included stormwater infrastructure improvements aimed at decreasing the peak discharge rate to Edgewood Avenue. At the Pavilion, the project has also been designed to eliminate the problem of stormwater runoff from vehicular hardscape draining into the Downer Woods.

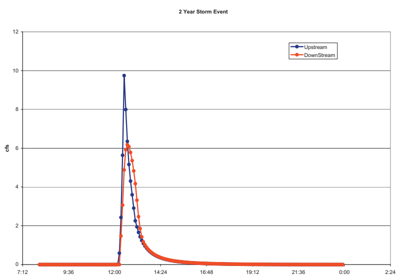
At Sandburg Hall, as-built drawings indicate the retrofit of a 6,361 cu. ft. ‘Stormwater Storage Pipe’ in line with the existing stormwater drain for catchment area 15. SWMM modeling by Locke suggests that this pipe reduces peak flow by 5.7 cfs and 40% for a 10 year storm event and 3.6 cfs, or 14% for a 100 year storm event. We do not currently have information on the increase in peak flow or total volume caused by the construction of the East Tower, but we assume that the pipe is designed to offset this increase in impermeable landscape. The footprint of the East Tower is 7,360 s.f.

At the Pavilion, working drawings indicate the retrofit of a similar 6,361 cu. ft. storage pipe in line with the existing stormwater drain for catchment area 16. The Environmental Impact Study states that this pipe is sized to produce a 10% reduction in peak flow for a 10 year storm event. The additional benefit of reducing the overall impermeable surface of the area by 0.53 acres is not quantified.

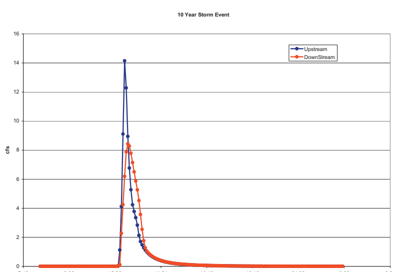


Construction as-built drawings, Sandburg East Tower project. Note the ‘Storm Water Storage Pipe’ -108 inch diameter, 100 feet long”

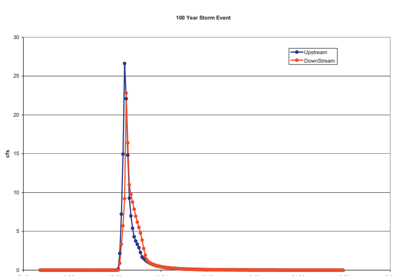
This large diameter pipe is inserted in line with the existing storm drain serving catchment 15. The connection between this pipe and the existing 30” pipe is made with a restrictive 10” diameter pipe. This restriction serves to back water up into the larger pipe, which acts as a temporary reservoir.



Locke SWMM Modelling of Sandburg Pipe
2 Year Storm Event- Peak flow reduced by 3.56 cfs and delayed by 10 minutes. 36% reduction.



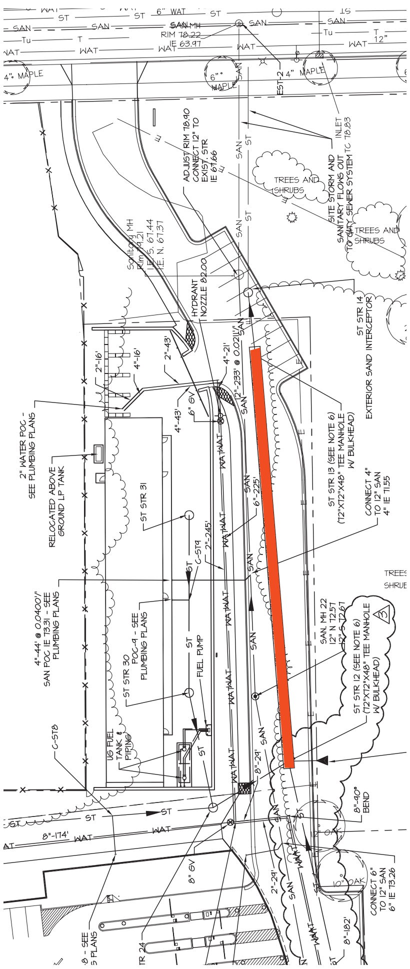
Locke SWMM Modelling of Sandburg Pipe
10 Year Storm Event- Peak flow reduced by 5.74 cfs and delayed by 10 minutes. 40% reduction.



Locke SWMM Modelling of Sandburg Pipe
100 Year Storm Event- Peak flow reduced by 3.61 cfs and delayed by 5 minutes. 14% reduction.

As temporary storage, neither pipe has any impact on the total volume of stormwater runoff from the campus.

As an aside, the SWMM modeling of the Sandburg Storage pipe illustrates clearly the difference between modeling 10 and 100 year storm events. Like other BMPs, the pipes have a limited capacity that makes a greater proportional difference for smaller storm events.



Construction drawings, Pavilion project. Note the highlighted 'UG Storage Pipe,' described elsewhere on the drawing as 72 inch diameter x 226 feet long.

University of Wisconsin-Milwaukee Klotsche Center Addition & Parking Final EIS
State Project #99J3N
October 17, 2001
Page 14

Storm Water
Impervious surfaces covered with asphalt, rooftops, and other hard surfaces in the Klotsche Center project site will be reduced from 2.87 acres to 2.34 acres as a result of project construction. Most of the increase in pervious surfaces will result from removal of the existing groundskeeping facility, North Building, and tennis courts, the sites of which will be replaced partially with landscape plantings. The result will be a net reduction in storm water runoff to adjoining streets and municipal storm grates. Existing roof drains on Klotsche Center and existing storm grates will continue to direct storm runoff to storm sewers that extend northward through the project site to municipal combined sewers in Edgewood Avenue.

Further benefits to storm water management will be gained from a subsurface detention pipe to be installed in the northern area of the project site to slow the release of storm water to municipal sewers. This pipe will produce a calculated 10 percent reduction in peak discharge in existing runoff during a 10-year storm event. Storm water runoff at the groundskeeping facility, and on the access drive to be developed through the northern portion of the site, will be managed with roof gutters and concrete curbs to prevent runoff into Downer Woods Conservation Area. The existing culvert that currently extends from its inlet at the north end of North Building, across the parking lot in a west-northwesterly direction, to its outfall in Downer Woods Conservation Area, may be replaced during construction. By directing storm runoff from the east side of the project site to the west side, the culvert maintains a portion of the predevelopment storm water flow from the Park & Woodland Area to the densely wooded Conservation Area. The project design team is working cooperatively with the UWM Downer Woods Stewardship Committee to improve existing storm water discharge through the culvert into Downer Woods Conservation Area.

Runoff Modeling

M.S. Engineering Thesis

Elizabeth Locke

Framework- Excerpts

(selected excerpts- emphasizing the northern drainage,
which is of particular concern to the Zero-Discharge Zone study)

RUNOFF MODELING OF THE UNIVERSITY OF WISCONSIN-MILWAUKEE AND STUDY OF STORMWATER REDUCTION PRACTICES
by
Elizabeth Locke

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Engineering at at The University of Wisconsin-Milwaukee, December 2005

2.3 MODEL BACKGROUND

…. The model chosen to be used for this project is XP-SWMM because of its ability to model hydraulic pipe networks and rainfall routing....

Since the hydraulics of this system are not very involved, much of the modeling focus was spent on the hydrology of the model. The XP-SWMM model supports several different methods of calculating runoff. The SCS Method and the SWMM method were both chosen for this analysis. Both methods were used and the results were compared to monitored data to determine the best fit for the model. (p.11)

The sewer system pipes contained within the UWM campus were not modeled. The model intends to simulate runoff from the campus as a whole, rather than detailed flows within the campus. (p.19)

The area of each basin and percent impervious and pervious were calculated using the AutoCAD drawing. Each basin was measured, and each area inside each basin was calculated to determine the percent impervious and impervious....

The curve number was calculated for each basin using the percent imperviousness and perviousness. The UWM campus is known to contain clay in the soil, and based on the SCS soil types to determine curve numbers, the UWM campus contains Group C soils. Group C soils are described as clay loams, soils low in organic content, and soils usually high in clay (Chow, 1988). Paved Parking lots, roofs, and driveways all have a group C curve number of 98, while open spaces such as lawns and parks in good condition have a group C curve number of 74. The Downer Woods area was given a separate curve number corresponding to wood or forest land with good cover, or a curve number of 70. These curve numbers were combined based on the percent impervious and pervious to determine an overall curve number for the basin. (p.23)

4.1.3 MODELING OF DESIGN RAINFALL EVENTS

After the XP-SWMM model was calibrated, the model was set-up to run several design storms. The design storms are based on the Southeastern Regional Planning Commission (SEWRPC Technical Report 40, 2000) 2, 10, 100 year events. The calibrated XP-SWMM model was used to analyze different alternatives for stormwater reduction.

The recommended design rainfall depths for the southeastern Wisconsin region for modeled events are listed in **Table 4.6.**

Each of these design rainfall events was modeled and the duration that had the strongest effect on the system

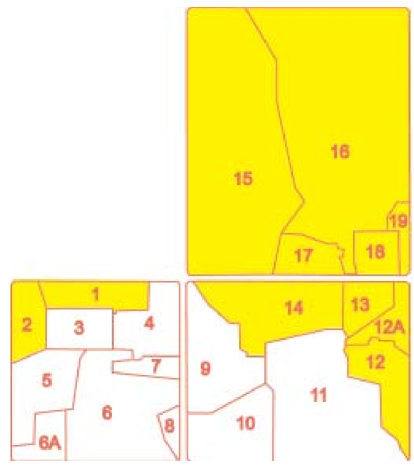


Figure 3.2 / 4.7 (combined) UWM Campus Basins. Basins draining to the North highlighted in yellow.

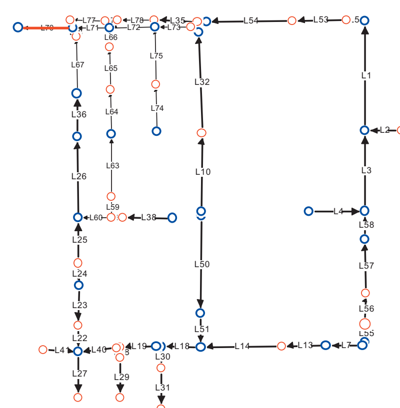


Figure 3.3 Schematic of the pipes modeled in the XP-SWMM UWM model

Zero-Discharge is defined as a peak discharge rate of 0.50 cfs/acre for the 100 year storm. The modeled peak discharge rate north to Edgewood Ave. is 206.5 cfs over a 106 acre area, or a 1.94 cfs/acre rate. This area includes the northern drainage of UWM, Columbia Hospital, and the residential blocks to the north of Columbia. Achieving the Zero-discharge rate for this entire area will require a ***75% reduction*** *in peak flow.*

was determined...(p.39) The results show that the strongest impact to the system occurs during the 0.5-hour duration events. This design event was chosen to be used for additional modeling. **Tables 4.12** and 4.13 list the total cumulative peak flows and volumes flowing to the north and south for the 0.5 hr event. **Figures 4.4** and 4.5 are the cumulative hydrographs of flow to the north and south. The cumulative hydrographs shown can not be observed at a single pipe, but are intended to demonstrate the magnitude of runoff from the whole campus.

Table 4.6 SEWRPC Recurrence Interval and Rainfall Depth

Storm Duration	Recurrence Interval and Depth (inches)		
	2 years	10 years	100 years
30 minutes	1.07	1.45	2.02
1 hour	1.31	1.84	2.82
2 hour	1.54	2.23	3.64
6 hour	1.95	2.79	4.70

Table 4.12 Cumulative Modeling Results of Peak Flows and Total Volume Flowing North

	2 year Event		10 year Event		100 year Event	
	Peak Flow	Volume	Peak Flow	Volume	Peak Flow	Volume
Duration	(cfs)	(acre-ft)	(cfs)	(acre-ft)	(cfs)	(acre-ft)
0.5 hour	115.8	4.3	147.9	6.1	206.5	9.6

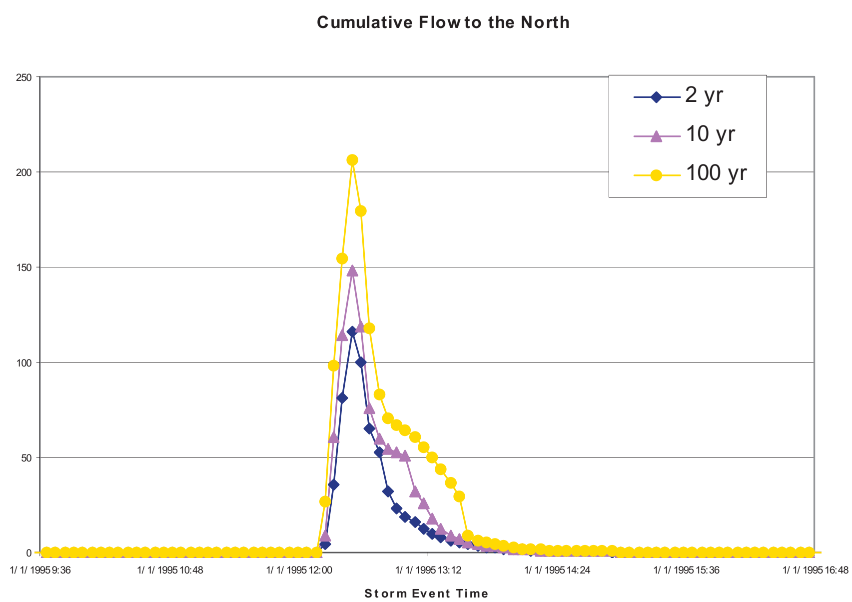


Figure 4.4 Cumulative Modeling Results of Peak Flows to the North for the 2-yr, 10-yr and 100-yr Events

BMP Studies- Excerpts

(selected excerpts- emphasizing northern drainage,
which is of particular concern to the Zero-Discharge Zone study)

4.2 Runoff reduction through BMPs
... The Chapter 13 rules for managing stormwater runoff are that the peak flow target rates are 0.15 cfs/acre for the 2-year return period storm, and 0.50 cfs/acre for the 100-year return period storm.... (p.43)

4.2.1 Downspout disconnection and Rain Gardens
…The rain gardens for these building were designed to be approximately 10% of the roof area draining to the rain garden. A spreadsheet was set up for each basin of the campus, and the rain garden area was inputted for each. The rain garden characteristics were estimated to be a 6.0 inch ponding depth, 16.0 inch soil mix depth, and a 0.2 fillable porosity. (p.48)

The results from these spreadsheet show that the BMPs exhibit the largest effect is on the 2 year and 10 year events. The 100 year event is so large that it will overwhelm most BMPs. These results show that by implementing rain gardens and disconnecting downspouts, the volume of runoff is reduced substantially, and in some cases entirely, for example in basins 13, 18, and 19. The basins affected by the rain gardens all flow to the north... The total reduction in flow volume to the north is listed in **Table 4.17**. A comparison with **Table 4.12** (previous page) illustrates the order of magnitude of the flow reductions.

4.2.2.1 Green roofs- Spreadsheet Results
A comparison of **Tables 4.23** and 4.24 with **Tables 4.12** and 4.13 illustrates the order of magnitude of the flow reductions.

4.2.2.2 Modeling Results
Table 4.26- The modeling results show that there are improvements in peak flows and stormwater volumes when green roofs are implemented ... (p.67)

4.2.3 Discussion of Results
The results from the MMSD spreadsheet and the XP-SWMM modeling were compiled so that they could be compared. **Tables 4.28** and 4.29 show the results from the spreadsheet calculations. The base runoff volumes from all of the basins flowing to the north or south was calculated and compared to the reduction in flow with the BMPs implemented. The percent reduction was also calculated.

Tables 4.30 and 4.31 show the results from the XP-SWMM modeling. The base runoff volumes from all of the basins flowing to the north or south was determined from the model output and is compared to the reduction in flow with the BMPs implemented. The percent reduction was also calculated.

The volumes calculated from the spreadsheet and from the model differ. The base flow volumes calculated using the spreadsheet are roughly double those calculated using XP-SWMM. The spreadsheet and the model used two different methods for calculating runoff. Furthermore, the spreadsheet was a way of calculating runoff quickly and did not have as much detail as the XP-SWMM model contains for each basin. Furthermore, the runoff calculated in the XP-SWMM model was run through the hydraulic pipe network and combined with flows from other basins before discharging into the pipes at the furthest north area and furthest south area. The results obtained by both methods are of the same order of magnitude though, and both reinforce the results of implementing either green roofs or rain gardens.

The results from both the spreadsheet and modeling show that the largest decrease in runoff flows are gained from implementing the green roofs. This may be because there are more buildings that can maintain a green roof on the UWM campus. The rain gardens also show a significant reduction in stormwater runoff. (p.72)

Storm Event	Priority Implementation	Full Implementation
	(ac-ft)	
2 yr	0.9	1.45
10 yr	0.9	1.57
100 yr	0.88	1.71

Table 4.17 Total Reduction in Flow to the North with Rain Gardens (spreadsheet results)

Storm Event	Priority Implementation	Full Implementation
	(ac-ft)	
2 yr	0.82	1.45
10 yr	0.82	1.57
100 yr	0.82	1.71

Table 4.23 Total Reduction in Flow to the North with Green Roofs (spreadsheet results)

According to the XP-SWMM model, full implementation (80% of all roofs target) of both green roof retrofits and downspout disconnection to rain gardens would amount to a 30.34 cfs reduction in peak flow to the north.

This would represent a ***15% reduction*** *in both peak flow (cfs) and total volume (1.4 acre-ft).*

	2 yr event	10 yr event	100 yr event
	Volume	Volume	Volume
	(acre-ft)	(acre-ft)	(acre-ft)
Base	7.2	12.46	24.31
Rain Garden Priority	6.3	11.56	23.43
Reduction	0.9	0.9	0.88
% Reduction	13%	7%	4%
Rain Garden Full	5.75	10.89	22.6
Reduction	1.45	1.57	1.71
% Reduction	20%	13%	7%
Green Roof Priority	6.38	11.64	23.49
Reduction	0.82	0.82	0.82
% Reduction	11%	7%	3%
Green Roof Full	5.49	10.75	22.63
Reduction	1.71	1.71	1.68
% Reduction	24%	14%	7%

Table 4.28 Cumulative Spreadsheet Results of Total Volume Flowing North

	2 year Event		10 year Event		100 year Event	
	Peak Flow	Volume	Peak Flow	Volume	Peak Flow	Volume
	(cfs)	(acre-ft)	(cfs)	(acre-ft)	(cfs)	(acre-ft)
Base	115.8	4.3	147.9	6.1	206.5	9.6
Rain Garden Priority	111	4.3	143.85	5.9	199.17	9.4
Reduction	4.8	0	4.05	0.2	7.33	0.2
% Reduction	4%	0%	3%	3%	4%	2%
Rain Garden Full	109	4.1	141.19	5.8	197.06	9.4
Reduction	6.8	0.2	6.71	0.3	9.44	0.2
% Reduction	6%	5%	5%	5%	5%	2%
Green Roof Priority	110.1	4.1	140.9	5.9	195	9.1
Reduction	5.7	0.2	7	0.2	11.5	0.5
% Reduction	5%	5%	5%	3%	6%	5%
Green Roof Full	103.1	3.8	134	5.6	185.6	8.4
Reduction	12.7	0.5	13.9	0.5	20.9	1.2
% Reduction	11%	12%	9%	8%	10%	13%

Table 4.30 Cumulative Modeling Results of Peak Flows and Total Volume Flowing North

Visualizing the Masterplanning Strategy Part 1

From a pedagogical perspective, the ability to graphically represent the dynamic conditions of stormwater behavior on campus is equally as significant as the data itself. This is especially true given the high degree of uncertainty within the model itself.

The top four graphs represent the decrease in stormwater discharge over time at the Edgewood Avenue sewer for the strategies listed. The lower two represent the PRIORITY and FULL implementation scenarios of the above four strategies.

The shaded area of each graph represents the decrease in discharge from the existing condition at the top.

The lowest plot represents the theoretical behavior of the site as fully wooded. Provocatively, the model predicts that the fully wooded site would not exceed the allowable discharge rate, with the vast majority of water never making it to the pipe, even though the soils of campus are considered poorly drained.

As stated in the overview, the modeling of individual strategies is open to review. Here, Vehicular Hardscape is visibly the most effective strategy. By the fact that the Pedestrian Hardscape is significantly larger in area and modeled with the same FULL target, there is clearly some error in the modeling.

On the other hand, Vehicular Hardscape beating out Internally Drained Roofs with half the area can be attributed to the difference between the 2" of storage capacity in the roof system and the 12" storage capacity of the pervious paving. This difference would be moot in a 2 or 10 year model.

Post-Thesis Studies

North Drainage, UWM

CAMPUS SURFACE INVENTORY

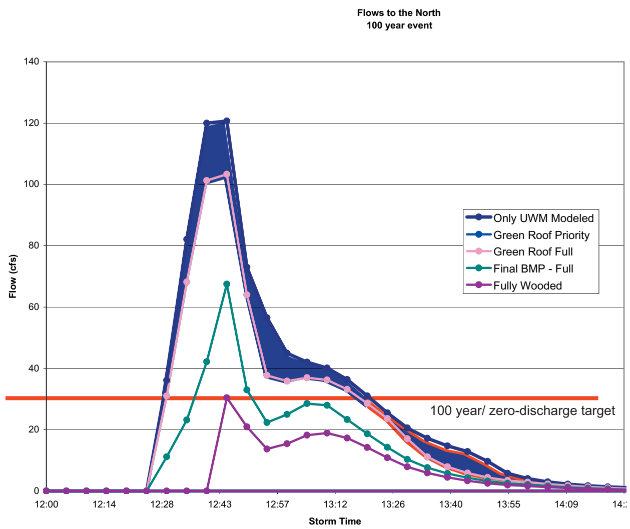
	North	South	Total	Notes
Internal	423,018	520,130	943,148	
Sloped	116,786	0	116,786	
Pedestrian	556,283	469,825	1,026,108	
Vehicle	195,143	190,852	385,995	
Landscape	1,410,461	413,953	1,824,414	Downer Woods is 33% of the North Basin
Total	**2,701,691**	**1,594,760**	**4,296,451**	
Total Acres	**62**	**37**	**99**	
Impervious%	**48%**	**73%**		

TARGET DESIGN VALUES FOR BMP STRATEGY MODELING

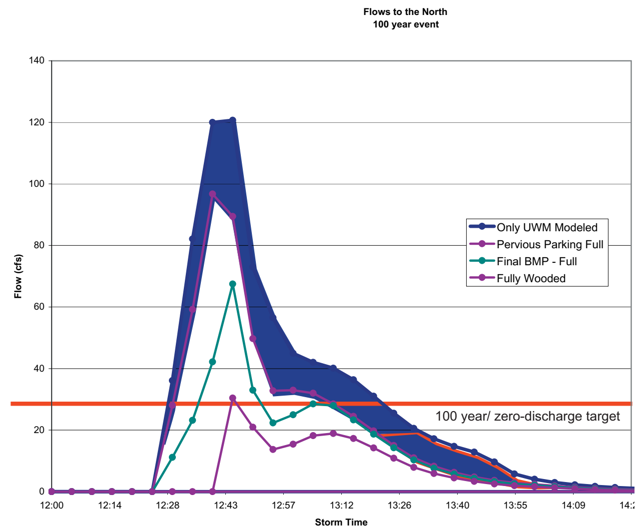
STRATEGY	VARIATION ON STRATEGY	PRIORITY IMPLEMENTATION TARGET	FULL IMPLEMENTATION TARGET	NOTES
Green Roof	Extensive (4") green roof	40% of internally drained roofs to green roof	80% of internally drained roofs to green roof	Actual values of __% and ___% modeled based on campus roof assessment, as shown.
Downspout Disconnect	Garden 10% roof area (MMSD standard)	40% of externally drained roof area disconnected	80% of externally drained roof area disconnected	Actual values of __% and ___% modeled based on campus roof assessment, as shown.
Pedestrian Hardscape	Multiple strategies	20% reduction in hardscape going to drains	80% reduction in hardscape going to drains	Targets modeled. Actual values of __% and ___% established post-model based on campus vehicular hardscape assessment.
Vehicular Hardscape	Bio-retention 5% paving area (MMSD standard)	20% reduction in hardscape going to drains	80% reduction in hardscape going to drains	Targets modeled. Actual values of __% and ___% established post-model based on campus vehicular hardscape assessment.
Storm Pipe Daylighting	Multiple strategies			No SWMM modeling- design to meet unmet demand after applying all other strategies

PREDICTED TOTAL VOLUME AND PEAK FLOW NORTH- 100 YEAR EVENT

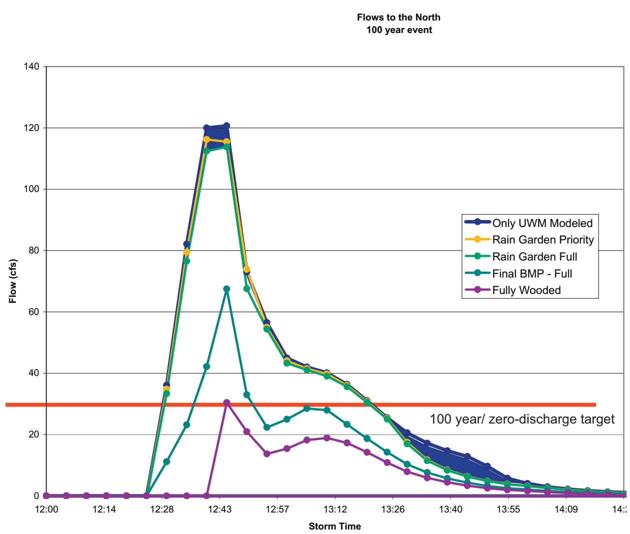
100 Year Event					
	Total Volume to the North	**Total Volume to the North**	**Peak Flow to the North**	**Total Volume Reduction**	**Peak Reduction**
	(cf)	**(acre -ft)**	**(cfs)**	**(cf)**	**(cfs)**
Full Impervious	401397.9	9.2	170.8		
Base- UWM Existing Conditions	243004.5	5.6	120.7		
Green Roof- Priority	error				
Green Roof- Full	199447.2	4.6	103.3	43557.3	17.4
Rain Garden- Priority	229044.6	5.3	116.2	13959.9	4.5
Rain Garden- Full	222635.1	5.1	113.8	20369.4	6.9
Pervious Sidewalks- Priority	237347.7	5.4	119.4	5656.8	1.3
Pervious Sidewalk- Full	229930.8	5.3	114.1	13073.7	7.1
Pervious Parking- Priority	217625.1	5.0	114.3	25379.4	6.4
Pervious Parking- Full	167268.3	3.8	96.7	75736.2	24.0
Final BMP Priority	184887.6	4.2	97.0	58116.9	23.7
Final BMP Full	113926.8	2.6	67.5	129077.7	53.2
Lot 16, 18 and Green Commons	219784.2	5.0	111.7	23220.3	9.0
Fully Wooded	57900.9	1.3	30.4		



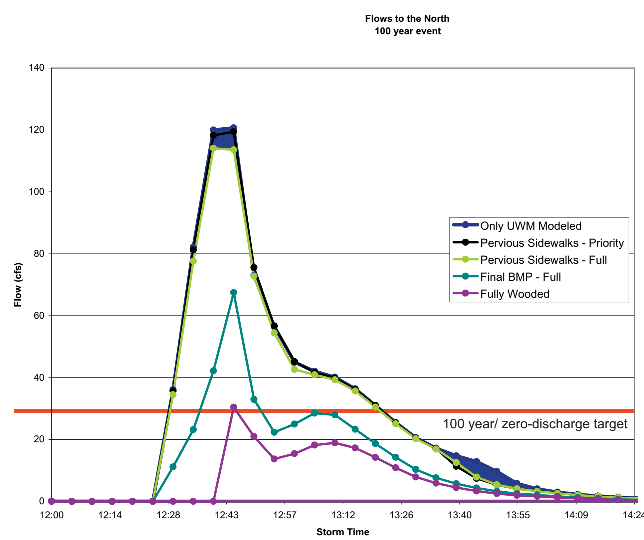
Internally Drained Roofs- FULL Implementation



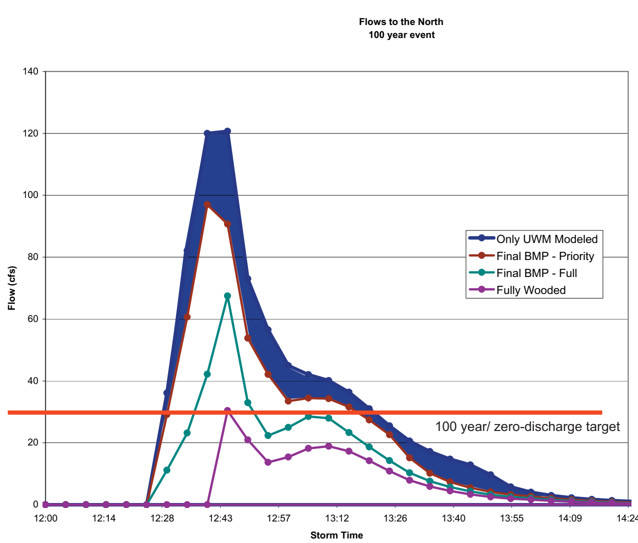
Vehicular Hardscape- FULL Implementation



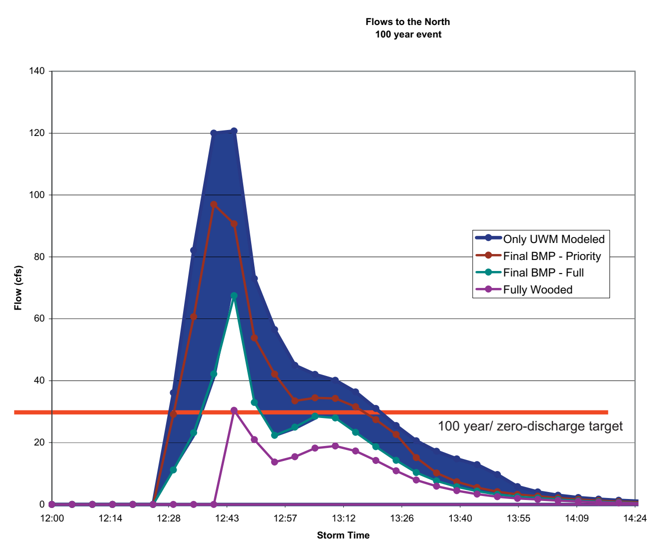
Externally Drained Roofs- FULL Implementation



Pedestrian Hardscape- FULL Implementation



MASTERPLAN- PRIORITY Implementation



MASTERPLAN- FULL Implementation

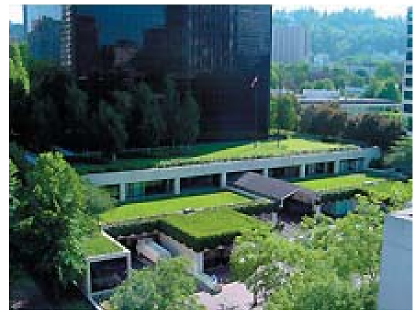
INTERNALLY DRAINED ROOFS

Campus Overview

*UWM should adopt a policy of installing **Green Roofs** for all appropriate internally drained (low-slope) roof replacement projects.*

'Green Roofs' are low-slope roofs that have as their ballast and roof protection systems a surface of living plants; an age-old practice reconceived using contemporary technologies and offering multiple benefits. Most significantly in the context of this study, Green Roofs control stormwater runoff from typically large expanses of otherwise impervious flat roof surfaces. Green roofs act as sponges, retaining stormwater through design and returning a portion directly to the atmosphere through evapotranspiration.

UWM Water Institute Green Roof



http://www.lcrep.org/fieldguide/examples/roofgarden.htm

Chicago City Hall green roof. Conservation Design Forum, Landscape Architects.

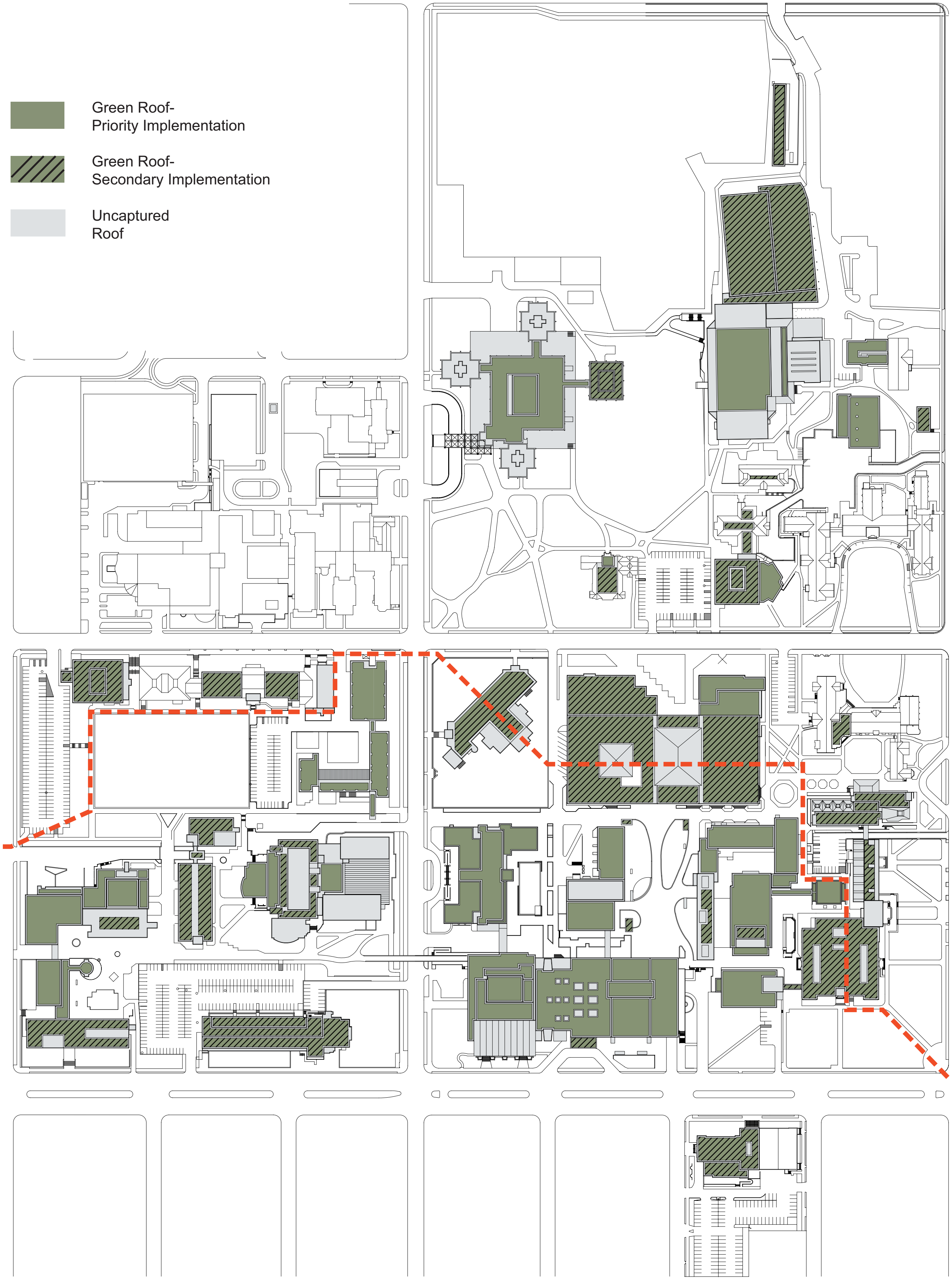
Chicago City Hall green roof. Conservation Design Forum, Landscape Architects.

Ford Rouge Dearborne Truck Plant. William McDonough and Associates, Architects.

GREEN ROOFS

- A layer of vegetation installed on top of a conventional flat or sloped roof.
- Extensive green roofs have a thin layer of soil and are usually composed of seedum.
- Intensive green roofs have a thicker soillayer and contain shrubs, trees and other vegetation.
- Can be constructed on a new or existing building.
- Retain from 15-90% of rainfall.
- Most effective in reducing run-off volume and rate.
- Extends the life of a conventional roof by up to 20 years.
- Reduces air pollution, provides habitat for wildlife and sound insulation.

INTERNALLY DRAINED ROOFS



LOW-SLOPE ROOFS ELIGIBLE FOR GREEN ROOF RETROFITS

Sandburg Residence Hall

North Drainage Catchment 16

Sandburg Hall is UWM's primary undergraduate housing, providing dormitory living for close to 2,700 students.

As a potential site for a green roof installation, the low commons building and mechanical penthouse above it are ideal 'high priority' candidates, with 25% of the dorms having a full view of the roofs and another 25%-50% having oblique views. The unique design opportunity here would be to create visually engaging patterns to be seen from above.

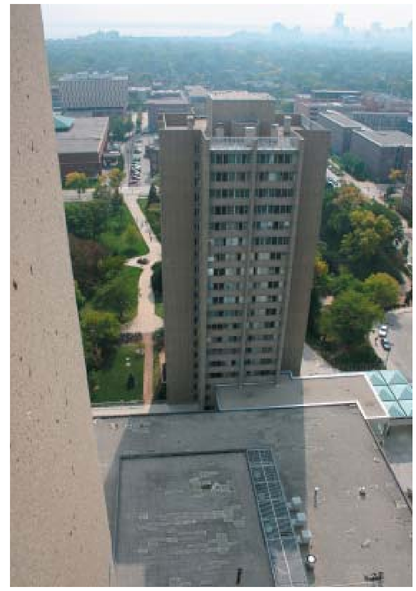
If desired, an ADA accessible terrace for public access could be created with access through the mechanical room.

Sandburg's location within the North drainage means that all stormwater measures have a direct positive impact on the Edgewood Ave. interceptor.

Only the square East Tower is a logical green roof candidate under the 'full' implementation scenario.

Roof, East Tower, viewed from the roof of the North Tower. Only the newly constructed East Tower suggests the potential for a green roof application.

(above and below) Sandburg Commons with a hypothetical green roof installation. An actual design would be elaborated to accomodate existing conditions such as the roof mounted anteenae, as well as to create visual interest from above. Maintenance paths can be created by replacing the growing medium with gravel or with paver blocks.

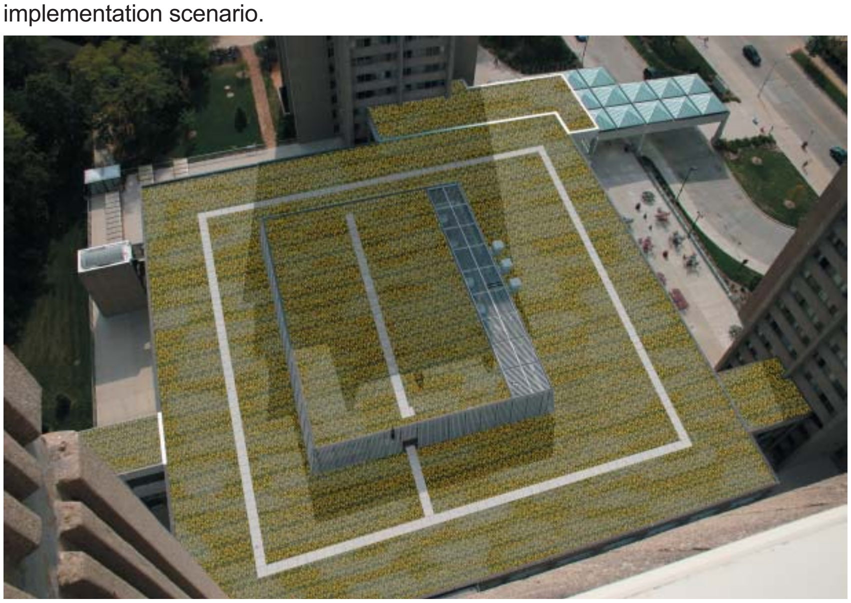


South Tower and commons roof, viewed from the roof of the North Tower. As evident from above, the insulation covering the commons is in need of repair. All four towers have commanding views of the commons roof.

Commons roof and mechanical penthouse, looking north east. While a metal screen surrounds the penthouse, the structure is concrete.

Commons roof insulation, disrupted and rising through the existing gravel ballast layer.

(Left) Sandburg Commons with a hypothetical green roof installation. (Below) The same view as is.



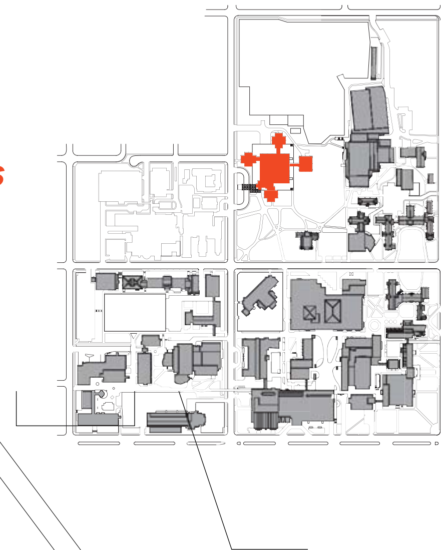
HYPOTHETICAL GREEN ROOF APPLICATION

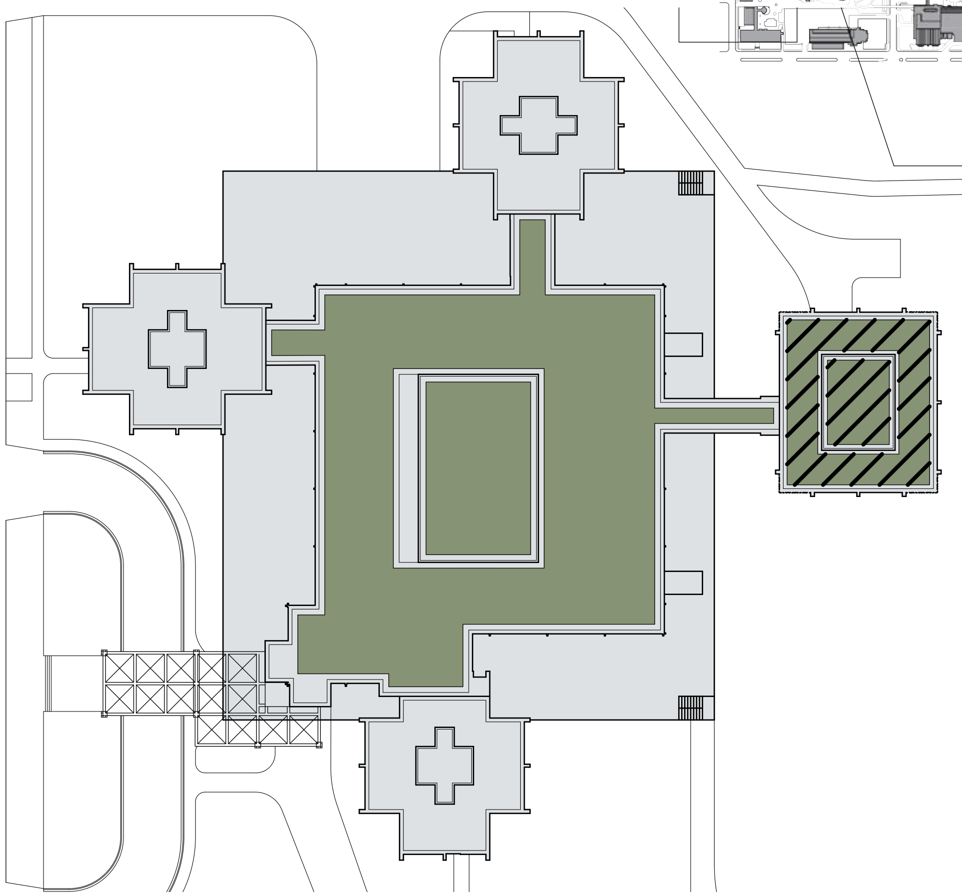
DEMONSTRATION PROJECT:

Commons potential green roof area approx. **25,920 s.f.**

Penthouse potential green roof area approx. **5,400 s.f.**

In Progress





Green Roof- Priority Implementation

Green Roof- Secondary Implementation

Uncaptured Roof

	Total Roof Area (s.f.)	Suitable Area	Priority (Area x .9 cover)	Secondary (Area x .9 cover)	Full (Area x .9 cover)	Access
Sandburg Commons	39023	37264	33538	0	33538	fair
North Tower	6945	0	0	0	0	poor
East Tower	7360	7360	0	6624	6624	poor
South Tower	5125	0	0	0	0	poor
West Tower	6720	0	0	0	0	poor

0' 100' 200'

North

Sandburg Residence Hall

Golda Meir Library

North Drainage Catchment 14

With 110,226 s.f. of internally drained roof area, Golda Meir library makes up ____ % of the internally drained roof area on campus, rivaling either Klotche or the Pavilion taken individually as the largest flat roof on campus. Unlike either of those special purpose buildings, the structural system of Golda Meir is presumed to be capable of carrying the added weight of a green roof.

The East Wing of the building is identified as 'priority' for green roof application. This single story roof with perimeter clerestory is visible from several surrounding buildings and the northeast corner windows of the West wing of the library. The lower portion of this roof is inaccessible, even though it is only a few feet above the plaza grade level. This area could easily be made into a public plaza, courtyard or garden.

The primary roof of the library has significant potential as a demonstration site for three primary reasons: 1.) Like the lower roof, it is visible from many buildings on campus. 2.) The office space beneath the taller of the two hipped roofs could easily be modified to offer elevator access and two legal fire stairs to the roof itself. This makes

From the northwest corner, looking southeast.

Looking northeast, from the roof of the business building.

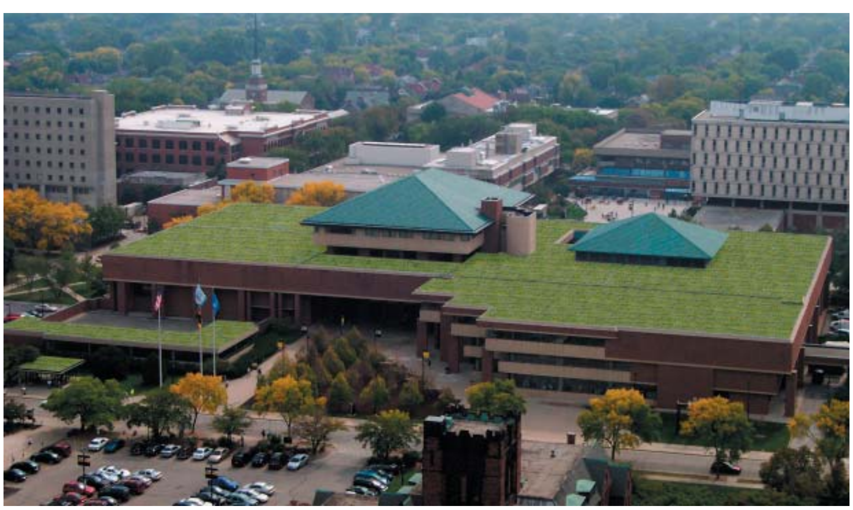
Roof opening to fountain area below

Service access door, north face of the lower hipped roof structure, housing the mechanical room

East wing- ________ reading room from the fourth floor, west wing

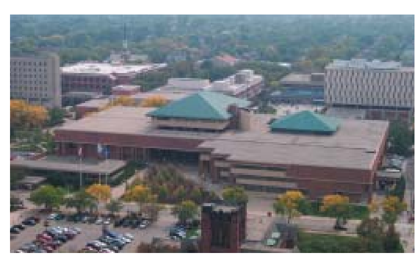
Southern roof area, looking west

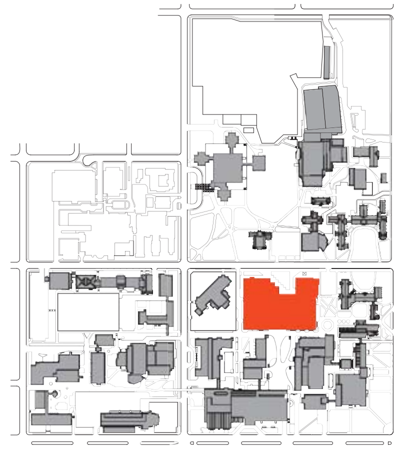
Overhang condition at central pavilion over library mall.



HYPOTHETICAL GREEN ROOF APPLICATION

(Left) Golda Meir with hypothetical green roof application. From north tower, Sandburg Hall
(Below) Same view as is





it the most significant roof on campus that could easily feature an ADA accessible observation deck. And 3.) A good percentage of the roof is tied to storm drains feeding the North Drainage, which is MMSD's priority.

Any plans to add stories to the building should consider stormwater management through the inclusion of a green roof.

Green Roof- Priority Implementation

Green Roof- Secondary Implementation

Uncaptured Roof

	Total Roof Area (s.f.)	Suitable Area	Priority (Area x .9 cover)	Secondary (Area x .9 cover)	Full (Area x .9 cover)	Access
Golda Meir Library	132000	110226	15480	83723	99203	fair

0' 100' 200'

North

UWM Union

South Drainage Catchment 10, 11

With 78,000 s.f. of potential green roof area, the UWM Union is paired with the Golda Meir Library (99,200 s.f.) as the largest two roofs on campus. Only the new Pavilion gymnasium, with 54,500 s.f. of potential green roof area, comes close. This and other advantages, such as the student-centered mandate of the Union, make it an ideal candidate for green roofs.

The central section of the building, characterized by the large pyramidal skylights of the entry hall, offers additional advantages that are unique on campus- the roof is bounded by a high parapet wall and served by the two sculptural egress stairs that bracket the building's mass on the south and north sides. Together, these features suggest that the roof was conceived of from its inception as an inhabited roof-deck.

Given the two means of egress and the high parapet, the only feature required to establish a roof garden that could be occupied for research and educational purposes would be to provide safety barriers around the skylights and a path design that connects the two stairs.

Elevator access is available through the service elevator via the mechanical penthouse. While not ideal for public use, this may be adequate for ADA accessibility for research and educational purposes.

Student Union (East) from Art, looking southwest

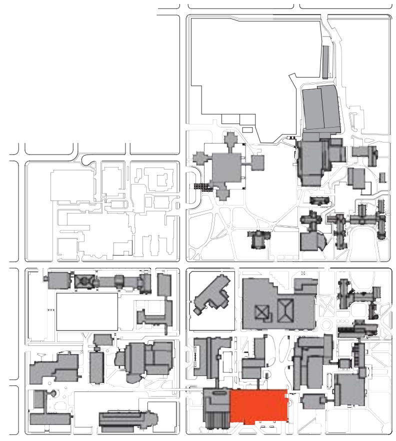
Student Union (East) from Bolton Hall, looking southeast

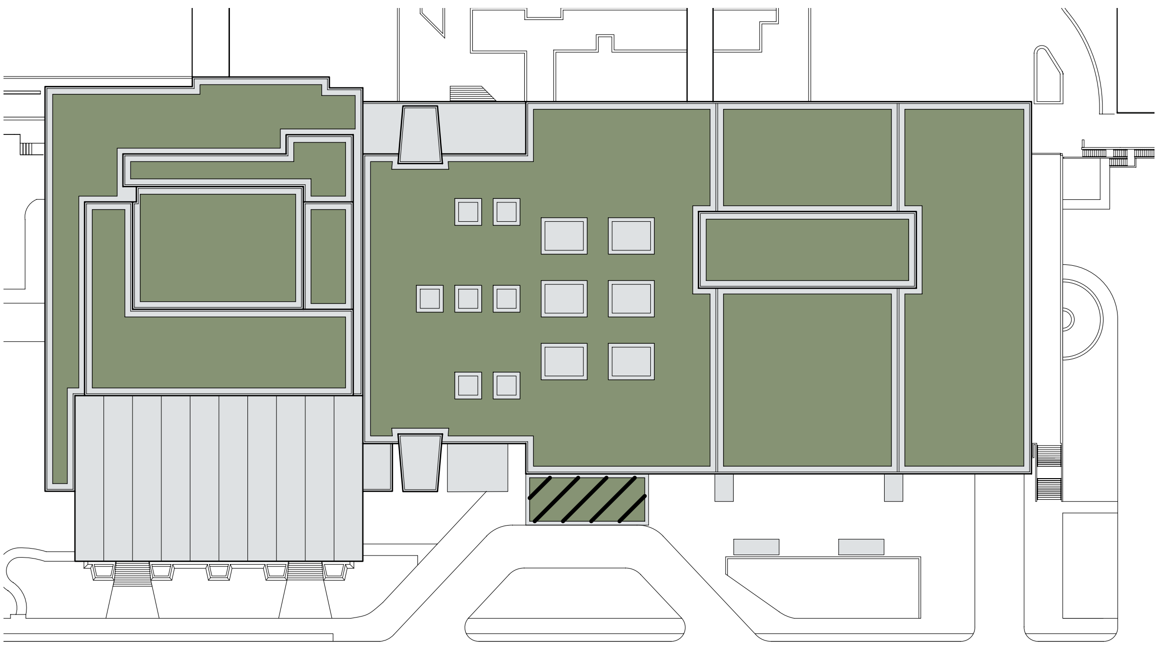
(Above) Student Union (West) from Business, looking southeast.

(Below) Student Union (East). The large skylights sit above the main circulation hall.

HYPOTHETICAL GREEN ROOF APPLICATIONS

Central roof over main entry hall, lower left. Note the south stair tower and door in the far corner.





Green Roof-
Priority Implementation

Green Roof-
Secondary Implementation

Uncaptured
Roof

	Total Roof Area (s.f.)	Suitable Area	Priority (Area x .9 cover)	Secondary (Area x .9 cover)	Full (Area x .9 cover)	Access
UWM Union-West	75405	57000	51300	0	51300	fair
UWM Union-East	32016	32016	28814	0	28814	fair

0' 100' 200'

North

Union Entry
Green Roof Demonstration Project

Approved for Construction Spring 2006

Ecotone Student Organization, sponsors

This small area of roof (175 s.f.) sits at the entry to the Student Union off of the pedestrian bridge crossing Maryland Avenue. The roof sits over a trash compactor room, and measures 14'-10" x 11'-10" inside the curbs, which are 8" deep. The scupper is 18" wide. The roof has good southern and western exposure.

The proposal calls for the roof to be planted with two distinct associations of plants- half of the area will demonstrate a typical 4" deep 'extensive' green roof system, planted with sedum. The other half will demonstrate the potential for Wisconsin native plantings in an 8" deep 'intensive' medium. The shallow extensive side will be underlaid with rigid insulation such that both beds appear to be level, or the difference in elevation will be integrated into the design in some way.

As suggested by the Student Union, the existing guard rail will be replaced with a new rail that will enclose all four sides of the green roof, allowing students to maintain the plantings without risk of falling.

Signage will be provided explaining the green roof system and acknowledging the role of the Ecotone Student Organization in the creation of this installation.

Ongoing maintenance will be provided by the Ecotone Student Organization, with the support of the Conservation and Environmental Sciences Service Learning project students.

(Above) View of roof as is.
(Below) View of roof with hypothetical green roof installation.

HYPOTHETICAL GREEN ROOF APPLICATION

Spaights Plaza Pavillions

Green Roof Demonstration Project

Pending Approval for Fund Raising

The stair pavilions and ventilation towers serving the Union parking structure are an ideal location for a Green Roof demonstration. They are highly visible and associated with the landscape features of the plaza, which itself is a traditional intensive (18" deep) vegetated roof structure. They are unheated, unenclosed, and structurally oversized, presenting a very simple technical challenge.

The project would be constructed by students of Architecture and planted and maintained by the Ecotone Student Group. The estimated cost of materials is $20,000. Approx. $5,000 is currently available through the Zero-Discharge Zone project and the Milwaukee Rotary Club. The remainder will be raised as material donations upon approval.

Total roof area for the seven pavilions:

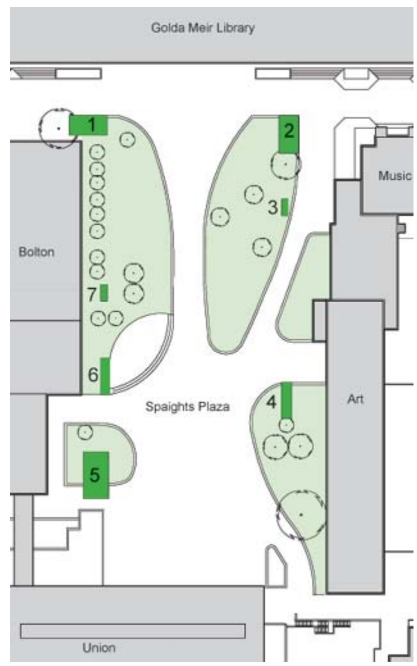
1,800 s.f.

Stair Pavillion 1

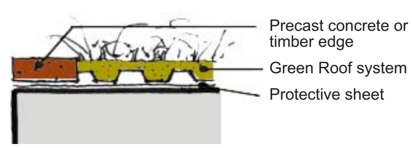
Stair Pavillion 4

Stair Pavillion 5

Pavillions 2 and 3 from Golda Meir Library roof.



Spaights Plaza Plan. Pavillions 1, 2, 4, 5, 6 are stairs to the Union parking. Pavillions 3 and 7 are ventilation stacks.



Roof Edge Detail. The green roof system would have no physical connection to the pavillions and would be completely removable.

Pavillion 5 from the Union balcony with hypothetical green roof installation. Below: Pavillion 5 as is.

HYPOTHETICAL GREEN ROOF APPLICATION

EXTERNALLY DRAINED ROOFS

Campus Overview

UWM should adopt a policy of disconnecting externally drained roofs from the storm sewer system and draining them into rain gardens wherever possible.

The ***Ecotone*** *student organization and the* ***Conservation and Environmental Sciences*** *program have together expressed strong interest in constructing and maintaining such rain gardens.*

'Rain Gardens' are landscape features designed to retain and to infiltrate stormwater. They can be simple to construct, requiring at a minimum only an open area that can be excavated to typically a two-foot depth. They are then graded to that water is held by the planting bed and planted with plants tolerant of being alternately immersed in water and dry. These plantings can feature Wisconsin native species, and are often quite beautiful.

This study presents an initial evaluation of the roof area drained externally and the downspouts that could be disconnected. The grounds around each downspout are evaluated for the potential to create a rain garden based on an MMSD rule of thumb of providing a garden area 10% of the area drained, and also doubling that recommendation by providing an area equal to 20% of the roof area drained. These recommendations do not accommodate the full volume of the 100 year storm event, which would require a rain garden roughly 50% of the roof area drained.

This study is not meant to provide designs for any specific rain gardens. In many situations on the UWM campus, the area required to construct appropriately sized rain gardens is constricted and more elaborate technical solutions become necessary. Such solutions might include above-grade planters and lined gardens designed with both sub-surface and overflow drainage systems to control the movement of water close to building foundations.

In other situations, gardens designed to accommodate the full 100 year storm event may be envisioned. Each downspout and roof presents its own unique possibilities.

Interestingly, all of the downspout disconnections contemplated here are in catchments that eventually drain to the north to Edgewood Avenue.

(Above) Downspout splash block and catch basin, Epler Hall Dormitory Plaza, Portland State University. (Below) Infiltration beds, Epler Hall Dormitory Plaza. Water runs is stone runnels between the downspout and beds. Unlike a typical rain garden, water passing through the beds is collected and used to flush toilets in the building.

RAIN GARDENS
MMSD Literature

- Small, vegitated depressions used to capture and infiltrate stormwater runoff
- Usually 6-18 inches deep
- Planted with appropriate soil mixture and planted with native shrubs, grasses, and flowering plants
- Water is detained for usually no more than 24 hours

18 Piper Drive, 2003 Dane County Better Lawns and Gutters Tour. Wisc. DNR website.

**EXTERNALLY DRAINED ROOFS ANALYSIS-
POTENTIALS FOR DOWNSPOUT DISCONNECTIONS TO RAIN GARDENS**

Greene/ Johnston/ Merrill Hall

North Drainage Catchment 16, 17, 18

Greene, Johnston and Merrill Halls sit opposite Garland, Pearse and Vogle Halls as part of the original Downer College campus. As with those buildings, roof structures are intricate and individual downspouts often drain small areas suitable for simple disconnection. Space for rain gardens is also often limited, suggesting the creation of lined gardens or planters, connected to existing drains.

Merrill Hall downspouts 1 through 9 and Greene Hall downspouts 8 through 11 are disconnected as part of the detailed design proposal for Catchment 16.

Johnston Hall, east facade, downspouts 4 and 5. This proposed rain garden location is on ground sloping away from the buildings and ideal for demonstration purposes. Adjacent to Downer Avenue, it would be a part of the proposed Downer Ave. interpretive gardens.

Merrill Hall, downspout 4.

Merrill Hall, downspout 9.

Merrill Hall, downspouts 7 and 8.

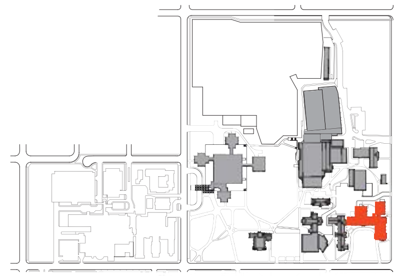
Merrill Hall, south facade, downspouts 14, 15 and 16.

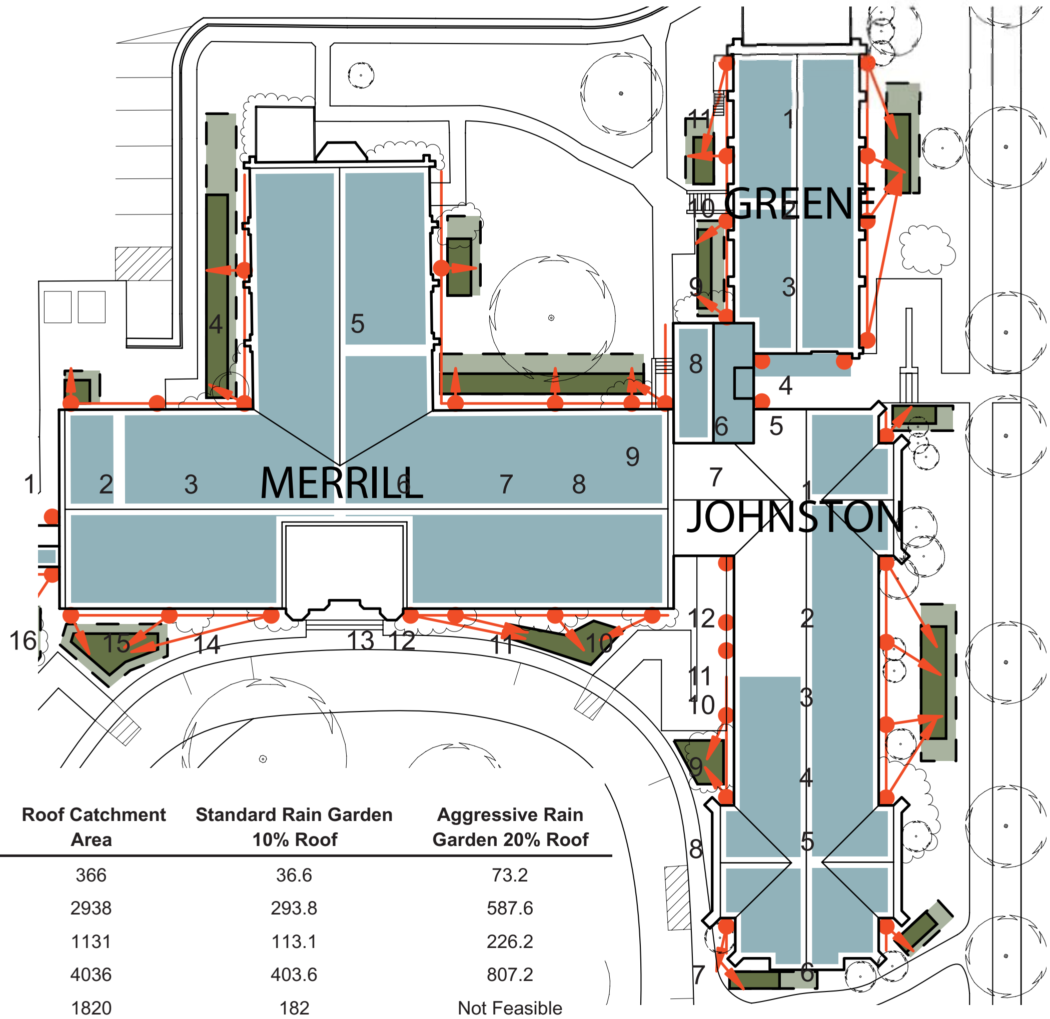
HYPOTHETICAL DOWNSPOUT DISCONNECTION TO RAIN GARDEN

(left) Hypothetical rain garden, Green Hall downspouts 1 through 4. East elevation, facing Downer ave.
(below) downspouts 1 through 4 as is.

DRAFT 3.12.06

DOWNSPOUT DISCONNECTION





Building	Downspout	Roof Catchment Area	Standard Rain Garden 10% Roof	Aggressive Rain Garden 20% Roof
Merrill Hall	1	366	36.6	73.2
	2 thru 4	2938	293.8	587.6
	5	1131	113.1	226.2
	6 thru 9	4036	403.6	807.2
	10 thru 13	1820	182	Not Feasible
	14 thru 16	1509	150.9	301.8
Greene Hall	1 thru 4	1267	126.7	253.4
	5 thru 7	475	Not Feasible	
	8 & 9	643	64.3	128.6
	10 thru 12	596	Not Feasible	
Johnston Hall	1	502	50.2	100.4
	2 thru 5	1890	189	378
	6	557	55.7	111.4
	7	557	55.7	111.4
	8 & 9	993	99.3	Not Feasible
Total	**15**	**19280**	**1820.9**	**3079.2**

Area drained to rain garden- Priority Implementation

Area drained to rain garden- Secondary Implementation

Standard Rain Garden

Aggressive Rain Garden

0' 100' 200'

North

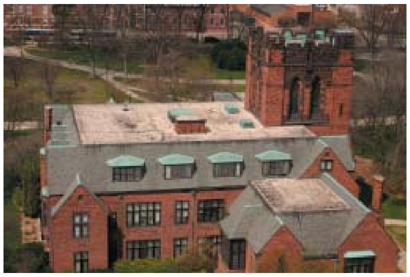
Greene/ Johnston/ Merrill Hall

Chapman Hall

North Drainage Catchment 17

As the offices of the Chancellor, Chapman Hall offers special symbolic significance to the UWM Campus. It's status on campus is reinforced by the atypical amount of open ground surrounding it, and in it's position close to the crown of the northern drainage of campus. All of these factors make Chapman Hall an ideal candidate for downspout disconnection demonstration projects.

Chapman Hall offers 5,284 s.f. of sloped roof for downspout disconnection, as well as 4,476 s.f. of internally drained low-slope roof (see green roof analysis).



Chapman Hall roof and east facade from the roof of Enderis Hall.

North elevation, downspouts 1 & 2

West facade, downspouts 12-16. Grounds clearly slope away from the structure and across open lawn.

North elevation, downspout 1

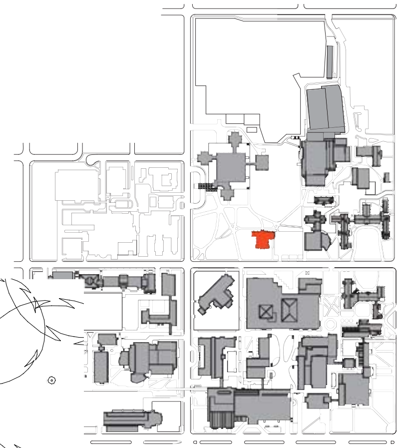
West elevation, downspouts 12 through 16

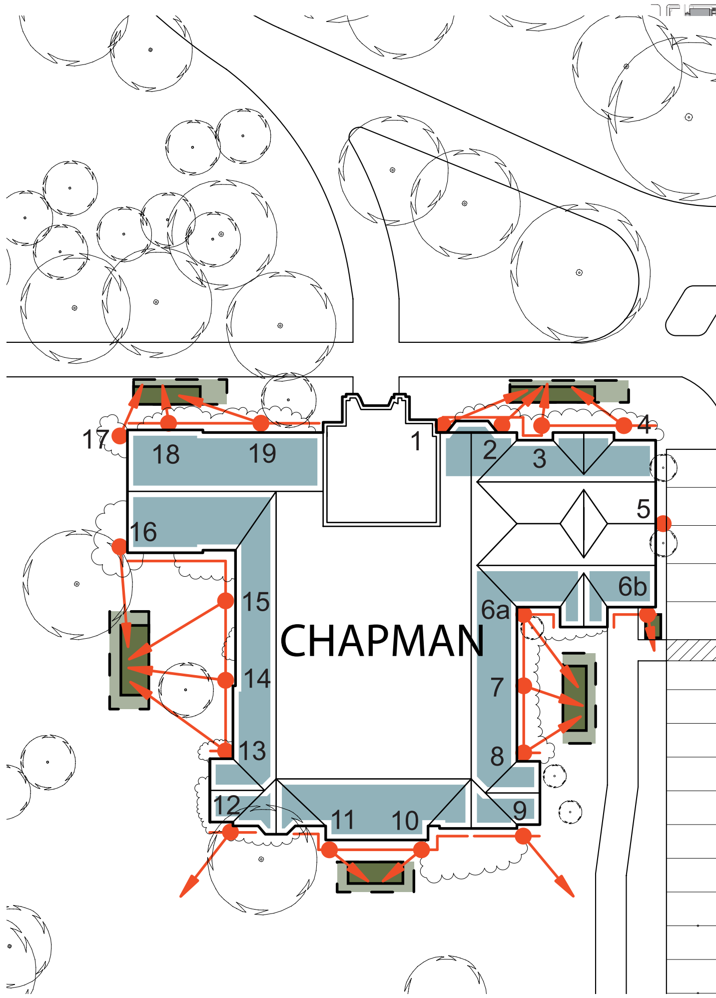
HYPOTHETICAL DOWNSPOUT DISCONNECTION TO RAIN GARDEN

(Left) Hypothetical rain garden, downspouts 6 through 8.
(Below) Downspouts 6a through 8 as is.

DRAFT 3.12.06

DOWNSPOUT DISCONNECTION





Area drained to rain garden-Priority Implementation	Area drained to rain garden-Secondary Implementation
Standard Rain Garden	Aggressive Rain Garden

Building	Downspout	Roof Catchment Area	Standard Rain Garden 10% Roof	Aggressive Rain Garden 20% Roof
Chapman Hall	1 thru 4	714	71.4	142.8
	5	407	Not Feasible	
	6 thru 8	970	97	194
	9	166	Disconnect Only	
	10 & 11	734	73.4	146.8
	12	166	Disconnect Only	
	13 thru 16	1332	133.2	266.4
	17 thru 19	795	79.5	159
Total	**19**	**5284**	**454.5**	**909**

0' 50' 100'

North

Chapman Hall

Curtin Hall

North Drainage Catchment 12

Curtain Hall is an unlikely but easy and intteresting candidate for the development of rain gardens capturing roof runoff. While the modernist high rise does not have a single downspout to be disconnected, the dramatic roofs of the lecture halls at the base of the building on both the north and south sides are drained to the ground below via expressive scuppers. These scuppers currently spill directly into grated man-holes set within a landscape of stones.

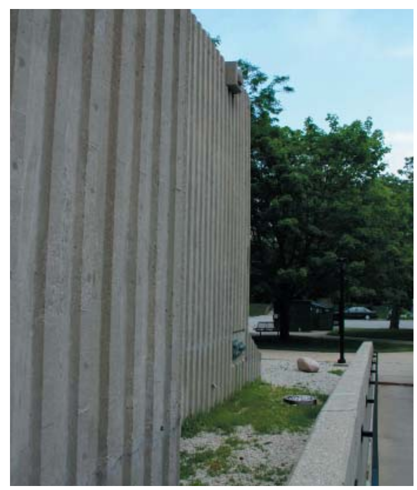
The current splash area on both the north and south sides of the building would make an ideal 'planter box' rain garden location, where the stormwater is retained by the garden but eventually drained to the existing storm drains.

These Curtain Hall rain gardens are included in the detailed stormwater designs for catchment 12.

North lecture hall roofs from above. Each pyramidal form is capped by a skylight. The portions of the roof captured between the skylight and the mass of the building drain internally. The remainder of the roof area is collected in a gutter at the perimeter and allowed to spill out of the scuppers.

South lecture hall roof from above. Downspout 5 through 9.

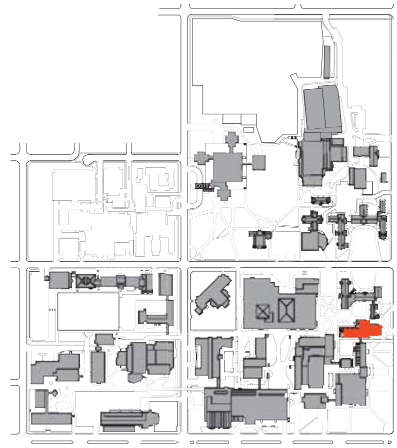
Expressed roof scupper.

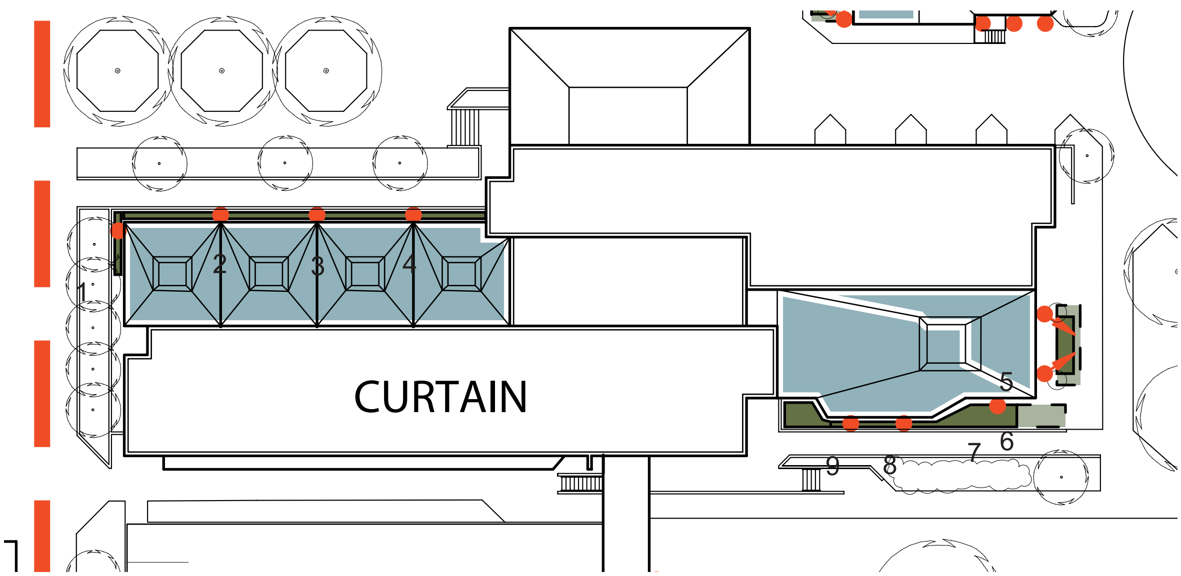


Scupper 7, showing the gravel filled area between the building and sidewalk that scuppers 7 through 9 drain into.

HYPOTHETICAL DOWNSPOUT DISCONNECTION TO RAIN GARDEN

(Left) Hypothetical rain garden, downspouts 5 through 9.
(Below) Downspouts 5 through 9 as is.





Area drained to rain garden- Priority Implementation

Area drained to rain garden- Secondary Implementation

Standard Rain Garden

Aggressive Rain Garden

Building	Downspout	Roof Catchment Area	Standard Rain Garden 10% Roof	Aggressive Rain Garden 20% Roof
Sabin Hall	1	1313	131.3	262.6
	2	2159	215.9	431.8
	3	1539	153.9	307.8
Total	**3**	**5011**	**501.1**	**1002.2**

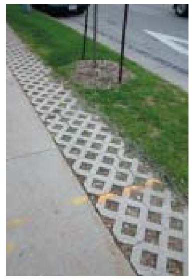
0' 50' 100'

North

PEDESTRIAN HARDSCAPE

Campus Overview

UWM should adopt a policy objective of achieving a ‘zero-discharge’ state for all pedestrian hardscape over time as landscape and maintenance projects are undertaken.



Grass Paver Blocks, Prospect Avenue, Milwaukee.

We would propose that all of the perimeter sidewalks be made pervious. This idea offers several technical advantages and has an apealing clarity as a demonstration project....

Pedestrian Hardscape is defined here as including all impervious surfaces not dedicated specifically to vehicular use. On the UWM campus, this means everything concrete, as little or no other pedestrian paving material is used on campus.

As a category, Pedestrian Hardscape represents 17% of the surface area of the campus, second only to internally drained roofs in overall impact. Unlike either category of roof surface, there is not a singular solution to be applied in all cases. Rather there are a range of possible solutions, depending on the specific situation. Our goal here is to analyze the problem in ways that might suggest novel as well as well established solutions.

ANALYSIS

The analysis (right) divides the campus hardscape into three categories: 1) areas that drain to the surrounding landscape, 2) areas that drain to areas of landscape roughly deemed to be inadequate to infiltrate the additional load, and 3) areas that drain directly to the storm sewer.

An inspection of category 1 (green) suggests that 25% of the hardscape already drains to the landscape and should not be a priority concern, except as much as the overall ability of the landscape to drain is an issue.

Category 2 (yellow hatch) tends to visually highlight areas of campus where large walkways are bordered by vestigial borders of landscape. Close inspection of individual areas suggest several potentials for specific rain garden type enhancements to the bordering landscape, pointing out that there is a close relationship between this hardscape analysis and the landscape analysis. They are also closely interrelated because many of the area drains located on the landscape analysis are in these vestigial landscapes and are primarily draining hardscape.

Category 3 (yellow) clearly highlights areas of campus that are interlaced with drains no less so than the roofs of the surrounding buildings. These areas tend to have limited potential to drain to existing landscape. This category is clearly the heart of the problem to solve, but again the solutions are likely to be very specific.

POTENTIAL STRATEGIES

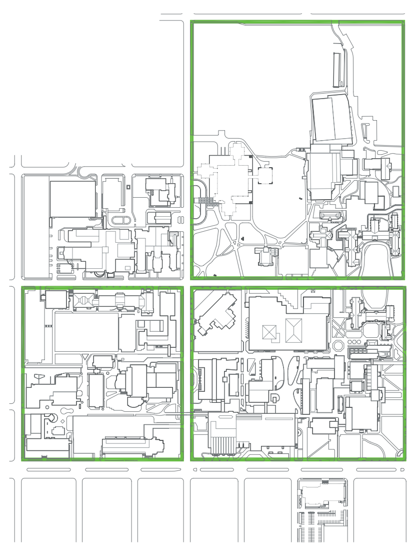
Pervious Paving

As with the vehicular hardscape, there is one default strategy that can be employed almost but not entirely universally- the use of permeable paving. Whether through the use of permeable concrete or paving stone, crushed stone or other walking surface, stormwater is allowed to infiltrate directly into the ground. In our clay soil situation, this requires excavation and creation of a drainage layer approximately 24” deep. As with rain gardens, infiltration itself may also be problematic due to proximity to building foundations and other infrastructure. Here, pervious walkways could be lined and provided with their own drainage.

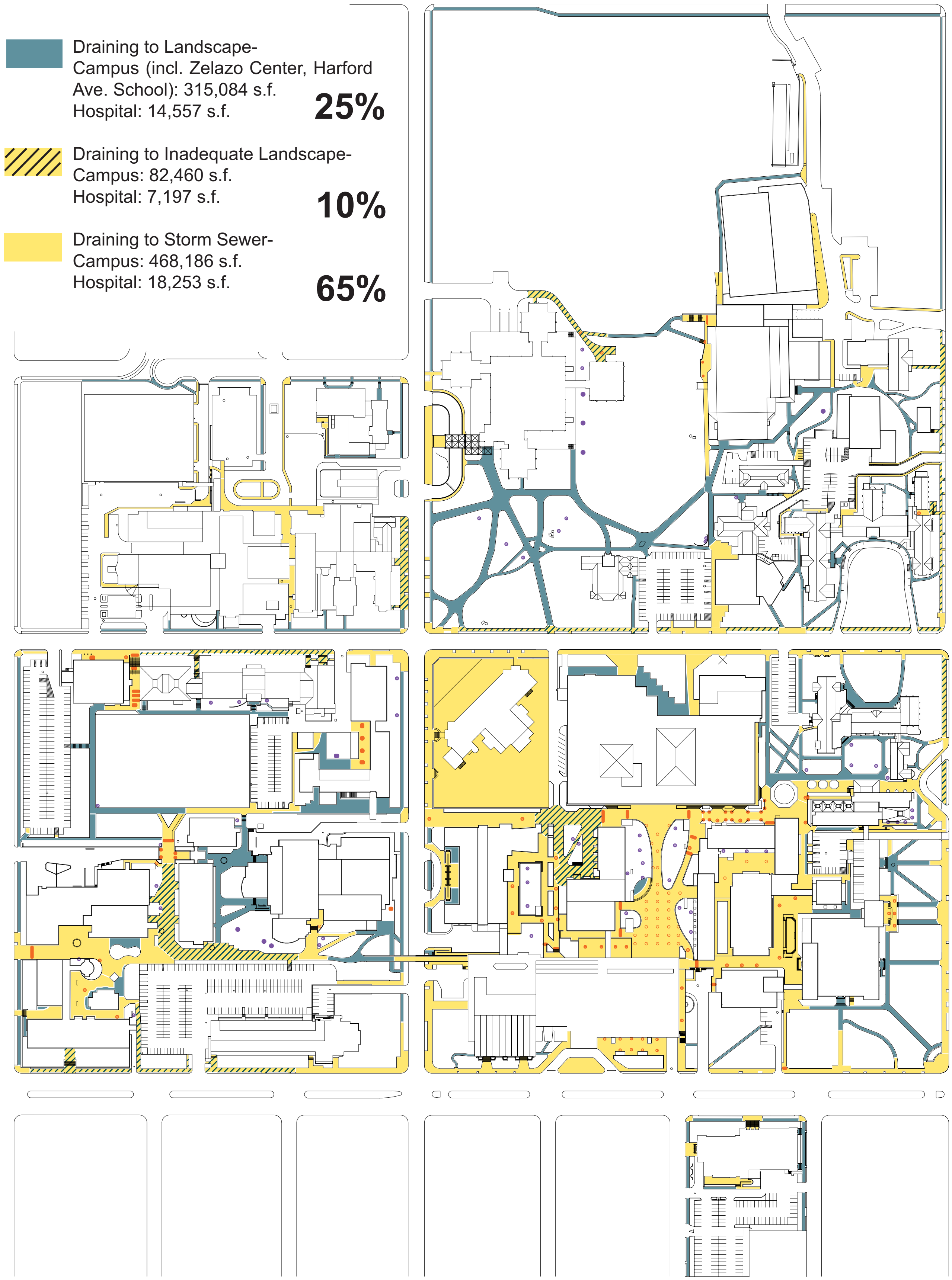
Our position is that all such underground retention is less preferable to keeping the water above grade and interacting with plants. All pervious hardscape is relatively more expensive to construct than rain gardens as well.

Surveying the existing conditions on campus, one exception to this rule suggests itself. Most of the perimeter sidewalks drain directly to storm drains, with little room for other options. These walks are typically downhill from the rest of campus and far enough away from buildings to avoid basement drainage problems. We would propose that all of the perimeter sidewalks be made pervious. This idea has an apealing clarity as a demonstration project and would work in tandum with the ultimate creation of a ‘garden wall’ around the perimeter of campus. (see storm pipe disconnection strategies)

Area Reduction



PERIMETER SIDEWALKS AS PERVIOUS PAVING DEMONSTRATION



PEDESTRIAN HARDSCAPE - EXISTING CONDITIONS
25% of the existing pedestrian walks do not require capture

Reducing the area of hardscaped surfaces is both an obvious and difficult step to take. In the time that this study has been underway, several new sidewalks have appeared on campus, suggesting that this is a loosing proposition. At the same time, the Physical Plant has itself undertaken to eliminate paving and reintroduce landscape features both at the EMS plaza and in the designs for the Lapham Hall Plaza.

Overhead Cover
One novel potential suggested by this analysis is that the area could also be reduced by providing cover above, in the form of covered walkways, entry canopies, or landscape structures. By elevating the catchment surface and gaining the ability to shape it to drain in specific directions, integration of rain gardens and other stormwater features may become possible where no options exist on the ground plane.

Exploiting Elevational Change to drain hardscape to Rain Gardens
Gravity is the key for passive stormwater management, and though the campus is relatively flat, anywhere that there is a small elevational change associated with a hardscape there is the potential to move water to a garden or catchment.

An extreme example of this situation and the opportunity that it offers can be seen in the level change between the playground of the Hartford Ave. School and the public sidewalk. A second example developed here is the landscaped transition between the east/west pedestrian path and the northern edge of lot 5 to the south of Lapham and Chemistry.

Sub-Surface drainage to Rain Gardens
The idea of clearing walkways with drains doesn't mean that every drain is directly tied to the storm system. Several areas of hardscape share the slope advantage of the previous category but may not be able to be pitched directly to the landscape. The slope of the emergency lane to the north of the business school directs water directly to the street, but a simple linear trench drain cutting across that slope could easily capture the drive's run-off and direct it to the landscape in front of the Business School.

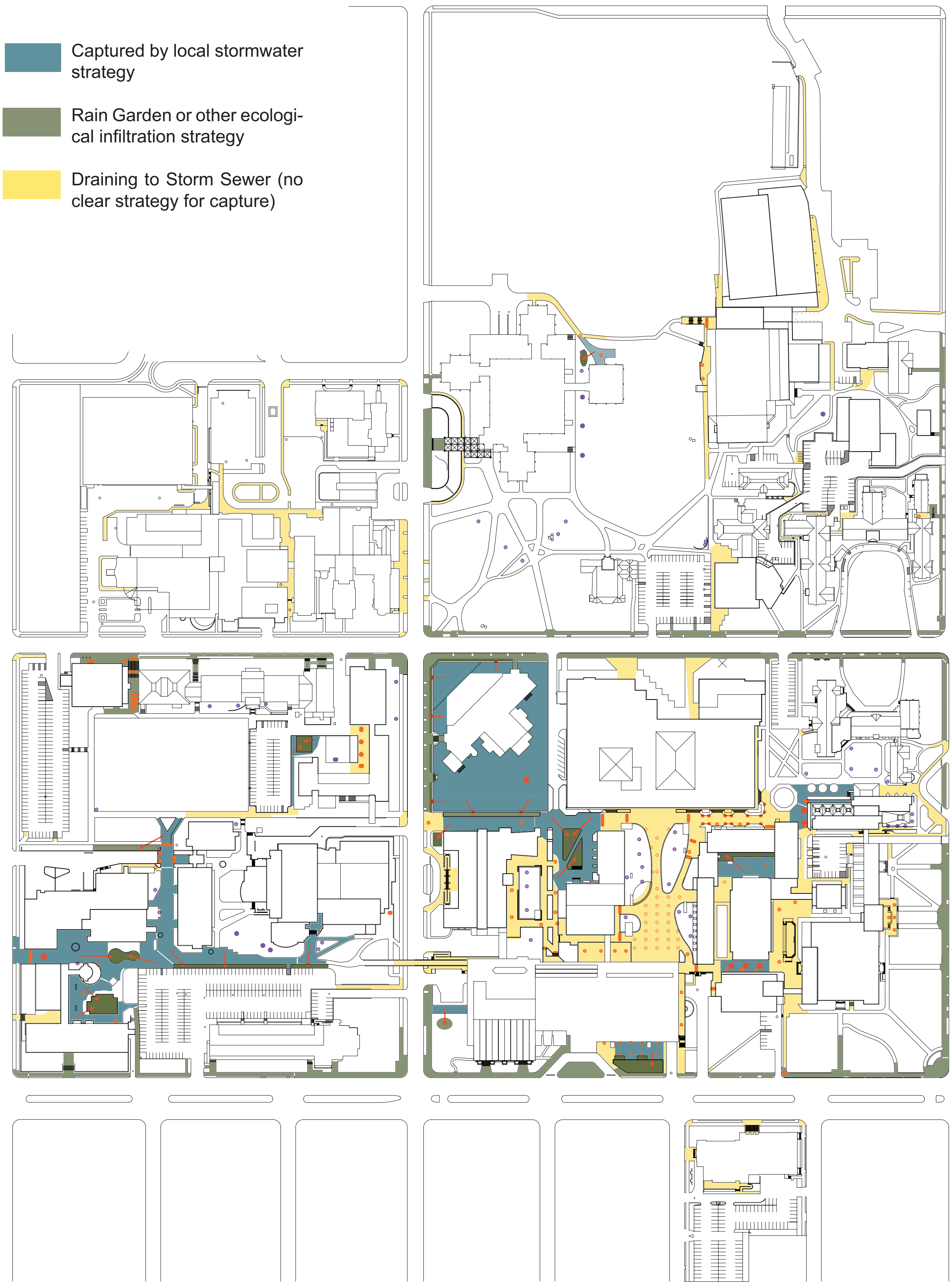
The more basic situation calling out for a solution would be the case of a level area of hardscape adjacent to landscape at the same level. Our proposition would be that the typical 24" or greater depth of excavation for a rain garden could be thought of as establishing a new, lower 'ground' or drainage plane, and that sub-surface sidewalk drains could be designed to drain into that lower water retention zone of the rain garden, even if the grades above are sloping in the opposite direction. The primary caution would be to insure that in overflow conditions, the drain would not back up and flood the sidewalk without another means of conveyance.

French Drains and Dry Wells
The next logical extension of envisioning alternatives to connecting local drains to the storm sewer system would be to imagine localized french drains and dry wells. In general, this has not been an option that we have been interested in exploring; both because of the poorly drained soils and because this strategy removes the water and its effects from view. In the spirit of seeking every small advantage as leverage in dismantling the storm system, however, one can imagine a network of small dry wells associated with individual drains and small catchment areas, rather than any single high volume solution.

The large expanse of asphalt at the Hartford Avenue School would be a logical area to start with, as this is the largest expanse of pedestrian hardscape in the area, ensuring that the dry wells could be adequately spaced and distanced from building foundations.

For this same reason, this strategy of distributed dry wells serving individual drains could be seen as more suited to use in the parking lots. We have not considered this, due to the increased water quality concerns that draining vehicular hardscape directly to the ground raise.

Temporary Detention Ponding
Finally, the notion of accepting and designing for intermittent flooding deserves consideration. While the public safety issues of this remain unexplored, a clear example of the potential for this exists in the small plaza at the northern entrance of Mitchell Hall. The current hardscape could easily be envisioned as providing a sunken hardscape pool that would serve as a holding pond and reflecting pool during heavy rain events.



PEDESTRIAN HARDSCAPE ANALYSIS-
HYPOTHETICAL DIVERSE STRATEGY IMPLEMENTATION SCENARIO

The Hartford Ave. School Planter Bench

South Drainage Catchment 9 **North** Drainage Catchment 14

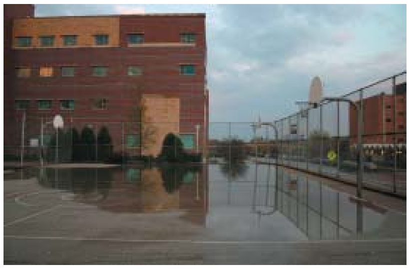
Looking at the existing condition map, it is clear that the paved playground of the Hartford Avenue School rivals Spaights Plaza as the largest single pedestrian hardscape.

The idea of the planter bench is to create a raised-bed rain garden exploiting the grade change between the School yard and its surrounds.

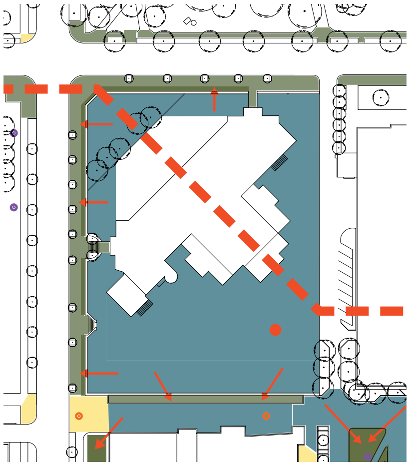
The planter would incorporate a low wall articulated into sitting areas for schoolchildren to use as they wait for their busses. Playground drains would be redirected through the existing retaining wall and into the terraced planters.

On the south face of the playground, an existing landscape strip is planted with evergreens that screen the School yard. This existing buffer could be similarly reworked to include some stormwater retention capacity.

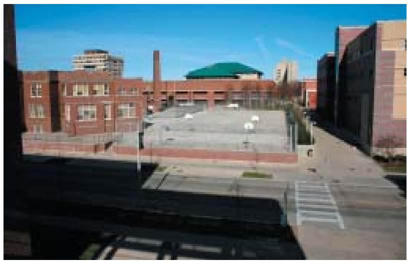
Other related strategies aimed at capturing stormwater from the playground and surrounding hardscape are shown in the diagram to the right: Pervious paving for perimeter walks and a vertical dry well located below the playground in one of the few spaces on campus open enough to support this strategy without fear of introducing water into surrounding buildings.



Existing ponding on the basketball courts after a rain. From Hartford Ave. School looking south to the Business School.



Diverse strategies at the Hartford Ave. School-
A) The planter bench drains a portion of the paved playground. B) Pervious perimeter block sidewalks. C) Playground dry well captures a portion of the paved playground



Existing asphalt playground and retaining wall. Looking east from the School of Architecture and Urban Planning.

(Above) Existing condition- Maryland Avenue sidewalk and retaining wall, looking north.

(Below) Existing condition- Sidewalk and retaining wall at the corner of Hartford and Maryland, looking east.

HYPOTHETICAL STORMWATER PLANTER

HYPOTHETICAL HARTFORD AVE. SCHOOL PLANTER BENCH
A rain garden planter draining the Hartford Ave. School playground

Hartford Avenue School Planter Bench

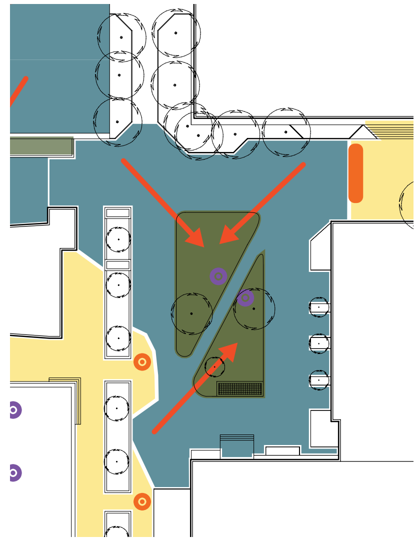
The Cross-Roads Pocket Wetland

South Drainage Catchment 9

The idea of the Cross Roads Wetland is to redesign this heavily trafficked intersection of the north/ south path from the Sandburg Commons to the Union and east/ west path connecting the campus as a whole and bordering the Golda Meir Library.

Currently, two landscape drains drain the entire area, including the sidewalks. We would propose to reimagine this green space as a Zen garden, with the diagonal sidewalk replaced by an arching foot bridge spanning a deeply contoured rain garden or 'pocket wetland.'

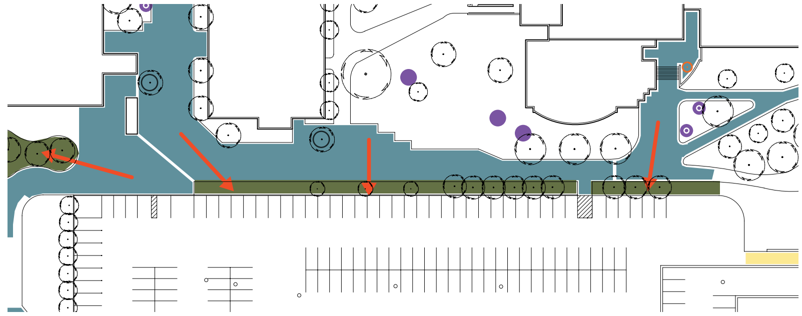
While this design concept satisfies the specific strategy of creating rain gardens at all landscape area-drains serving hardscape, it's potential capacity and experiential significance suggests that this 'rain plaza' should also incorporate water from the roofs of the surrounding buildings. In this way, the Cross-Roads Pocket Wetland serves as a companion to the Upper and Spiral Gardens of the Pavilion Gateway Demonstration Project, creating a significant and integrative stormwater feature at a key juncture in the circulation of the campus.



Cross-Roads area as is. Looking South past Bolton on the left and Business on the right, towards the Union.

HYPOTHETICAL POCKET WETLAND
An existing walkway is transformed into a Zen garden bridge, as existing berms become rain garden deprssions.

A Linear Garden for South Sciences Walk

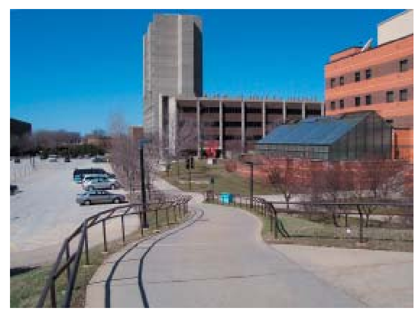


(Drawings incomplete) The walkway is currently separated from the parking lot by a planter strip only a few feet wide. Significantly, however, the walkway is also separated by a grade change of 12”- 18” down to the parking lot.

The existing tree planted berm will be redesigned to function as a terraced rain garden planter, hopefully without loosing the trees in the process. Water sheeting across the sidewalk towards the parking lot will be retained within this engineered volume.

A more agressive reworking of this edge could also capture run off from the parking lot in a bio-swale. This option does not show up in the basic Vehicular Hardscape study, as it would require eliminating existing trees. As proposed in the Lot 18 island of the Pavilion Gateway Demonstration Project, such a swale could incorporate new water tolerant trees in its design.

South Sciences walk looking east, towards the pedestrian bridge over Maryland Avenue to the Student Union. The existing planter strip is on the right.



South Sciences walk looking west, from the pedestrian bridge over Maryland Avenue.

HYPOTHETICAL LINEAR RAIN GARDEN
An existing grade change is used to capture sidewalk run-off

VEHICULAR HARDSCAPE

Campus Overview

Each parking lot has been analyzed and documented for adjacencies to landscape suitable for the construction of bio-retention features. Criteria include land that is level with or below the parking area and clear of large trees or underground infrastructure such as steam tunnels. An assumption has been made that any such feature would be excavated to a four-foot depth, providing approximately two cubic feet of stormwater storage capacity for every square foot in area available.

This storage capacity has been mapped on the parking lot as a representative area served. The construction of bio-retention features is considered as the first or 'priority' tier of treatment.

As discussed in the overview, the criteria that the capacity of the bio-retention feature be represented in terms of the 100 year/ zero-discharge target presents a scenario in which their impact is put in the worst possible light. The MMSD's own recommendations call for bio-retention features equalling 5% of the surface area drained, which all of the features shown here surpass.

The lots have also been mapped in terms of service drives and other heavy traffic requirements. All parking surfaces not displaced by bio-retention capacity and not required to be heavy traffic bearing are considered as pervious paving for the final or 'full' tier of treatment.

BIO-RETENTION

-Shallow, landscaped depressions with native plantings that can withstand the hydrolic regime
- Generally applied to small sites and commonely located in parking lots.
- Typically covers about 5% - 10% of the impervious area draining to it.
- During storms a small depth of water (6" to 9") should pond above the filter bed

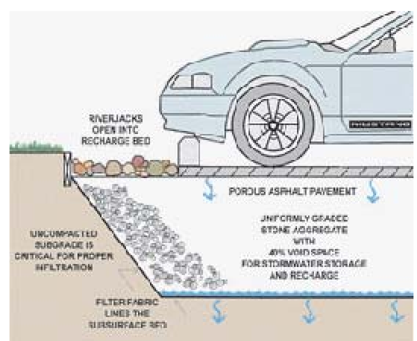
Bio-swale parking island. Courtesy of City of Portland Oregon.

Hopes 6 Housing, Seattle. Mithun Architects, Designers and Planners. Curb cut draining to bio-retention areaunder construction.

POROUS PAVING SYSTEMS

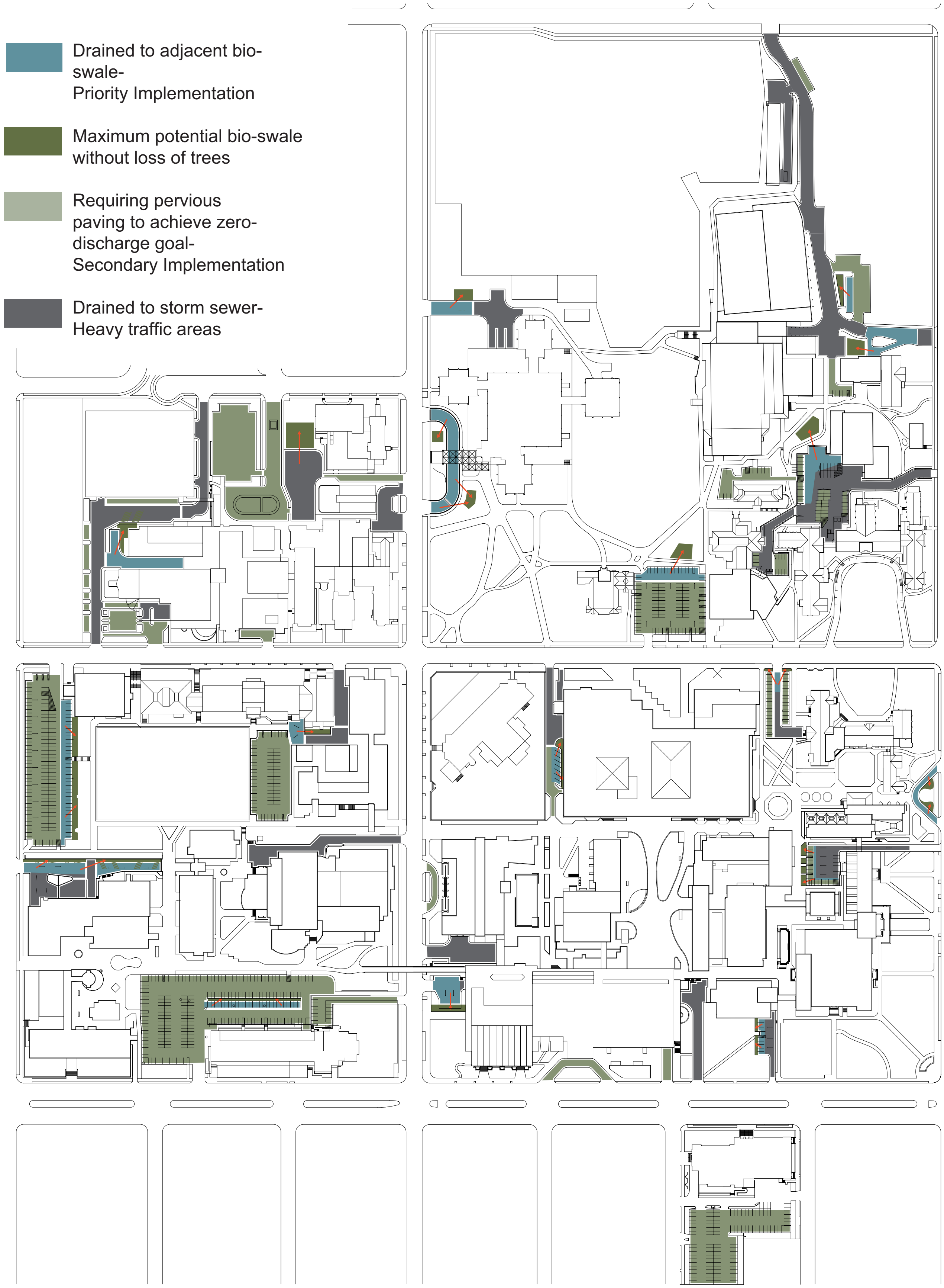
- Porous asphalt and concrete
- Modular block systems
- Grass pavers
- Gravel pavers
- Low traffic and low bearing areas

MMSD Pervious Concrete demonstration project. Photo courtesy of Dave Kendziorski.



www.lowimpactdevelopment.org

Source: Invisible Structures, Inc.; EP Henry Corp.



VEHICULAR HARDSCAPE ANALYSIS

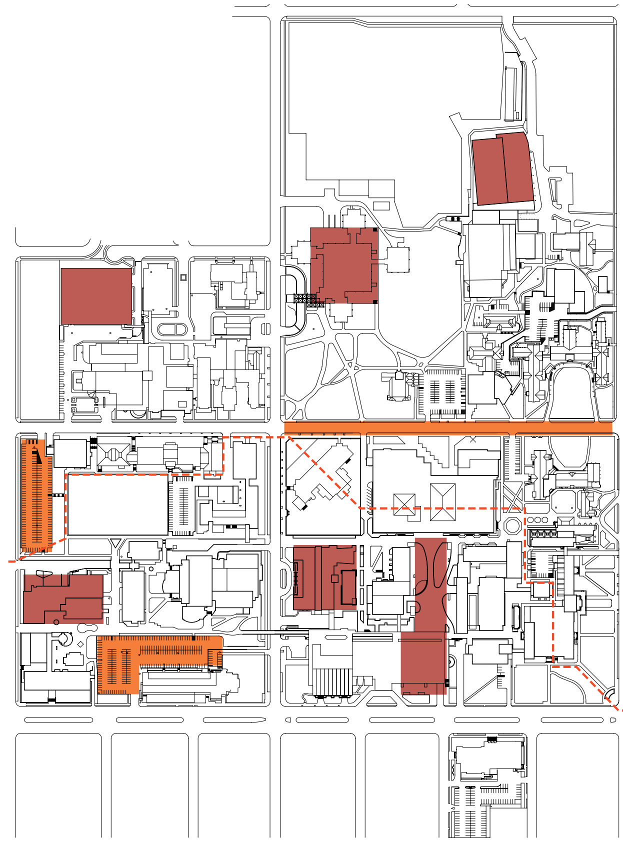
Parking Consolidation Study

These two diagrams graphically examine the potential of replacing surface parking with structured parking, and the resulting impact of removing all surface parking from the UWM campus, leaving only service drives and specifically required parking.

The upper diagram locates all existing parking structures, and identifies potential sites for future structures, including the novel concept generated at the 'Waterscapes Design Charrette' to construct a linear ramp under Hartford Avenue.

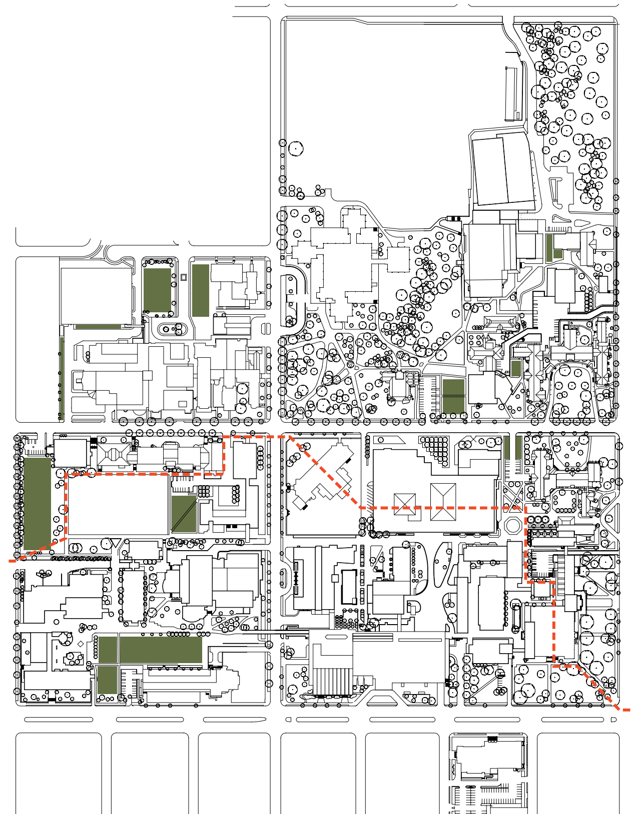
The lower diagram identifies all of the potential green space that could be created by eliminating all but service-access and essential parking.

Perhaps surprisingly, surface parking represents a relatively small piece of the stormwater puzzle for the campus, and nearly every lot serves dual purpose as access for loading docks, etc.. Also, many parking spaces on campus turn out to be dedicated to either handicap access or other special access to individual buildings. Very few of the fingers of asphalt that reach into the campus from every border can be eliminated completely.



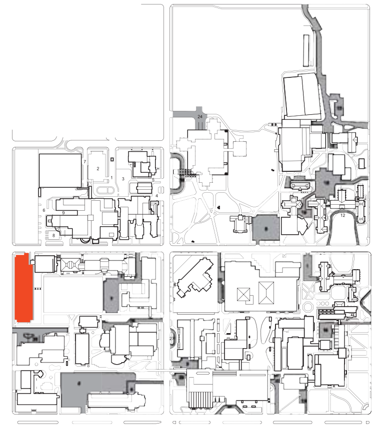
Existing and Possible Parking Structures

Red= existing structures. Orange= possible sites for future structured parking.



Minimum Required Vehicular Hardscape

Approx. **___acres- ___%** of the total campus area can be reclaimed as greenspace given the elimination of all non-critical surface parking



Cunningham Parking (Lot 20)

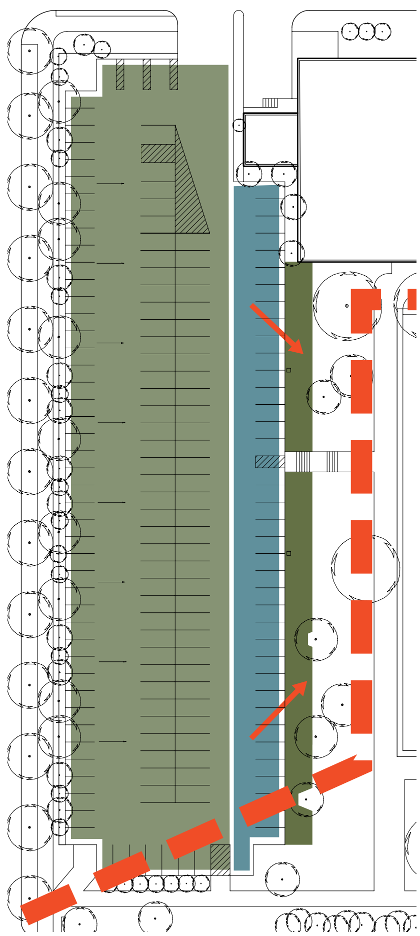
North Drainage Catchment 2

At 48,650 s.f., Lot 20 is the second largest lot on campus and the largest lot draining to the north. As such it is an inviting candidate for an early demonstration project.

Using conventional parking standards, the efficient shape of the lot does not offer any tolerance to introduce a linear bio-swale except by altering the contours of the hill that drains into the lot on it's eastern side. The remainder of the lot is shown as pervious paving; a clean solution given that this is one of the few lots that does not require a heavy traffic area.

Going beyond the evaluative criteria of the masterplan study towards an actual design for the lot, several additional possibilities present themselves. The lot slopes towards its entry on the north, where a certain amount of space is lost for parking as the drive jogs. The entry itself could be reworked to incorporate a significant bio-retention area with the loss of a minimal number of spaces.

In addition, a portion of the lot could be dedicated to compact cars as has been done in the Pavilion Gateway project, freeing up space for a center island feature.



Lot 20 from the roof of Cunningham, looking southwest.

Lot 20 from entry on Hartford Avenue, looking south. Note the striped triangle that allows the drive to shift around the Cunningham loading dock

(Below) Campus corner signage and landscaping, corner of Hartford and Cramer. Save for the vaults in the foreground, this corner offers a striking potential to become a stormwater garden at the mouth of Lot 20

Drained to bio-swale (Priority Implementation)

Maximum bio-swale without loss of trees

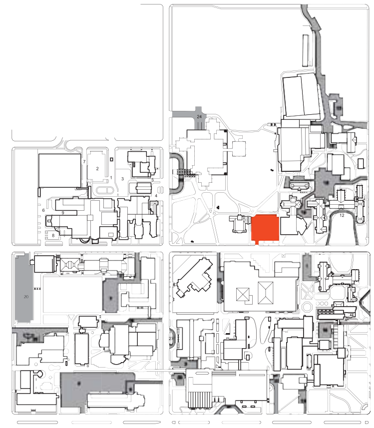
Pervious paving (Secondary Implementation)

Heavy traffic area (unserved)

Lot	Total S.F. Area	Retention S.F. Available	Parking S.F. Area to Retention	Pervious Paving	S.F. Area Not Retained	% to BMP	5% MMSD Recommended
20	46550	4470	14885	31665	0	100%	2327.5

0' 100' 200'

North

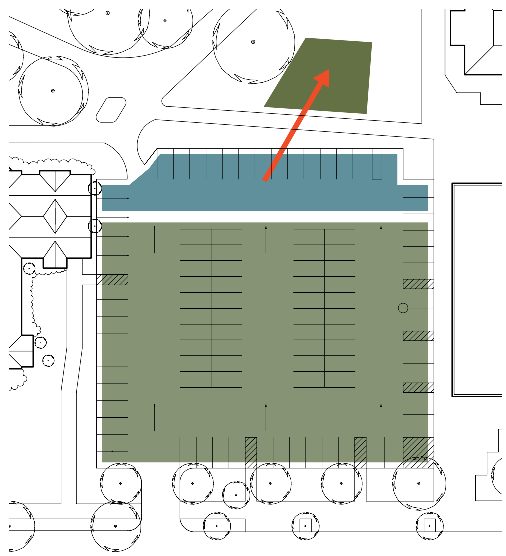


Chapman Parking (Lot 8)

North Drainage Catchment 17

With existing trees to the south and the landscape falling to the north, the bio-retention area is best located on the north side of Lot 8. This lot is in poor to fair condition. Utilities noted include a steam tunnel on the far east side of the lot along with various electrical and water lines running through the lot.

There is a significant open space to the north of the lot that could conceivably become a bio-retention feature. The scale of this feature is circumscribed, however, by the noted steam tunnel and the electrical and telecommunications access vaults that straddle it.



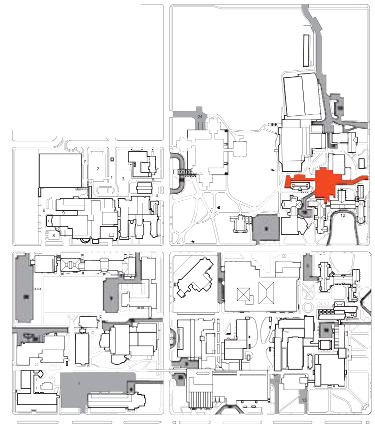
Drained to bio-swale (Priority Implementation)

Maximum bio-swale without loss of trees

Pervious paving (Secondary Implementation)

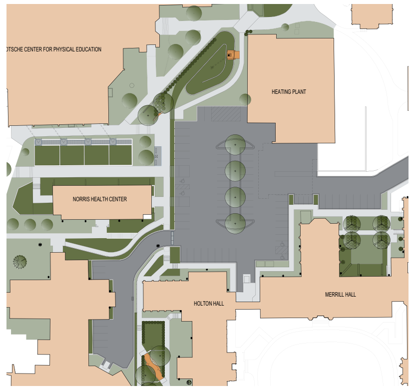
Heavy traffic area (unserved)

Lot	Total S.F. Area	Retention S.F. Available	Parking S.F. Area to Retention	Pervious Paving	S.F. Area Not Retained	% to BMP	5% MMSD Recommended
8	28604	1657	5518	23086	0	100%	1430.2



Merrill Hall Loading Dock & Parking (Lot 18)

North Drainage Catchment 16



Lot 18- Pavilion Gateway Demonstration Project plan. In the demonstration project, the entire basin draining into Lot 18 is brought to the 100 year/ zero-discharge target. Lot 18 is expanded and reconfigured, while several other lots are eliminated or reduced. The bio-retention area is engineered to expand on the capacity assumptions of the masterplan.

Lot 18 from Enderis Hall, looking north east. The grass area adjacent to the Power Plant is the area of the bio-retention feature.

Lot 18 is the heart of the Pavilion Gateway Demonstration Project. As such, its masterplanning analysis illustrates both the strengths of the masterplanning criteria, and how those criteria are transcended by the actual task of designing an implementation project.

At this masterplan level, we see an unusually large area available for bio-retention, that none-the-less captures only a fraction of the parking lot. We see the use of pervious paving in the parking stalls and side lot, avoiding the heavy traffic area that provides access to the loading docks that ring the lot. And we see that area unserved.

If we were to compare this to the proposed Pavilion Gateway design, we would see that the same core logic of draining to the north and using pervious paving in the parking stalls clearly expressed. On the other hand, even without considering the elimination of the Norris Lot and other more ambitious aspects of the design, the Pavilion project's more in-depth investigation uses these elements to capture the entire Lot 18, including the areas unserved here.

Drained to bio-swale (Priority Implementation)

Maximum bio-swale without loss of trees

Pervious paving (Secondary Implementation)

Heavy traffic area (unserved)

Lot	Total S.F. Area	Retention S.F. Available	Parking S.F. Area to Retention	Pervious Paving	S.F. Area Not Retained	% to BMP	5% MMSD Recommended
18	37452	1993	6637	8380	22435	40%	1872.6

0' 100' 200'

North

LANDSCAPE

Campus Overview

The role of the landscape as a contributing factor to the stormwater runoff profile of the campus remains a question as far as this study is concerned.

(Discussion of soil conditions.)

(Discussion of SWMM model's relative capacity to model differing soils conditions.)

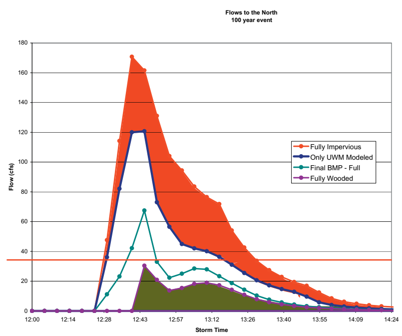
STRATEGIES

Area Drain Rain Gardens

Increase Deep Rooted Vegitation and Tree Canopy

Countour Landscape to Retain Water

Condition Soil



Bracketing the Northern Drainage.

AREA DRAINS and RAIN GARDENS

Red dots indicate the location of area drains, which occur in low areas when not directly related to a specific building drainage issues. The more open and landscape oriented of these drains suggest the location of a network of rain gardens, several of which have been identified in other analysis.

A. The Demonstration Project's primary rain garden, the SPIRAL GARDEN

B. The constellation of drains flanking Sandburg Hall suggest a terraced set of rain gardens arching down through the woods. This would require little more conceptually than restricting the inlets to the drains.

C. The CROSSROADS GARDEN (see Pedestrian Hardscape Analysis)

D. The SARUP EAST GARDEN (see Storm Pipe Daylighting Analysis.)

E. Area drain at what is already a densly vegitated swale capturing runoff from the hillside above. Performace may be able to be enhanced through additional plantings.

F. The south lawn of Lapham hall drains the walks to the north. This area already features one prairie demonstration plot, and may suggest a larger rain garden serving the roofs of adjacent buildings etc...

LANDSCAPE AREA DRAIN ANALYSIS

STORM PIPE DAYLIGHTING

Campus Overview

Everything wants to see daylight! In architectural design, 'daylighting' refers to the environmentally progressive practice of using natural light to provide lighting within buildings; a return to historical norms where building interiors were closely related to the exterior environment. In regional stormwater management, 'daylighting' refers to the practice of restoring culverted waterways to the surface, where they once again become ecological and aesthetic amenities.

'Daylighting' here refers to the strategy of capturing stormwater once it has entered the stormwater system. The goal is to capture water that has already found its way into a pipe and to return it to the surface where it can interact with the environment.

Our conception of this category is expansive, including the idea of diverting water from the drain lines of internally drained roofs back to the environment using only gravity, as well as the idea of using sump pumps to recapture water at any point in the stormwater system before it joins the combined sewer system as it leaves campus.

DAYLIGHTING INTERNALLY DRAINED ROOFS

As dramatically exploited in the Pavilion Gateway Demonstration Project, the Campus' internally drained roofs are not out of reach. They are instead both the largest category of impervious surface (20% of the Campus, excluding Downer Woods) and offer opportunities for pipe daylighting without the need for pumps. The graphic at the right identifies several examples. Many more remain to be investigated.

A. Enderis Hall and the UPPER GARDEN. (See the Pavilion Gateway Demonstration Project)

B. The public plaza at Sandburg Hall is actually the top of an above grade parking structure. Plaza drain lines are accessible, suggesting cistern storage in unusable space within the garage.

C. The parking ramp at Columbia Hospital. The proposal (to be developed) is to capture the twin drain lines from the parking deck at the first floor level, and to divert them to the landscape area to the north of the garage. Here a significant rain garden and retention pond will celebrate the downpour.

D. The SARUP EAST GARDEN. A row of easily accessible perimeter storm drains within the AUP building would be diverted through the wall at the second floor level, creating a linear fountain along Hartford ave.

E. Golda Meir Library. The building's large open portal makes capture of the roof drain lines a sculpturally exciting possibility.

F. The Union.

HARDSCAPE OVER UNDERGROUND PARKING

This analysis identifies specific hardscape areas that have accessible drain lines. This unique access potential remains to be fully explored.

A. EMS Plaza
B. Business School east lawn
C. Spaights Plaza

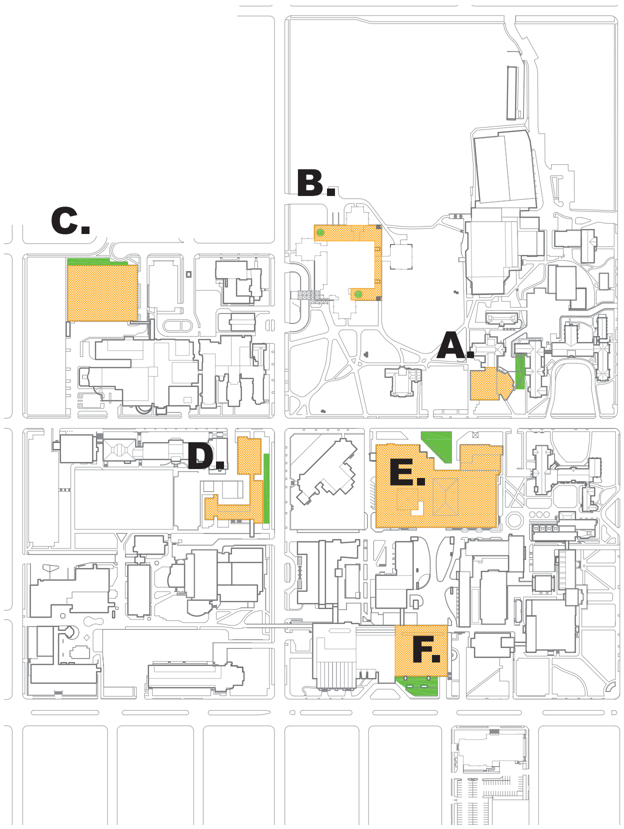
STORM DRAIN DAYLIGHTING WITHIN THE CAMPUS INTERIOR

Regardless of how completely all other strategies are employed, the key to solving the 'zero-discharge' challenge is to be able to daylight stormwater that has entered the system before it leaves the campus. This trump card is developed here in two phases; both using the existing architecture of the stormwater system on campus as a starting point by identifying the locations of the largest trunk lines. The first layer of defense identifies a series of potential rain garden locations related to large branch lines within the campus.
A. and B. The Pavilion and Sandburg Detention Pipes. We would propose significant rain garden/ retention areas adjacent to each existing underground storage pipe. These would double the capacity of each pipe.

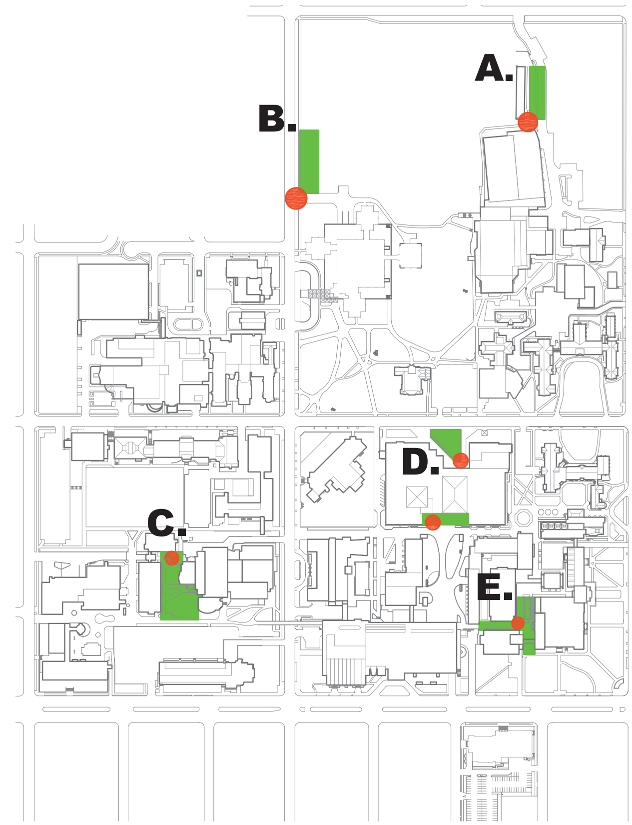
C. D. and E. Lapham west lawn, Golda Meir plaza and Mitchell Hall plaza. The presence of significant trunk lines below each of these areas reinforces their potential as described elsewhere.

STORM DRAIN DAYLIGHTING AT THE PERIMETER OF CAMPUS

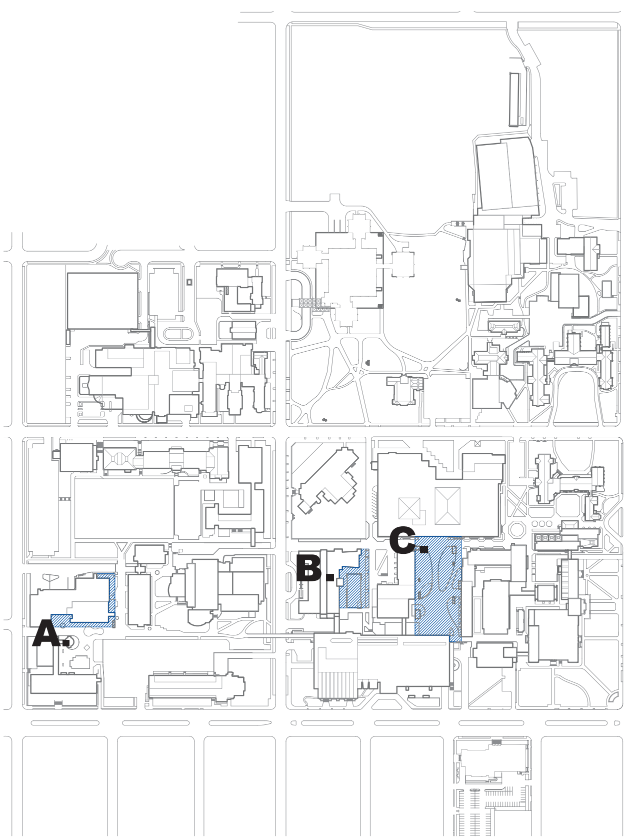
The second and more important strategy proposes the creation of a GARDEN WALL for the Campus, in the form of a ring of linear rain gardens fed by sump pumps at the exit point of each major storm sewer line. (see GARDEN WALL study below.)



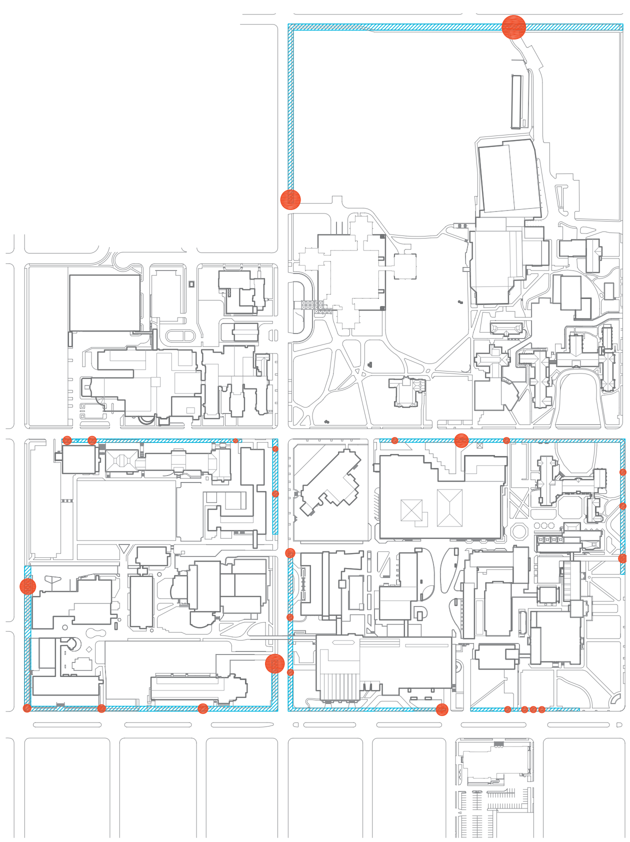
Examples of the potentials for Daylighting Internally Drained Roofs



Significant Upstream Storm Drain Capture Points and distribution to rain gardens



Hardscape over Underground Parking-Accessible Drain Lines



The GARDEN WALL : Downstream Storm Drain Capture Points and distribution to linear rain gardens

POTENTIAL DAYLIGHTING APPLICATIONS

Sandburg Storage Pipe Folly

North Drainage Catchment 15

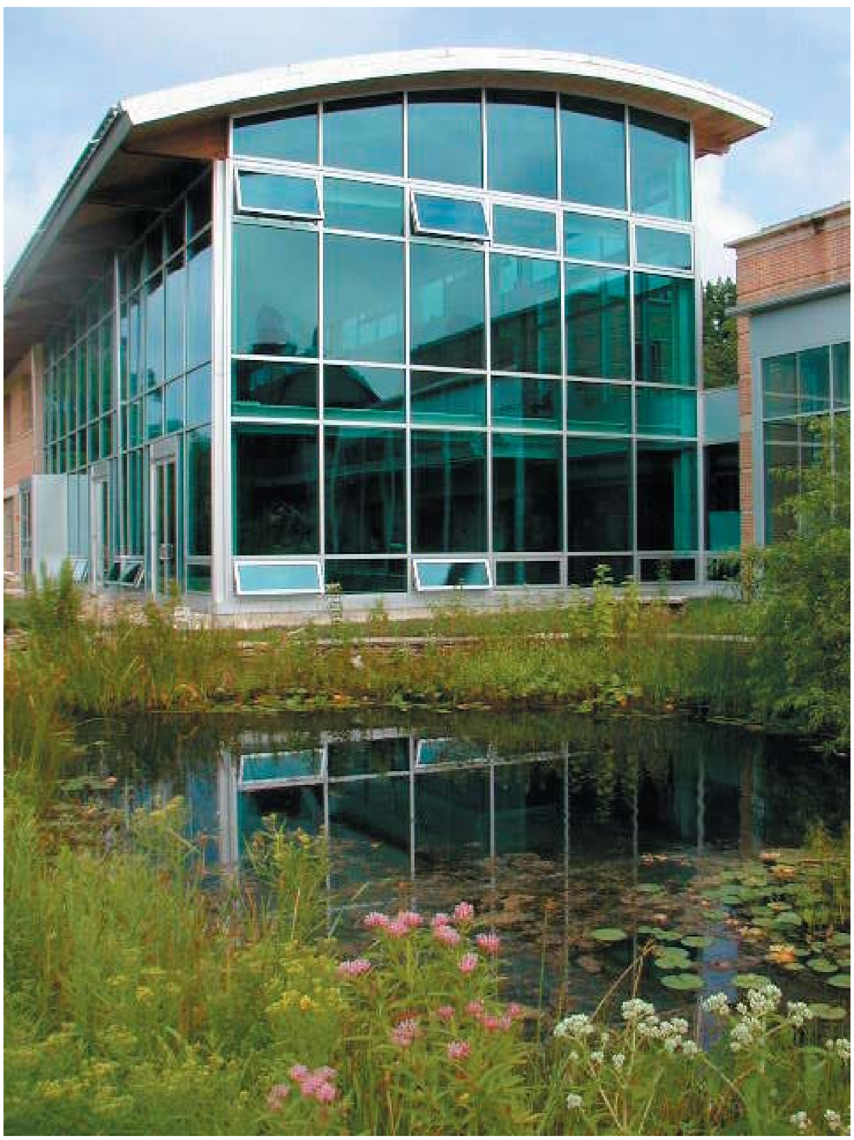
Folly site looking south towards Sandburg Towers

With the construction of the East Tower of Sandburg Hall, UWM recognized the need to offset the increased imperviousness of the site by installing underground storage capacity within the storm-sewer system. As shown in the construction drawings, a pipe nine feet in diameter and 100 feet long lies buried beneath the lawn to the north of the North Tower.

This hypothetical 'folly' or water feature proposes to create a temporary storage basin or rain garden that doubles the 6,300 cubic foot capacity of this underground pipe. In a rain event, water would be pumped out of the storage pipe into the folly. As with the storage pipe, the water detained by the folly would drain slowly back into the storm system over a 24 hour period; it's purpose of reducing the peak discharge into the Edgwood Avenue interceptor having been accomplished.

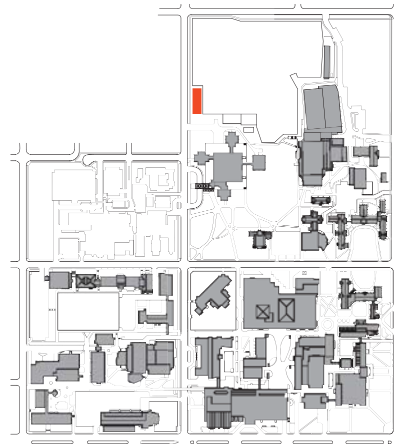
We have not yet generated a design concept for this folly, which could range from a large rain garden to a sculptural landscape designed as a basin. To the left, we reference the artificial wetland at the Adam Joseph Lewis Center at Oberlin College. This precedent is compelling as an educational environment, and as a campus water feature that depends on a cistern collecting stormwater to maintain its water level during dry periods.

The question that this precedent poses is whether the existing storage pipe could be re-engineered to retain a volume of water over a longer period of time, so that it might function as a cistern and dissipate that water slowly through evaporation at the folly.

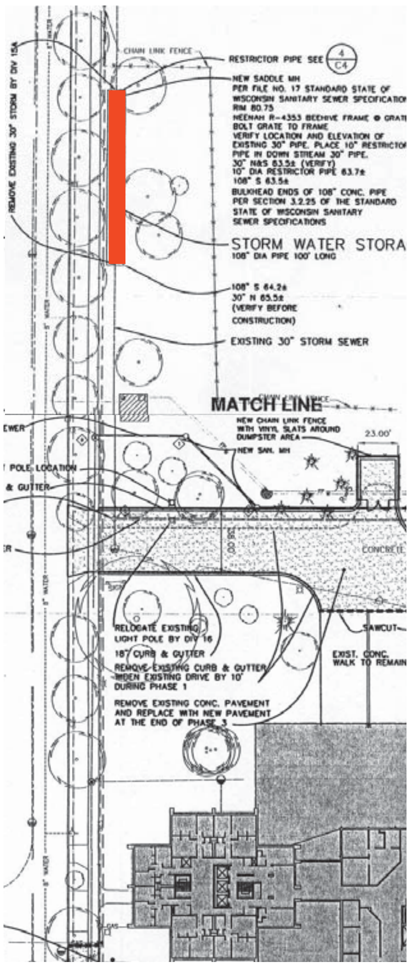


(left) Wetland, Adam Joseph Lewis Center for Environmental Studies, Oberlin College. William McDonough and Associates, Architects. John Lyle, Landscape Architect.
(below) Man-made pond and waterfall, Talliessin. Frank Lloyd Wright, Architect.

STORM PIPE DAYLIGHTING

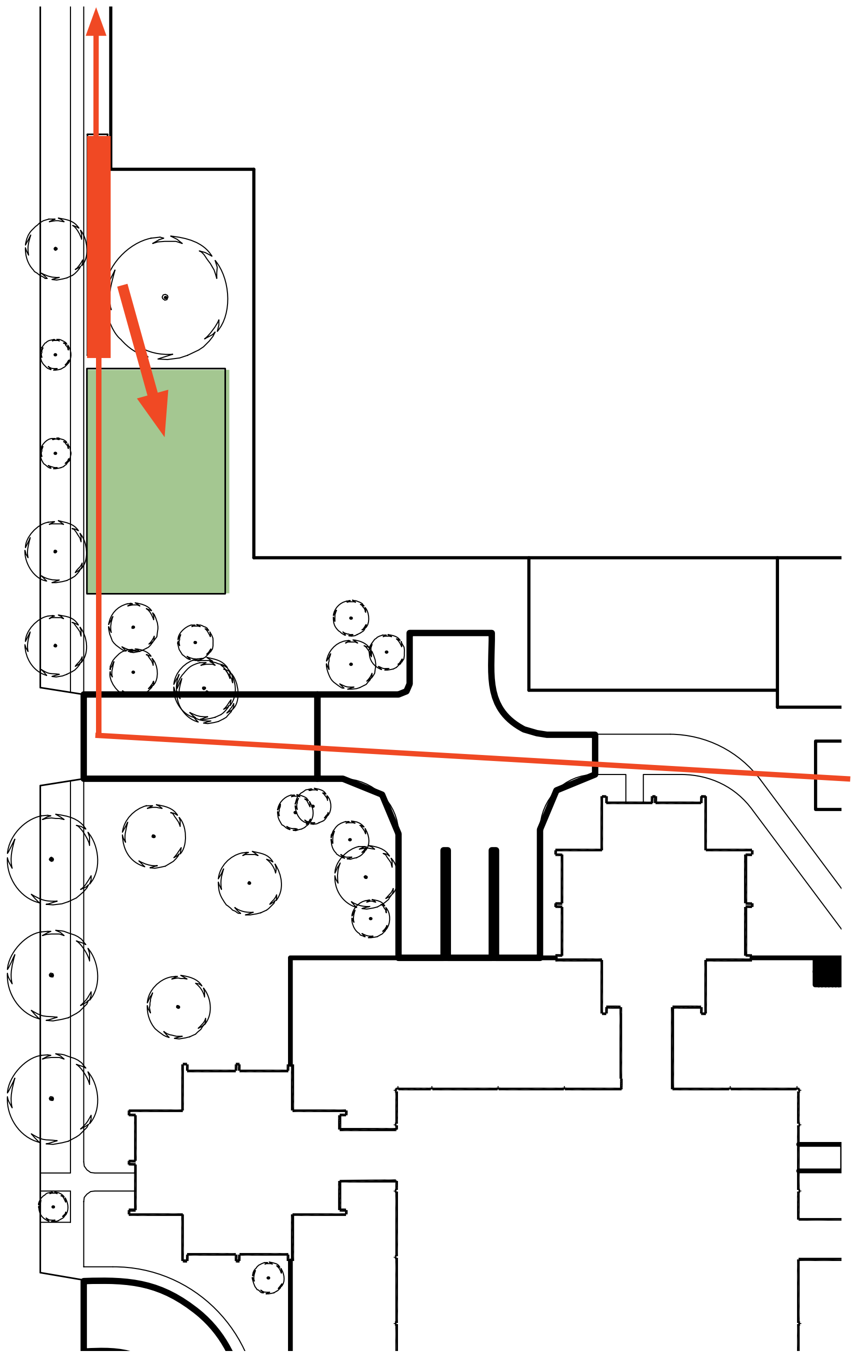


Folly site looking north, towards Downer Woods



Construction as-built drawings, Sandburg East Tower project. Note the 'Storm Water Storage Pipe' -108 inch diameter, 100 feet long- below the open grass area that is excluded from the fenced preserve of Downer Woods.

This large diameter pipe is inserted in line with the existing storm drain serving catchment 15. As noted in the drawing, the connection between this pipe and the existing 30" pipe is made with a restrictive 10" diameter pipe. This restriction serves to back water up into the larger pipe, which acts as a temporary reservoir.



Sandburg Storage Pipe Folly

Downer Pond

North Drainage Catchment 16

Campus area roughly identified as Pold location. Looking west from the mowed swath. Summer, 2005.

Perhaps the single largest, most transforming gesture that could be made on the UWM campus to manage stormwater would be to construct a permanent pond at the northern end of campus. Even with the proposed implementation of the Pavilion Gateway demonstration project capturing the upper half of Catchment 16, this feature would capture both the Klotche and Pavilion roofs, two of the largest impervious surfaces on campus.

A pond would also be the most transforming gesture in the sense that it would significantly reshape the single largest remaining open space on campus; an area that may in fact fall under the same protections that apply to the Downer Woods proper.

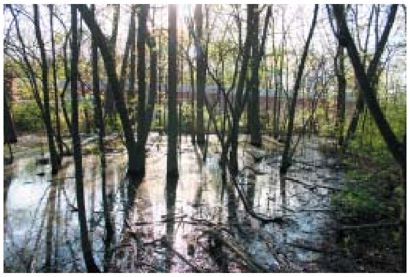
We do not claim to have studied this strategy in depth or to have the expertise to evaluate its appropriateness. We put it forward as one hypothetical option that deserves discussion. Developing such a proposal would include addressing issues of risk management, conservation of the campus natural areas, the aesthetics of creating a pond as a landscape feature and the ecological questions of both creating habitat and controlling for insect breeding. The logical site for the pond is already a low and poorly drained area that frequently has standing water several inches deep.

Here the landscape of the Portland Water Pollution Control Laboratory in Portland, Oregon provide a reference. This pond acts as a stormwater control feature for a large residential area up-hill from the facility. Quoting the landscape architect's web site, "an innovative flume directs stormwater to a detention pond planted with a variety of aquatic and emergent plant material that naturally facilitate sedimentation and biofiltration to ultimately return clean water to the Willamette. (www.murase.com)

As with the Sandburg Storage Pipe Folly, the Downer Pond is potentially served by the new constructed, 6,300 cubic foot capacity storage pipe adjacent to it. Conceivably, this pipe could be reengineered to function as a cistern, providing make-up water to the pond in dry conditions.

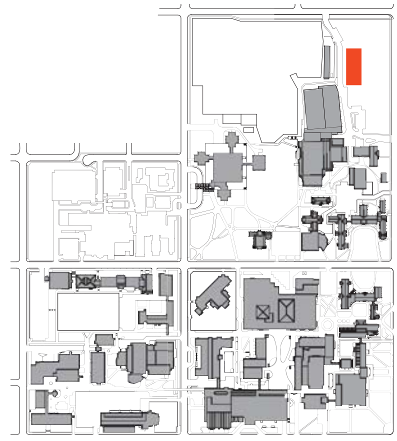
(left and above) Portland Water Pollution Control Laboratory. Portland, Oregon. Miller/ Hull Associates, Architects. Murase Associates Landscape Architects.

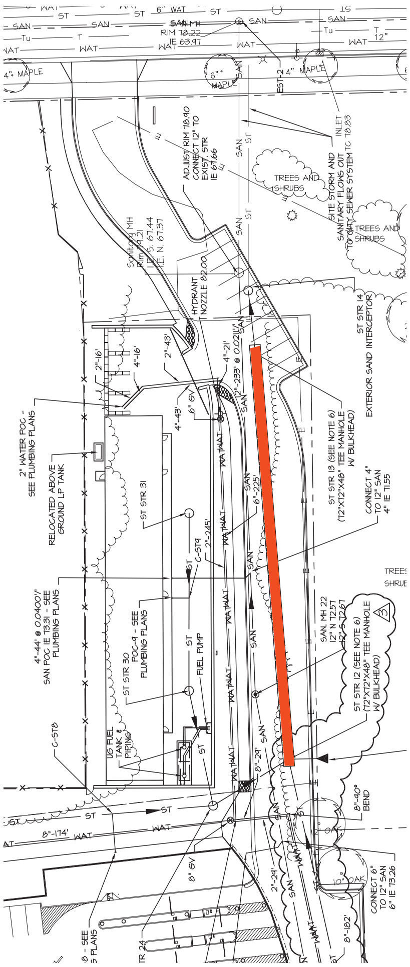
STORM PIPE DAYLIGHTING



Campus area roughly identified as Pold location. Colse to the service drive, looking west. Summer, 2005.

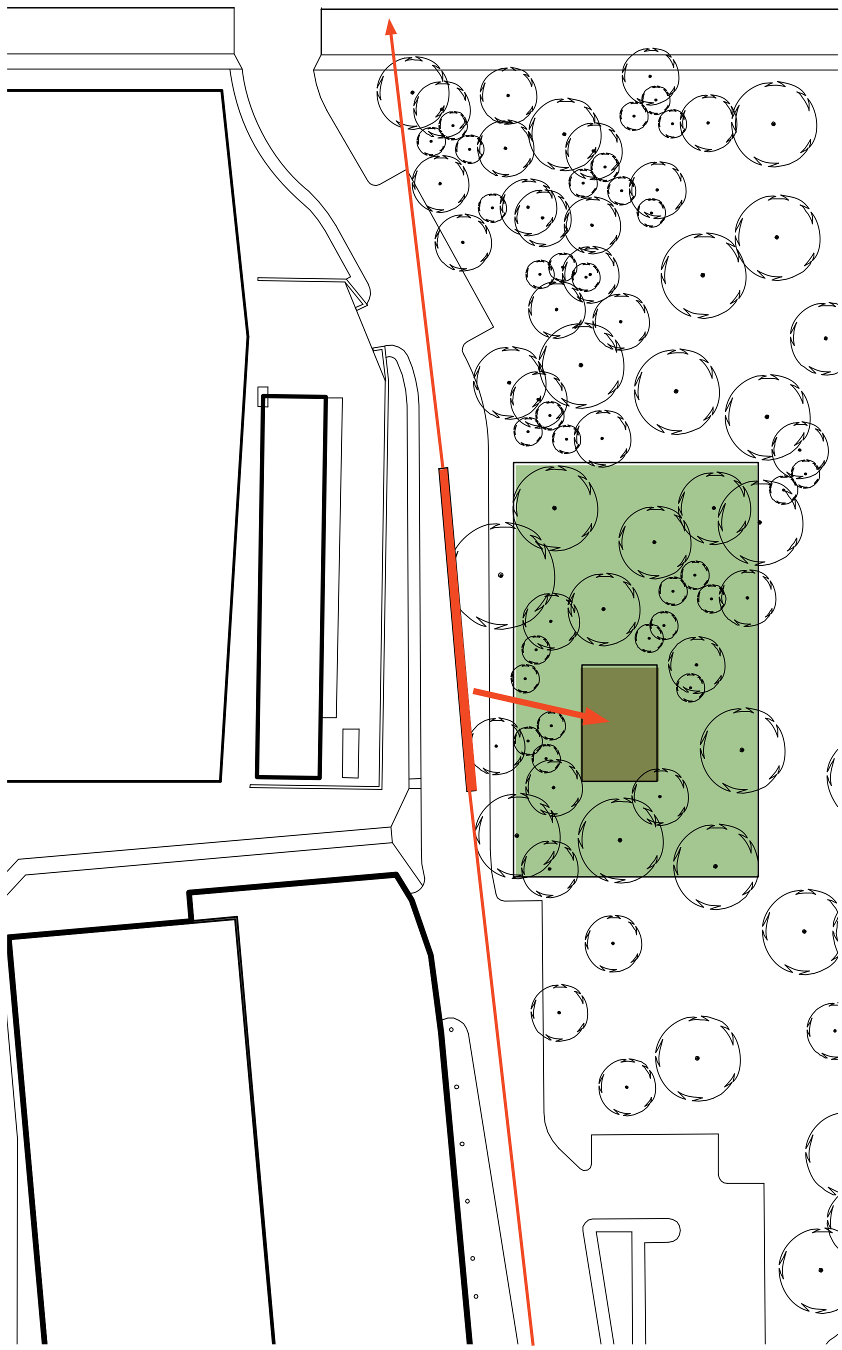
Campus area roughly identified as Pold location. Looking north. January, 2006.



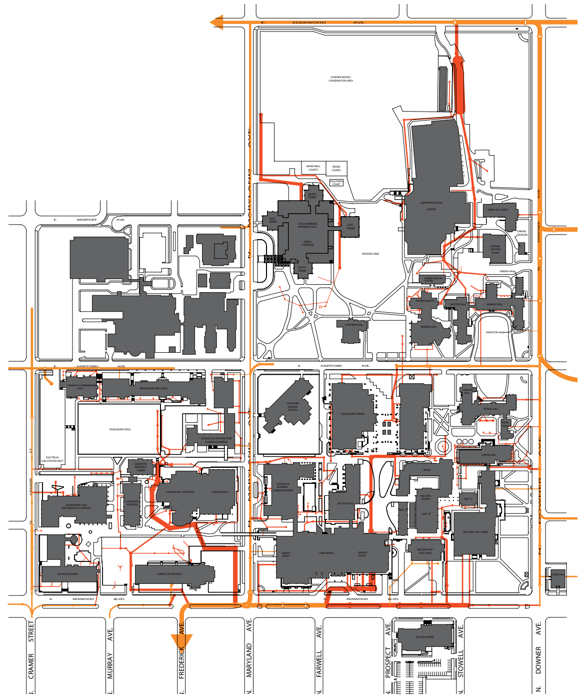


Construction drawings, Pavilion project. Note the highlighted 'UG Storage Pipe,' described elsewhere on the drawing as 72 inch diameter x 226 feet long.

(below) The north service entry to the Pavilion, below which the storage pipe runs.



The Garden Wall



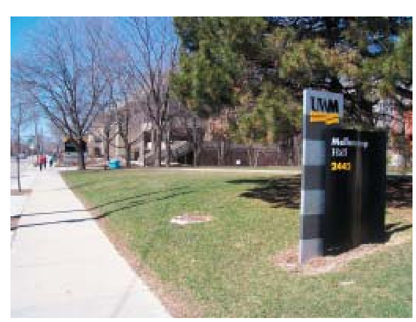
Existing Storm Pipe Network
Line thickness correlated to pipe size. Red lines are storm lines. Yellow Lines are combined sewer lines

Technically, the Garden Wall is a perimeter ring of sump pumps that intercept water in each of the storm pipes leaving the campus and daylight it to linear rain garden features. Their function is to shave the spike of stormwater discharge that remains after all other strategies have been employed, ensuring that the campus functions at a zero-discharge rate.

As revealed in the divide between the northern and southern drainages, the campus sits on a subtle but very real hill. It makes sense then that the campus' final line of defense in terms of capturing stormwater is also it's perimeter and public face, as this is the lowest ground on campus.

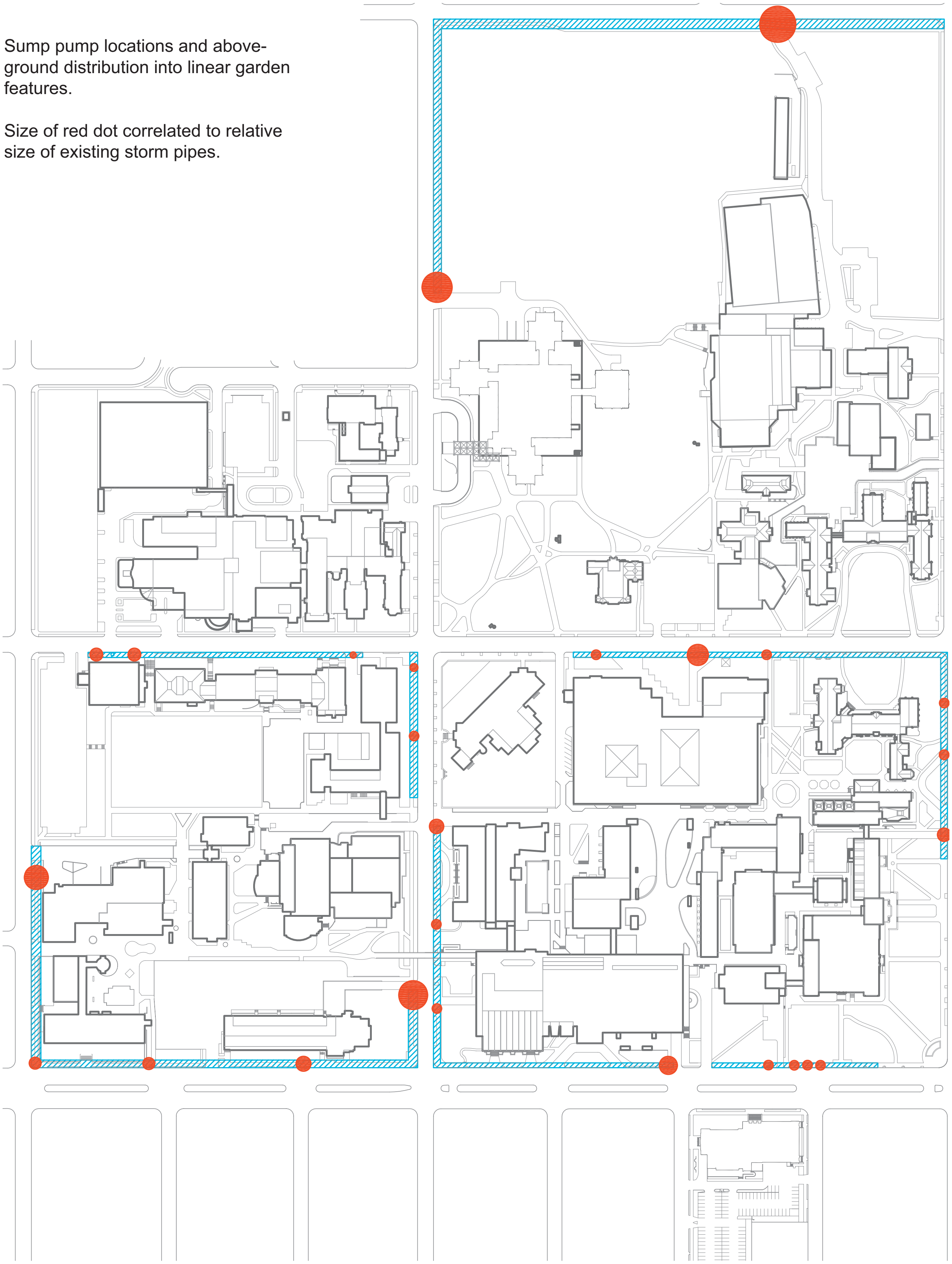
The aesthetic idea of the Garden Wall is to create a formal border around the perimeter of campus that also happens to feature terraced gardens designed to distribute and detain stormwater. In places this border might be articulated with low masonry walls feathering into the landscape, in keeping with the formal landscape elements of Mitchell Hall and the other early buildings. In places this border might drop to grade as a simple swale, or rise up to seating height and become a planter. As an identifiable design element of the campus, the Garden Wall concept has the flexibility to address the many differing edge conditions that currently exist and to take on different characters as the landscape dictates. At the same time, it becomes a unifying feature much as the currently planned corner plantings unify and demark the boundaries of campus.
The Garden Wall's most important aesthetic calling is to serve as a true garden wall around the Downer Woods. Such a wall, whether decorative metal work or imposing masonry, would

GARDEN WALL CONCEPT ILLUSTRATION
Kenwood ave. at Mitchell Hall



Sump pump locations and above-ground distribution into linear garden features.

Size of red dot correlated to relative size of existing storm pipes.



THE GARDEN WALL

raise the stature of the Woods to the ecologically and historically valuable State Protected Natural Area that they are. Such a high wall would also evoke other great academic precincts, such as the Gothic walls of Cambridge, or the Gates of the Harvard Yard.

As a stormwater management strategy, the elaboration of the wall around the Downer Woods also corresponds to the storm pipes that have the largest impact on Edgewood Avenue. The two pipes that collect Catchment Areas 15 and 16 drain 41 Acres together. Daylighitng water in these pipes at the perimeter of campus may in the final analysis be the first line of defense to pursue rather than the last.

Finally, while all of the analytical studies in this masterplan are presented as separate issues, the true opportunities lie in the confluence of potential solutions in given locations. The perimeter of campus is one such location, and the confluence is between the Garden Wall concept and the sidewalks that also edge each block.

The perimeter sidewalks have already been highlighted as a logical demonstration site for pervious paving; they are removed from the surrounding buildings more than the interior walks are, they are generally downhill from the lawns that separate them from the rest of campus, and they rarely have adequate landscape to drain to before the street edge.

This strategy of making a perimeter of pervious paving meshes exceptionally well with the Garden Wall concept. As a stormwater infiltration feature, the use of pervious walkways in conjunction with perimeter rain gardens broadens the infiltration zone of both features. Pervious paving may also support the growth of street trees, which in turn provides some flexibility in relocating sidewalks to accommodate Garden Wall features.

As an integrated border condition, the combination of the sidewalks and garden features suggests an engaging, functional way to give a distinctive identity to the campus as a whole.

GARDEN WALL CONCEPT ILLUSTRATION

Downer Woods along Maryland avenue.

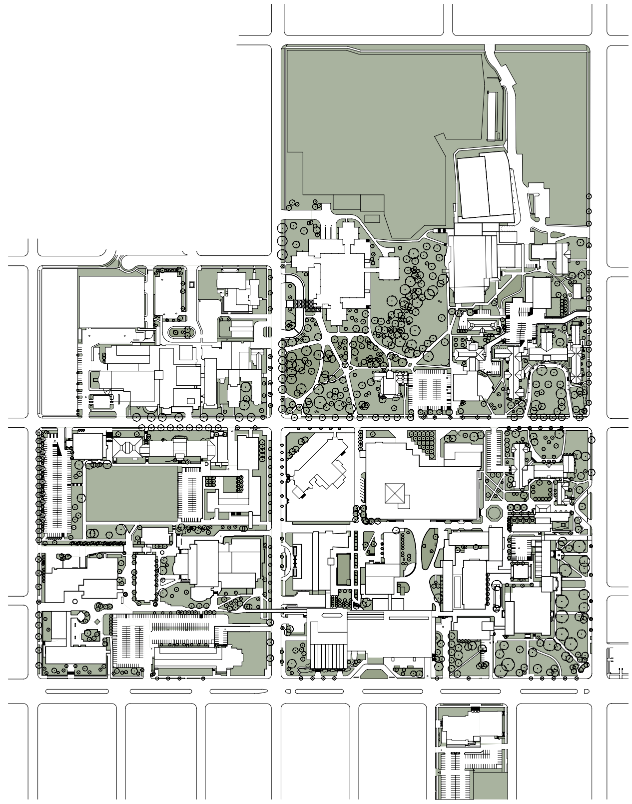
One of the most compelling arguments for the Garden Wall the idea of creating a coherent border to the campus that would replace the utilitarian chain link fence surrounding the Downer Woods with a proper wall or ornamental fence. Space for the stormwater planter has been created by shifting the now pervious sidewalk closer to the street.

'Zero-Discharge Visualization

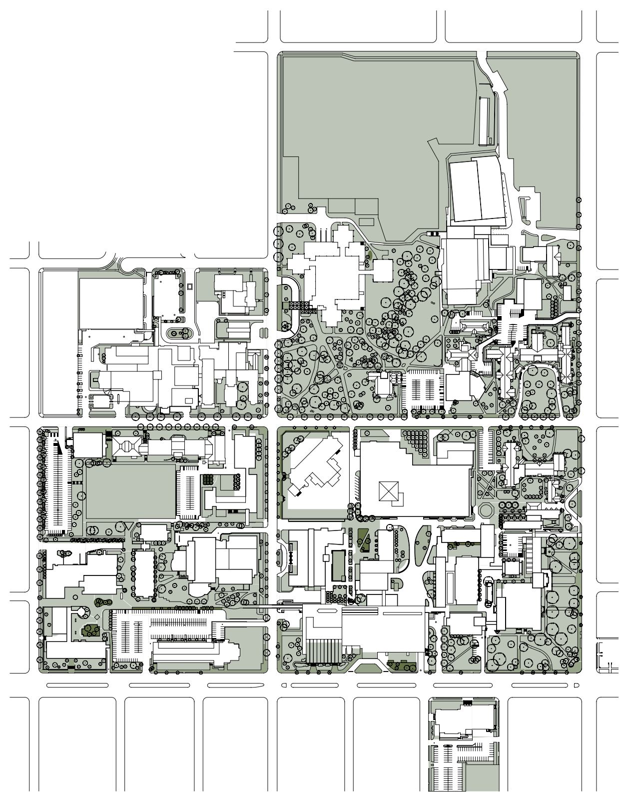
These maps are the final graphic product of this Masterplan; an animation of the campus as each strategy applied brings it closer to the goal of 'zero-discharge.' This sequence will eventually be accompanied by SWMM graphics that chart the cumulative impact of each strategy against the 100 year-0.5 cfs/acre goal for both the north and south drainages.

Visualize this: each surface of the campus is either contributing to the storage and dissipation function that keeps stormwater from surging into the storm sewer or it isn't. Working from the top down, the addition of green roofs to the fullest extent partially but not completely neutralizes those surfaces. The disconnection of downspouts partially neutralizes the sloped roofs, while changing partially pervious lawn to fully functioning rain gardens.

The patchwork of greens of partial or full intensity spreads across the campus, revealing areas not well served by the initial strategies. Finally, once the outflow has been limited to the greatest extent possible, the sump pumps of the GARDEN WALL capture the required flow to meet the goal. The campus has come to life with a garland of flowers.

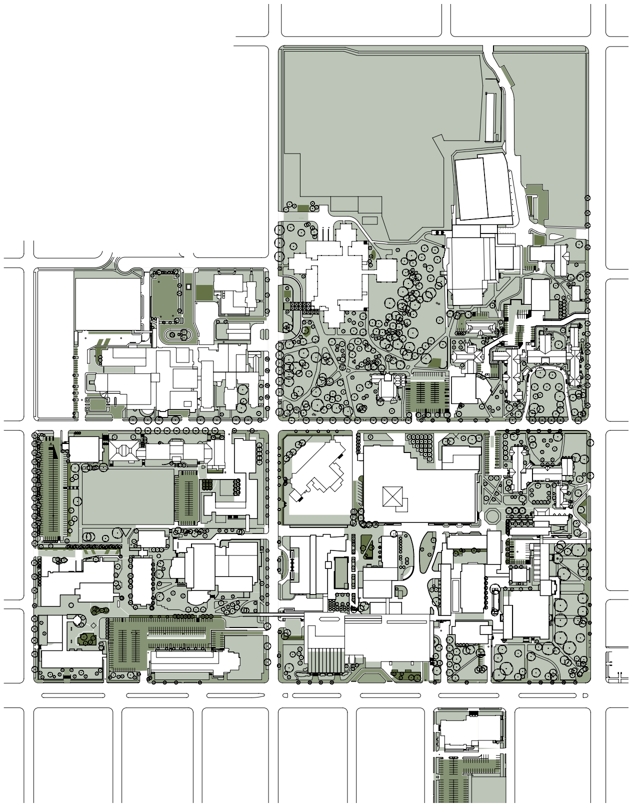


BASE

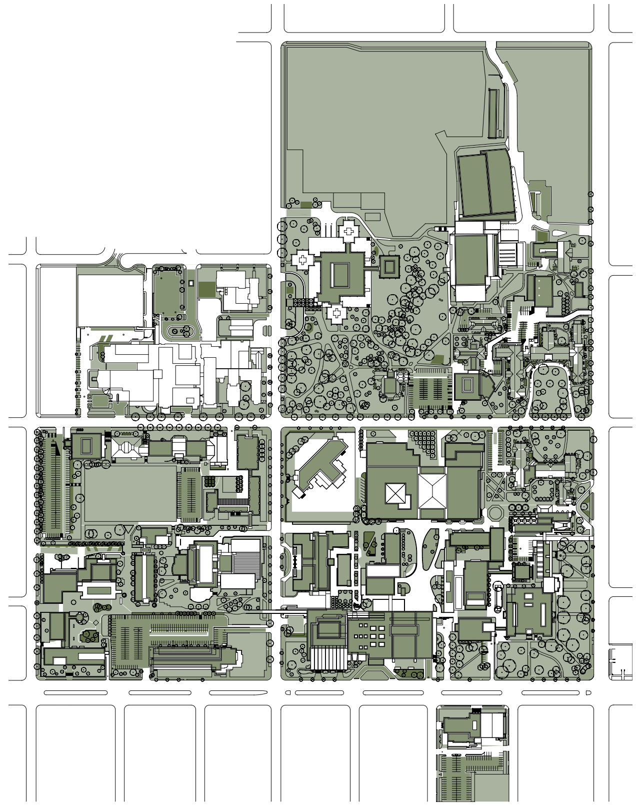


Pedestrain Hardscape

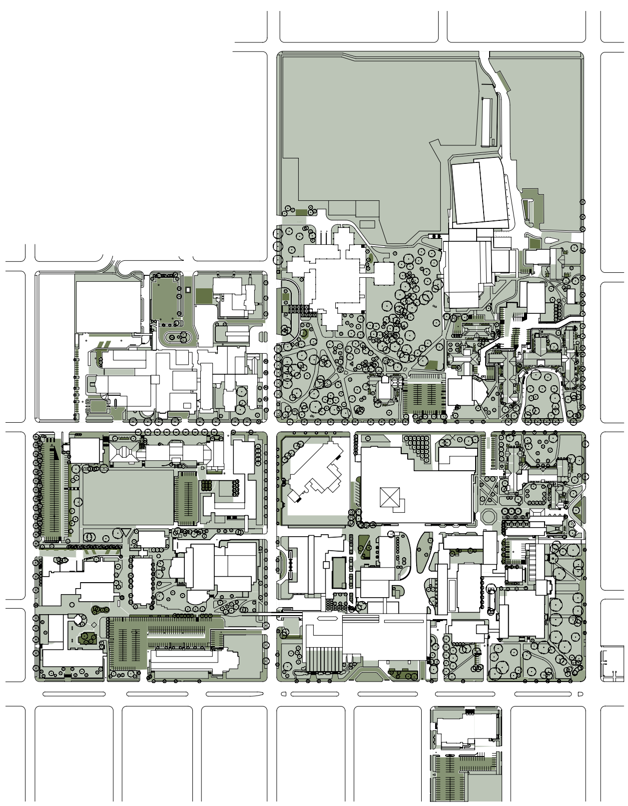
'ZERO-DISCHARGE' VISUALIZATION



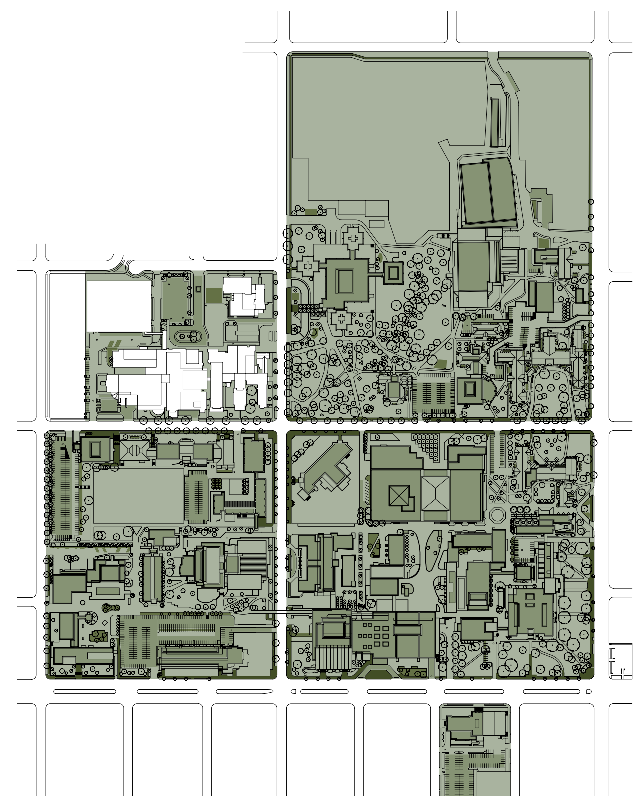
Pedestrain Hardscape
+ Vehicular Hardscape



Pedestrain Hardscape
+ Vehicular Hardscape
+ Externally Drained Roofs
+ Internally Drained Roofs



Pedestrain Hardscape
+ Vehicular Hardscape
+ Externally Drained Roofs



'ZERO-DISCHARGE' STATE
GARDEN WALL implementation to establish the target discharge rate of 0.5 cfs/acre for both North and South drainages