REVERSE ENGINEERING
THE ENGINEERING CAMPUS AS CATALYST

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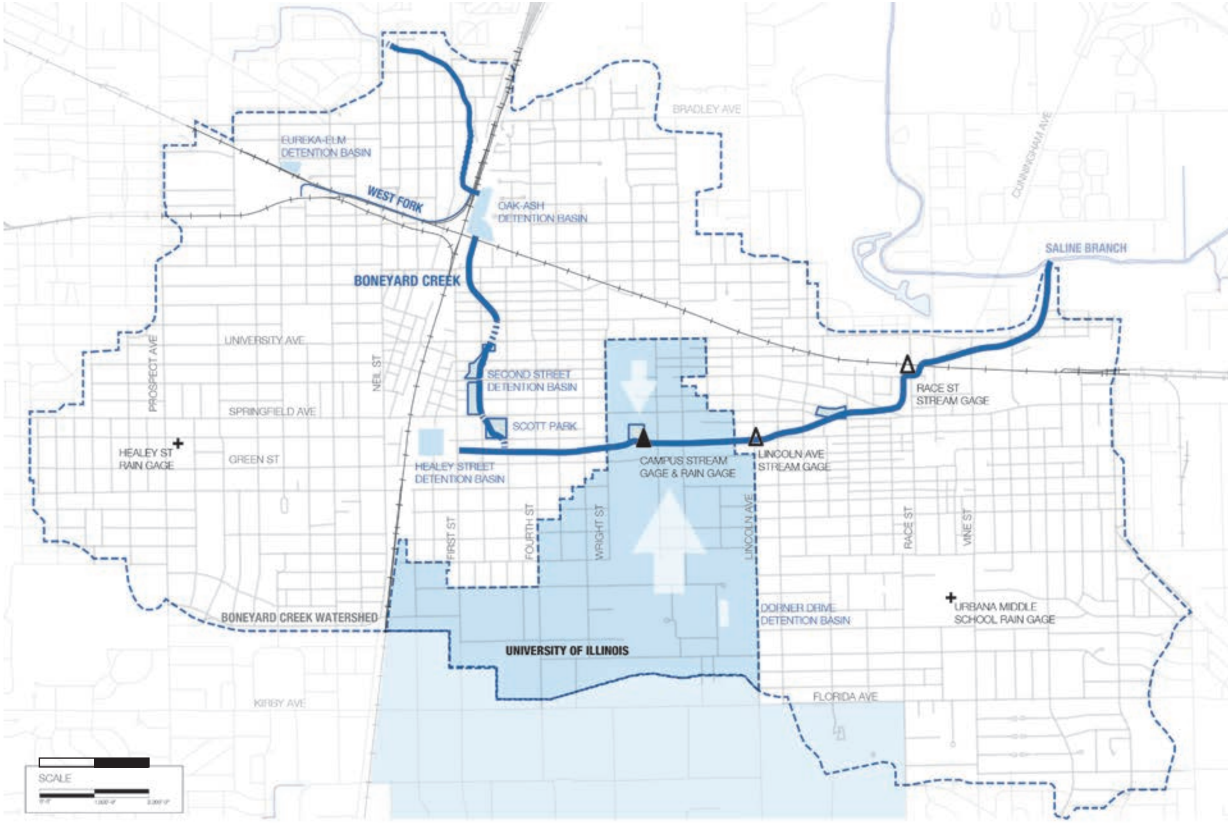
PROJECT ABSTRACT

EDGE ENGINEERING

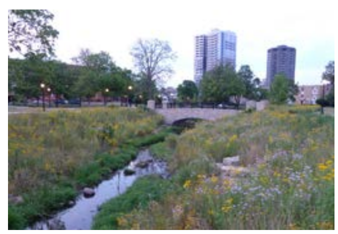
The Boneyard Creek drains an urbanized watershed of approximately 7.45 sq. miles including the campus of the University of Illinois at Urbana-Champaign. Over several decades, multiple detention ponds have been constructed upstream from the University, and despite eliminating recurrent flooding, the problem of poor water quality persists. The creek receives its base flow from both urban and agricultural areas producing runoff laden with nutrients, sediment, heavy metals, and other pollutants. Because of this, the Boneyard Creek makes the EPA's 303d list of impaired waterways, however, with a University goal of carbon neutrality by 2020 in accordance with the Illinois Climate Action Plan, coupled with aging subsurface infrastructure as well as a cultural paradigm shift from campus landscape as turf to a classroom extension, there exists an economic, ecological, and educational argument for green infrastructure.

Extending the current network of green infrastructure over the existing subsurface network would develop a hybrid management system. This method would lower construction and life-cycle costs while providing eco-system services such as groundwater recharge through infiltration and water quality control. Additionally, infiltration would stabilize base flow, bio-infiltration would reduce BOD, and a reduction in runoff would manage peak flows. The threat of flooding is eliminated by existing detention measures upstream, therefore facilitating the reclamation and both physical and cultural transformation of the highly channelized ditch into a terraced multifunctional landscape supporting native prairie plants providing bio-filtration and pollinator habitat, as well as new recreational amenities including ice skating in the winter and swimming in the summer.

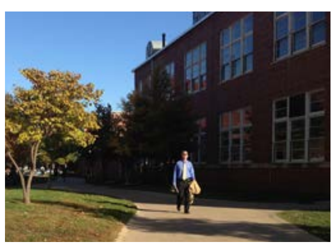
PROJECT CONTEXT: WATERSHED ANALYSIS











ENGINEERED WATERSHED

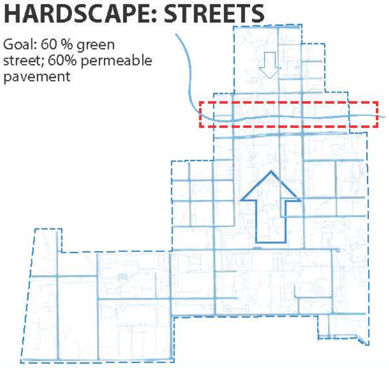
1. Detention Basin for Flood Control
2. Buried Creek
3. Decorative Creek (Engineering Quad UIUC)
3. Channelized Creek

FLOOD CONTROL WATER QUALITY CONTROL

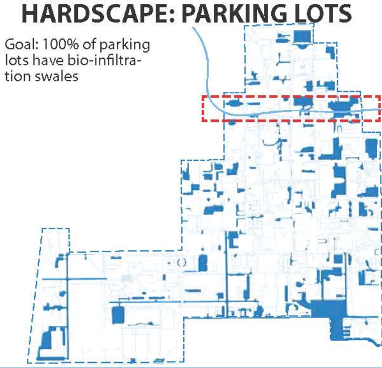
Boneyard Creek drains an urbanized watershed of approximately 7.45 sq. miles that flows, in up-stream to downstream order, through the city of Champaign, the campus of the University of Illinois at Urbana-Champaign, and the city of Urbana, Illinois. Over the past several decades, several detention ponds have been constructed upstream of Campus Town and the UIUC Campus. Despite effectively eliminating recurrent flooding along the banks of the creek, the problem of poor water quality persists. The Boneyard Creek makes the EPA's 303d list of impaired waterways, and receives much of its base flow from urban runoff laden with nutrients, sediment, heavy metals, hydrocarbons and other pollutants.

CAMPUS SITE ANALYSIS AND DESIGN STRATEGIES

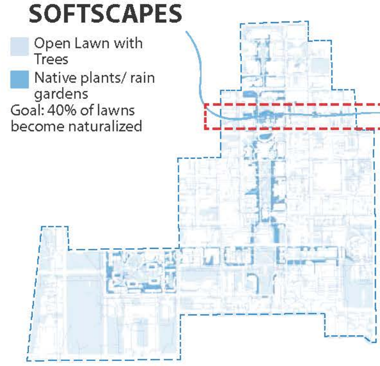
HARDSCAPE: STREETS



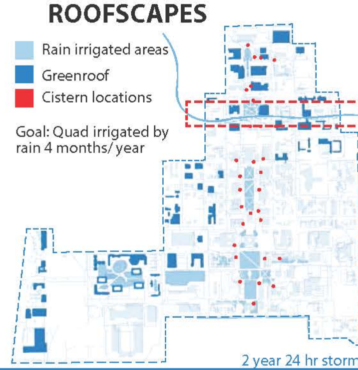
HARDSCAPE: PARKING LOTS



SOFTSCAPES

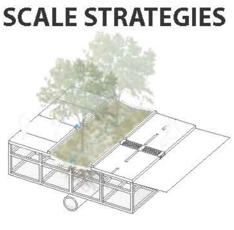


ROOFSCAPES

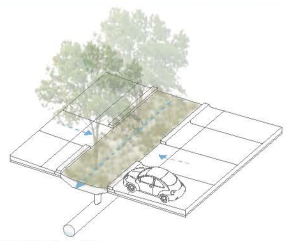


Hardscape: Streets		Hardscape: Parking Lots		Softscapes		Roofscapes	
14% Runoff Volume reduced	28% Peak flow reduced	10% Runoff Volume reduced	8% Peak flow reduced	17% Runoff Volume reduced	36% Peak flow reduced	71% Runoff Volume reduced	81% Peak flow reduced
21% Nitrogen Reduced	23% Suspended Solids reduced	2% Nitrogen Reduced	7.5% Suspended Solids reduced	8% Nitrogen Reduced	2.5% Suspended Solids reduced	8% Nitrogen Reduced	46% Suspended Solids reduced

SITE SCALE STRATEGIES

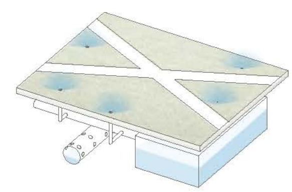


GREEN STREET

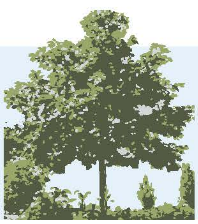


PARKING LOT

RAIN GARDENS



CISTERN IRRIGATION



1 Swamp white oak (10 yo)

77 lb CO_2 Sequestered/yr

505 gal rain intercepted/yr

427 Swamp white oaks

33088 lb CO_2 Sequestered/ yr

217183 gal rain intercepted/yr

CO: 85.5 ounce/yr

O_3: 4231 ounce/yr

NO_2: 812.1 ounce/yr

PM10: 1837.8 ounce/yr

SO_2: 384.6 ounce/yr

OVERALL PLAN

This design transforms the campus through the implementation of green infrastructure to mitigate storm water before it reaches the Boneyard Creek. Currently, there are only two rain gardens installed on campus, and there is no storm water management strategy included as part of the campus master plan even though a majority of storm water drains directly into the creek. These existing conditions and the reliance on conventional storm water infrastructure creates flooding issues on campus and contributes to low water quality in the creek.

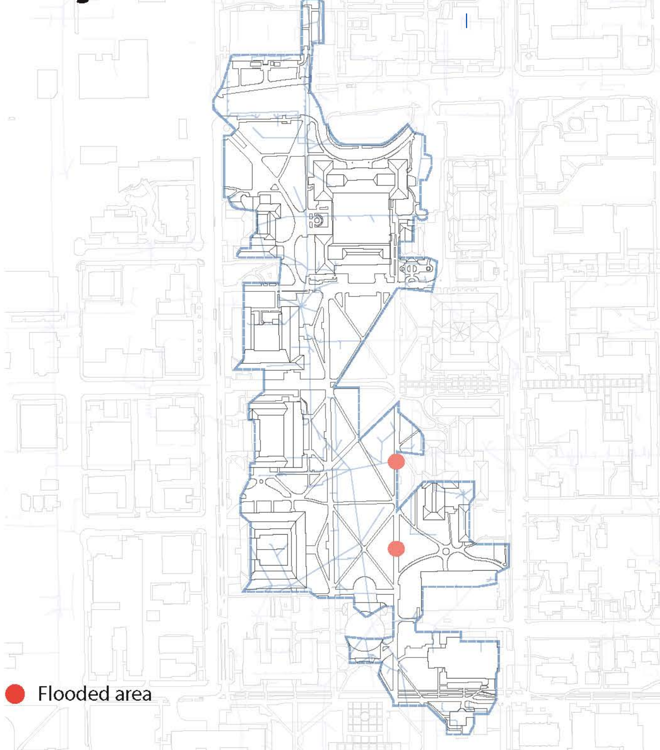
The Boneyard Creek is the focus of the design, however this is supported by a larger planning and design framework that seeks to develop a campus landscape network capable of managing storm water more effectively before it reaches the edge of the creek. Four typologies were developed to support these objectives including: green streets, roof catchments, bioswale parking treatments, and rain gardens. The application of these typologies upon the campus landscape will create a significant impact leading to a 60% increase in impermeable street surfaces as well as the conversion of 40% of all lawns to native prairie landscapes and rain gardens.

In order to measure the potential effectiveness of the proposed green infrastructure, the rational method and the EPA Storm Water Management Model was used to calculate peak flow for the 2-year, 24-hour storm. In addition, NCRS was used as the method to determine total reduction in runoff volume. Furthermore, a literature review provided the methodology for measuring nitrogen sequestration and total suspended solids (Martin et. Al, 2010).

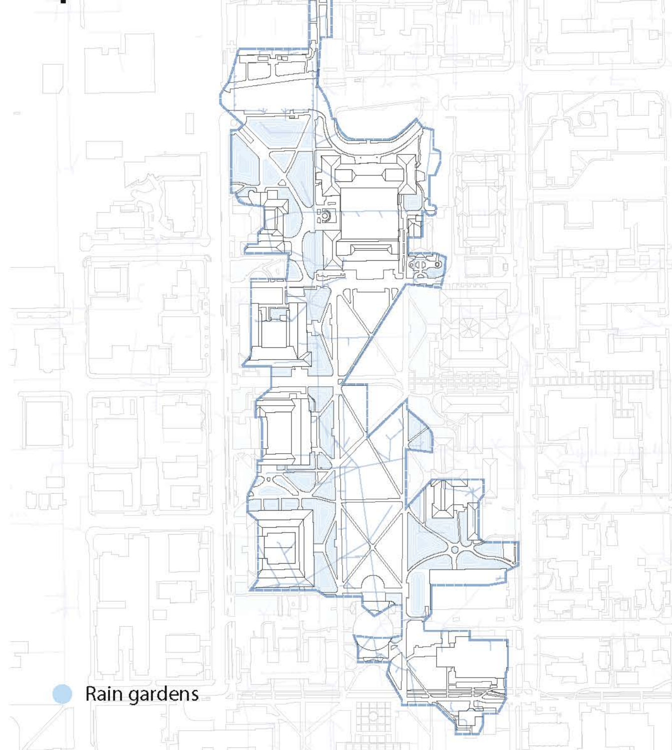
The proposed implementation results in the conversion of 34 acres of streets to green streets, with 36 acres of all pavement types becoming permeable. The calculations estimated that this will remove 20.7% more nitrogen and retain 11.6% more water at peak flow. Through the addition of 83.2 acres of green rooftops, the levels of nitrogen were reduced by 8% with an increased retention rate of 16.7% during peak flow. The proposed 83 acres of parking lot bioswale treatments would remove 2% of nitrogen and manage 7.4% more water volume at peak flow. In addition, cisterns would collect excess water and may be used to irrigate 230 acres for up to 4 months. Lastly, the conversion of 40% of the lawn surfaces to prairie plantings and rain gardens would result in the increased sequestration of 8% of nitrogen along with a 36% reduction in surface runoff during peak flow.

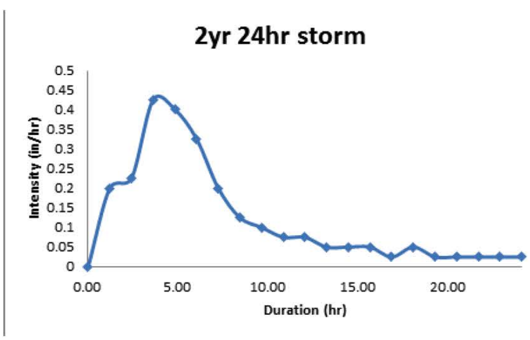
MODELING CONDITIONS: SWMM AND RAIN GARDEN EFFECTIVENESS

Existing



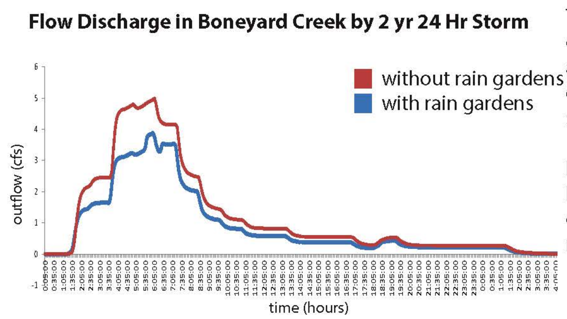
Proposed





Top: flooding problems around campus quad subwatershed.

Bottom: Huff Distribution of 2yr 24hr storm in Champaign



Top: locations of rain garden around campus quad subwatershed

Bottom: Rain garden effect in runoff reduction

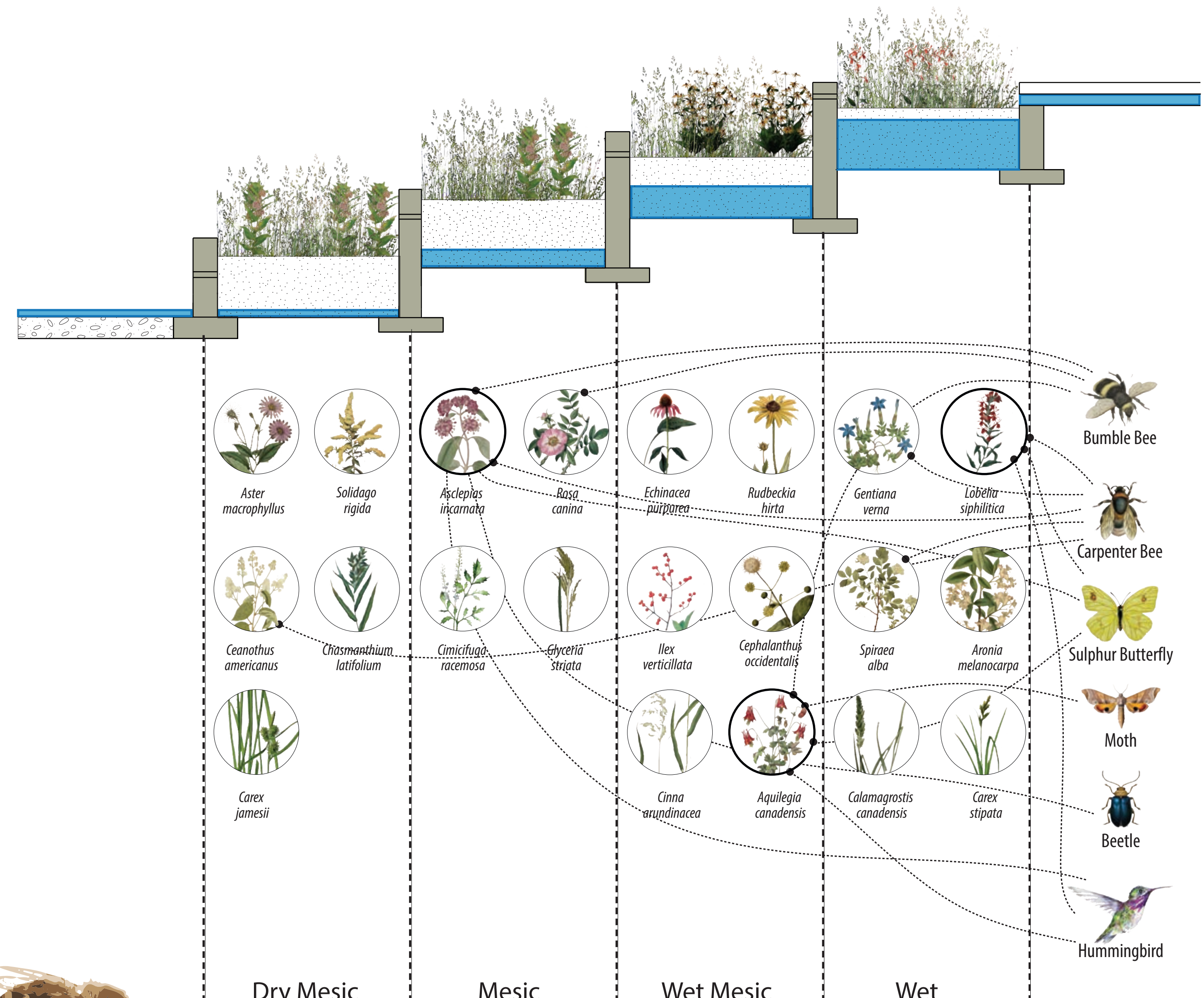
LEARNING BY SWMMING

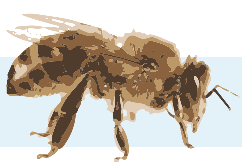
The goal of this study was to learn how green infrastructure, namely rain gardens, could accommodate flooding issues on campus as opposed to conventional storm water systems. The proposed rain gardens are designed with native prairie soils and are connected to existing sewer infrastructure in the case of overflow. Typically, the rain gardens will allow the runoff and rain water to infiltrate the different layers of soil slowly effectively retaining and cleaning the water while mimicking the pre-settlement landscape function.

The EPA Storm Water Management Model (SWMM) was used to analyze the effectiveness of rain gardens in reducing surface runoff from the Main Quad. The Main Quad was selected as a modeling site because of its central campus location, flooding issues and potential for future LIDs. The model uses a typical 2-year, 24-hour storm in Champaign, IL and the calculation is distributed by the Huff Method.

The results show that the total runoff from the identified Quad sub-watershed that reaches the Boneyard Creek is 91,173 cubic feet. Implementation of the recommended rain gardens would reduce 35.4% of this (32,256 cubic feet) from ever entering the Boneyard. In addition, the rain gardens are more effective when in more intense rainfall events, successfully reducing higher volumes of water from entering the Creek. Therefore, the rain gardens would be effective at treating and retaining more water during storm events.

CAMPUS-CREEK INTERFACE: A NEW EDGE CONDITION





1 hive of bees

87 workers

15000 square footage coverage

x5 species of pollinators

EDGE ECOLOGY: FROM SHEET PILES TO POLLINATOR TERRACES

The terrace plant palette was selected to support local pollinating species. University of Illinois professor May Berenbaum (Department of Entomology), was recently awarded the National Medal of Science in plant-insect co-evolution, locally reinforcing the importance of insects in the built environment.

Plant diversity within the campus environment is key for pollinators to thrive, however typical planting pallets found on campus are homogenous and include invasive species such as Kentucky bluegrass, Maples, Yews, and Oaks. This lack of plant biodiversity reduces the survival rate of native pollinators such as bees, butterflies, moths, beetles, flies, and birds. Therefore, plants were carefully selected in order to accommodate these species through the use of a series of pollination syndromes, including: color, odor, nectar, pollen, and flower shape.

The proposed planting plan specifically targets the reintroduction of five pollinator species to campus and the terraces will create an environment capable of sustaining their populations thus supporting more diverse wildlife along the creek edge while providing new and unique educational opportunities.

CAMPUS-CREEK INTERFACE: A NEW EDGE CONDITION

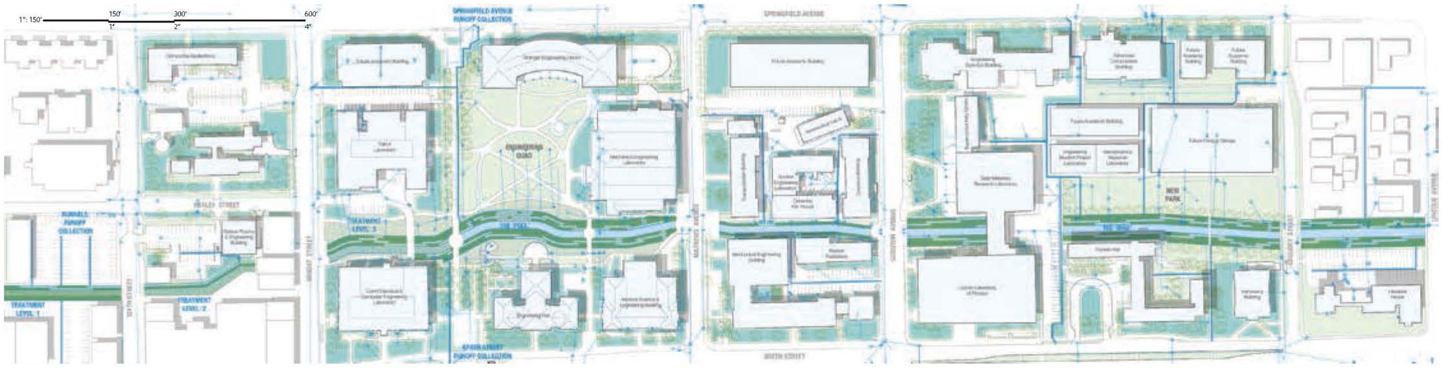
EDGE ECOLOGY: CAMPUS LIFE ON THE EDGE

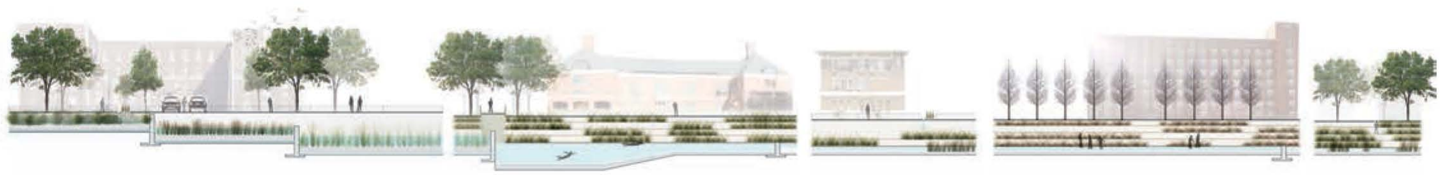
With the threat of flooding eliminated through upstream detention measures accommodating up to a 100-year storm event, and water quality improved through campus-wide green infrastructure, the perpendicular steel walls of the former drainage 'ditch' give way to a linear system of multifunctional terraces filled with native prairie planting. These terraces will provide a variety of services including habitat for pollinators, bio-filtration, ecological education, and seasonal recreational amenities serving as both a skating rink and swimming hole.

The terraces will be fed by and filter surface runoff from the surrounding campus. The terraces form a series of horizontal and vertical planes mimicking the function of a wet prairie, effectively treating water before it enters the stream. In addition, the terraces provide physical access to the water's edge as well as create a continuous pedestrian pathway following the linear creek channel.

FUTURE VISION:

The Boneyard Creek as Bio-filtration Infrastructure, an Ecological Hotspot and Recreational Corridor



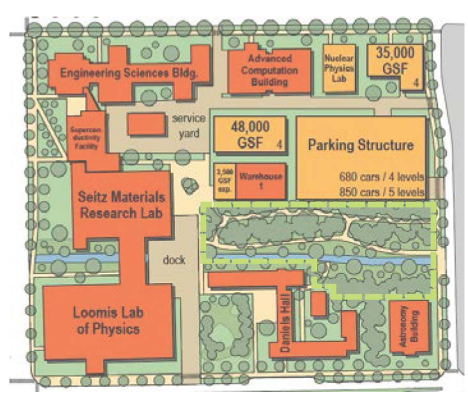


The proposed vision for the Boneyard Creek unfolds as a series of planned interventions, initiated by the desire to combine existing stormwater systems with new elements of green infrastructure. The synthesis and coordination of these systems will produce a campus landscape capable of enhanced ecological performance while also supporting new recreational and education programs.

satellite aerial: existing conditions

phase 1: **CATALYST**

Delineated as future open space by the 2007 campus master plan, this site serves as the basis for creek-edge intervention. The edge of the creek will be developed in a series of bio-filtering terraces cleansing surface runoff as well as stormwater discharge from local sub-watersheds. These terraces will also support pedestrian circulation reorienting the edge of the creek as a recreational and education amenity allowing students, faculty and locals to enjoy the space year round.

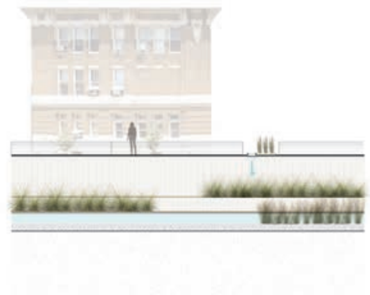


2007 Campus Master Plan: building construction map

+2 ACRES
+permeable surface

phase 2: **CONNECT**

The campus master plan suggests the day-lighting of the stretch of creek buried between Mathews and Goodwin Avenues. While also creating new space for bio-filtration, recovering this site will develop an existing circulation void, vital for uninterrupted pedestrian access along the creek completing the connection from the Engineering Quad to the eastern portion of campus and towards Urbana.

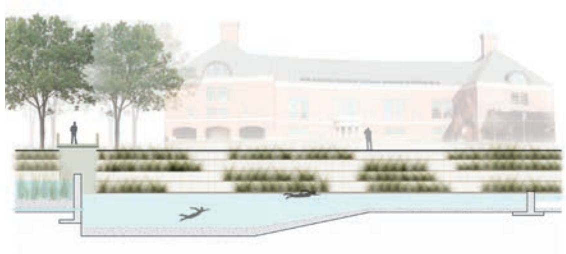


phase 3: **FILTER**

Whereas Phase 1 addresses runoff contamination from within the local sub-watershed, Phase 2 focuses on upstream pollutants already present in the water including E. coli bacteria. A three-tier terraced system utilizing phytoremediation will be implemented over a half-mile stretch of the Creek reaching from the Healey St. Detention Basin to the Engineering Quad. 80% of this stretch will require day-lighting, successfully reorienting the space for enhanced ecological, educational and recreational performance. Each level of the terrace system will correspond to a distinct native wet habitat including: 1) wet meadow , 2)shallow marsh , and 3) deep marsh. Water levels will be managed by a series of dams, with the first terrace being fed by a controlled water pump from the Healey basin. The water will be cleansed as it filters through the soil and gravel bed to pipes leading to the next terrace before re-entering the normal stream flow at the Engineering Quad. In addition, overflows at the dams will provide additional filtration through aeration.

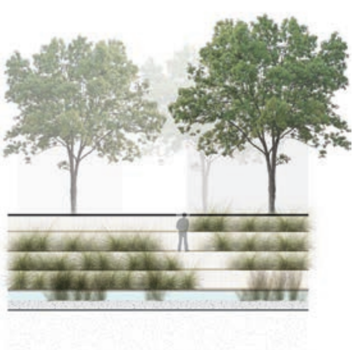
phase 4: **PROGRAM**

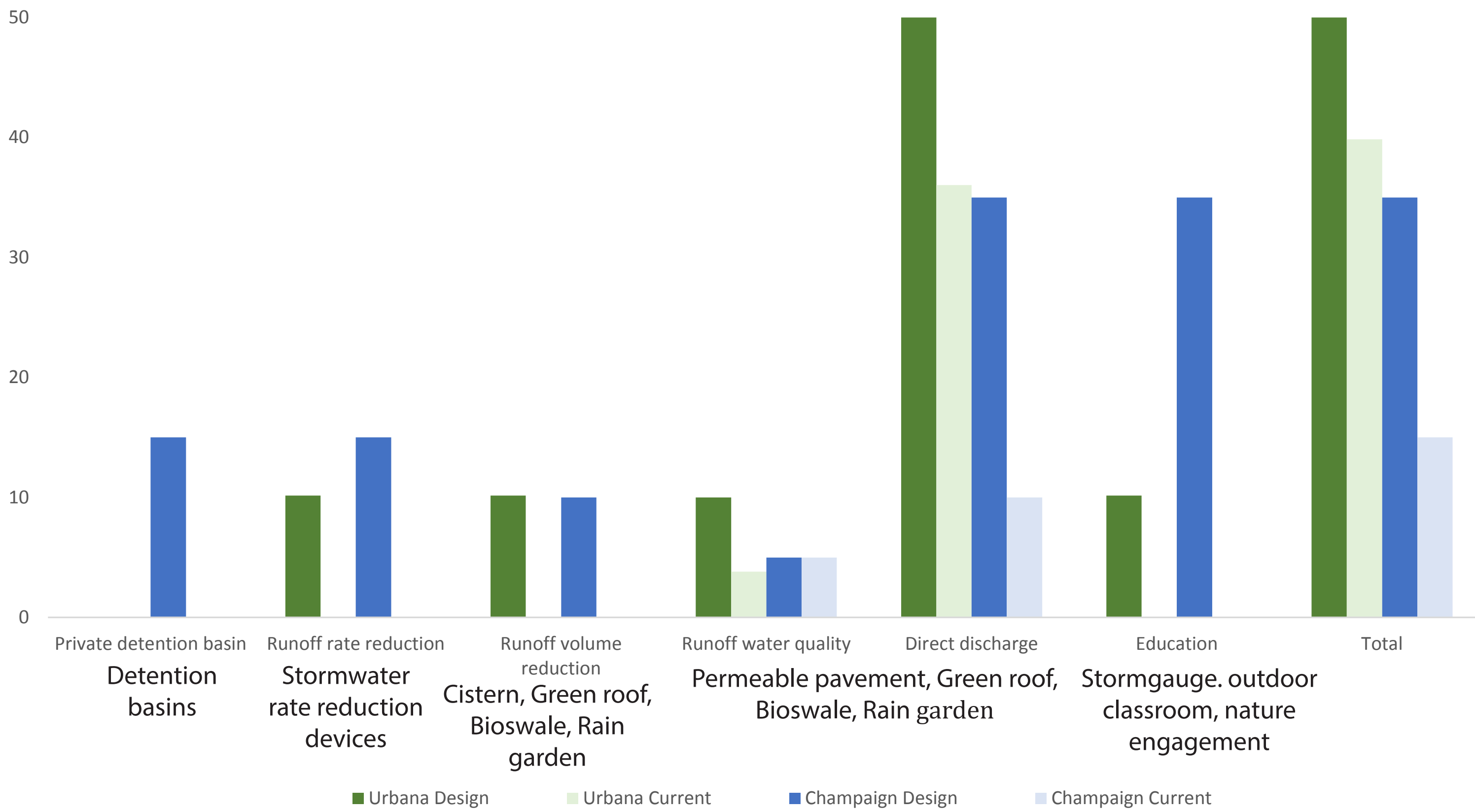
As a result of the newly implemented green infrastructure and bio filtration marsh upstream, improved water quality in the creek supports new programmatic elements including the development of a swimming hole. A dam on the eastern edge of the Engineering Quad will manage water depth as well as water quality of the pool facilitating new recreational use of the space.



phase 5: **EXTEND**

As a linear system, the Boneyard has the potential to continue beyond campus and establish itself as a more comprehensive ecological engine and pedestrian connection. By continuing the implementation along the creek edge eastward into Urbana, the Boneyard will effectively link campus with the community as a recreational amenity while providing vital ecological services.





Charts: University of Illinois of Urbana-Champaign's increase in credits will be received from the city of Urbana and Champaign. after the design implementation. Many stormwater criteria exceed the maximum requirement, thus recieve full credits.

$

1
Equivalent Residential Unit

Urbana- 3100 sqft impervious surface — $4.94/mo

Champaign- 3478 sqft impervious surface — $5.24/mo

$144,684
per year
stormwater fee to cities

PROFITS FROM GREEN INFRASTRUCTURE

The University of Illinois is divided between the two cities of Champaign and Urbana. Each city charges a stormwater utility fee based on the total impervious area located in each respective city. These stormwater utility fees are meant to compensate Champaign and Urbana for conveying stormwater from University property.

There are credits and incentives available to the university in order to reduce its bills from both Champaign and Urbana. The potential credits and incentives can only reduce the total bill by 50% in both Champaign and Urbana. The chart above illustrates different ways that the university can reduce its stormwater utility bills. Each credit or incentive opportunity has a potential credit limit. For example in Urbana, a runoff rate reduction can receive a 15% maximum credit. In addition, the university may mix and match credit incentive methods, but cannot reduce its total bill by more than 50%.

If the University were to implement low impact design (LID) and take full advantage of the stormwater credits and incentives, it could save $35,012 per year (see the calculations section below) in stormwater fees. The suggested conventional development designs are expected to cost the University $1.93 million for Matthews Avenue improvements, $739,000 for Main Quad improvements, and $452,000 for stormwater



$35,102

per year
reduced stormwater fee to cities

	conventional	proposed
Cost	**$ 3,121,000**	**~$ 3,000,000**
	Quad area only; design fees not included	Quad area only; design fees not included
Benefits	- Stormwater fee - flood prevention	- stormwater fee - bike/pedestrians safety - native habitat - potential recreations - landscape beauty - flood prevention

infiltration/filtration BMP's: $3,121,000 in total (2011-1215 Matthews-Quad Final Report). These costs do not include design, administrative, or construction-phase engineering costs, and provide no additional benefits to the University other than flood control.

Our proposed LID methods are more cost-effective than the conventional designs proposed because they provide additional benefits to the community in addition to flood control along with the $35,012 yearly savings. Such positive externalities include better bike access, enhanced pedestrian safety, increased property values, beautification, wildlife habitat, and potential recreation services. A 2013 willingness to pay (WTP) experiment surveyed 131 randomized families in the Champaign-Urbana community, and showed that the community highly values LID; "widespread investment in LID stormwater solutions could have very large total benefits, and stormwater managers should be wary of policies and infrastructure plans that reduce flooding at the expense of water quality and aquatic habitat" (Cadavid & Ando, 2013).

A similar stormwater abatement project in Seattle transformed 30 city blocks as a part of a large infill development with natural drainage controls, and found that housing prices were 5.5% higher in the project areas than for similar houses in the same neighborhood (Ward 2008). Adjacent residential communities are primarily rental due to rhe more transient student population, so the housing price may not be applicable. However, it would be possible to gauge the value of the LID project in terms of rental prices and rental revenues from local businesses in the vicinity of the improvements compared to businesses not in the vicinity of the improvements. This method would be more appropriate, since there are several apartment complexes on-campus where students rent apartments, in addition to several small businesses on campus.

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