Campus Creek Re-Envisioned

A Stream Restoration and Design Proposal

Students of LAR 648 Specialization Studio 2014
Professors Jessica Canfield & Tim Keane

Kansas State University
College of Architecture, Planning & Design
Department of Landscape Architecture and Regional & Community Planning

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In celebration of the Landscape Architecture program's 50^{th} anniversary, this compendium of work is a gift from our department to the university.

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LAR 648: Re-Envisioning Campus Creek, December 2014

01. Introduction

In fall 2014 a team of 16 landscape architecture and biological & agriculture engineering students analyzed and redesigned the Campus Creek Corridor in order to demonstrate how it could be transformed into a resilient, environmentally- and socially-beneficial campus amenity. This work expanded and deepened initial recommendations proposed for the stream in the Kansas State University 2012 Campus Master Plan Update.

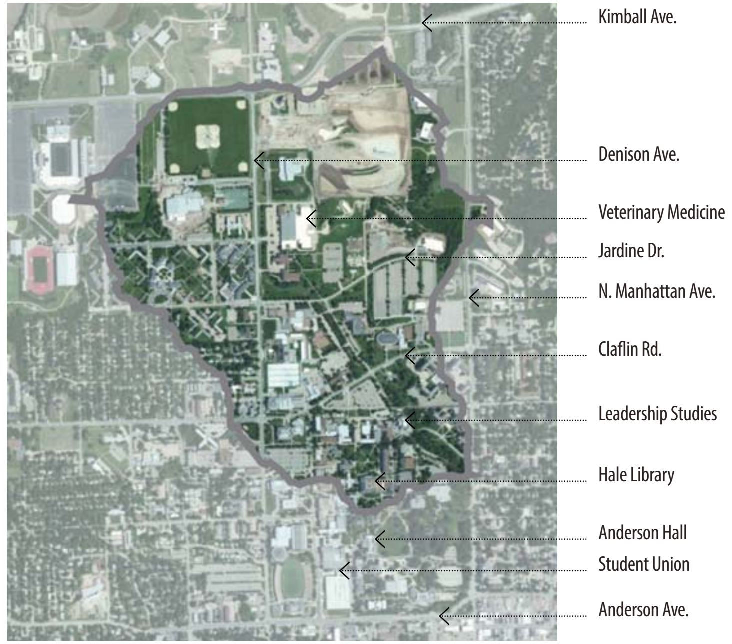
Beginning at the watershed scale, students modeled the area's hydrology and calculated runoff; at the site scale they surveyed the entire stream channel, analyzed bank stability and erosion potential, assessed habitat and water quality, and inventoried the soil. Students also surveyed user preferences and studied the corridor's existing design features, amenities, and aesthetics.

Working in teams, students then tested a number of stream channel design alternatives that would increase the corridor's natural flood storage capacity. They explored different planting design strategies that were informed by local prairie ecosystems. And they generated new circulation and seating options to increase opportunities for recreation, relaxation, and education.

The rigorous research and investigation led to a data-driven design proposal and a set of restoration plans and guidelines.

Background

Campus Creek, which flows through the heart of the Kansas State University Manhattan Campus, receives most of the stormwater runoff from the surrounding campus grounds. Because nearly half of the Campus Creek watershed's 400 acres is covered by impermeable surfaces (roofs, roadways and parking lots, plazas, and walkways), the creek suffers from increased flood frequency and intensity, stream channel and habitat degradation, and poor water quality. The K-State community needs a more natural Campus Creek Corridor that can reduce flooding, provide enhanced habitat for plants and animals, and serve as an educational, recreational, and aesthetic amenity. Such a place begins with Re-Envisioning Campus Creek.

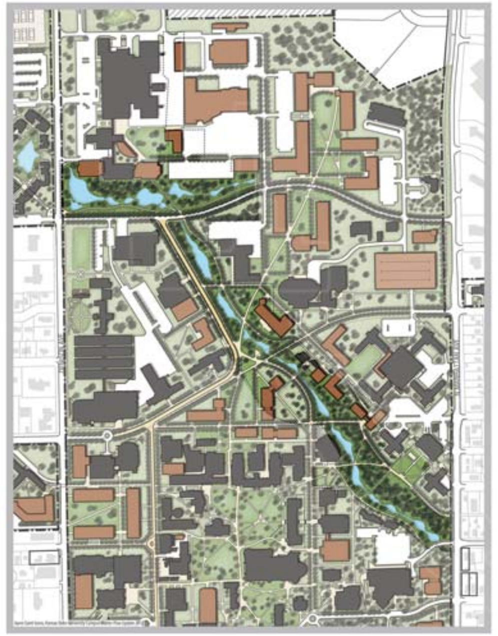


Campus Creek Watershed (Adapted from Google Earth 2014)

Existing Conditions

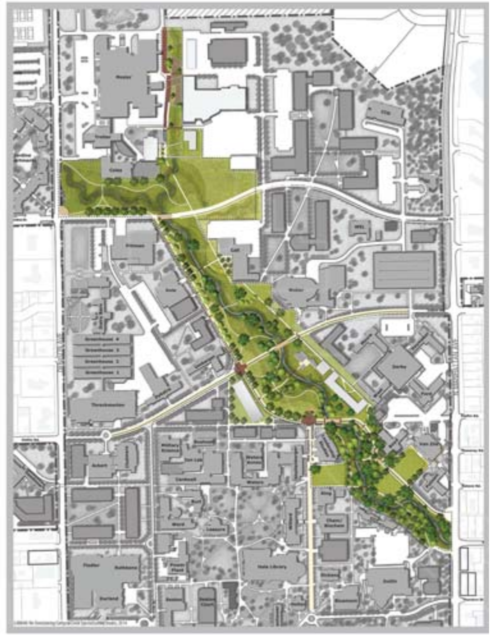
(Adapted from Google Earth 2014)

2012 Master Plan



(Kansas State University Master Plan 2012, Ayers Saint Gross)

Re-Envisioned Proposal



(Students of LAR648 2014)

Project Vision

Our design aims to create a naturally stable stream channel and floodplain that tolerates and rebounds from floods while also providing: a rich pedestrian environment that offers places to gather, study, socialize, or contemplate; a place that grows more complex, diverse and sustainable over time; and a place that honors the heritage of Kansas State University and of the Kansas Flint Hills.

Goals

• Respect the K-State region, heritage, and academic values
The design celebrates and honors the unique ecosystem of the Flint Hills region by drawing on the character of the Kansas tallgrass prairie.

• Enhance existing campus conditions
The design supports an enhanced network of amenities, circulation routes, and ecosystems, which will promote our legacy of academic excellence and social experiences on campus.

• Expand campus research opportunities and experience
The design expands campus open space and adds new amenities that will meet the needs of a growing academic community, and offer new opportunities to research, socialize, learn, and find joy in our landscape.

• Restore natural processes and local ecosystems
The design increases flood storage capacity within the corridor and lessens potential flood impacts. Native vegetation will help control erosion, increase biodiversity, provide habitat for diverse species, and lessen maintenance requirements.

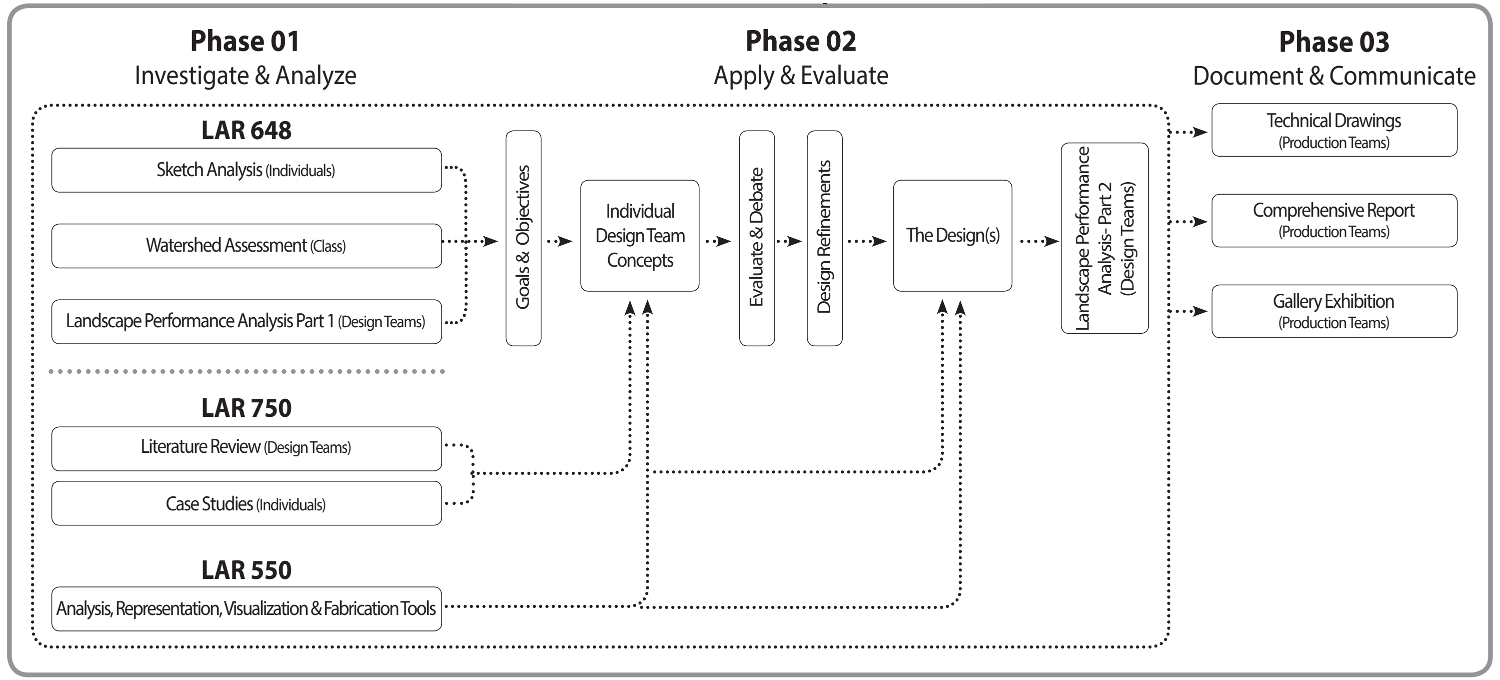

Campus Creek existing condition 2014

02. Design Process

The design for a re-envisioned Campus Creek corridor was supported by analysis and investigation conducted by students during Phase 01 of the project. Students were divided into four teams, each focusing on a major design consideration: channel restoration & stormwater management; vegetation, habitat & soils; amenities & user experience; and economics. During Phase 01, each of those teams conducted a watershed assessment, landscape performance assessment, case study, and literature review. Additionally, each student artfully considered qualities of the Campus Creek corridor through a sketch analysis.

Phase 02, the design stage, commenced after the completion of the watershed and landscape performance assessments. Students remained focused on channel restoration, vegetation, or amenities during the conceptual design development. After presenting their initial concepts to stakeholders, each student adopted more specific design tasks. While continuing to refine a design for the re-envisioned campus creek corridor, students began the process of organizing and producing construction documents, conceptual renderings, technical reports, and exhibition materials.

Project Work Plan



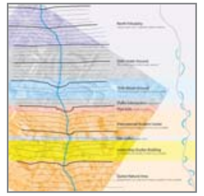
Sketch Analysis

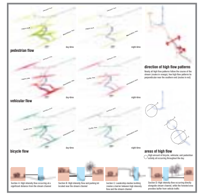
Through sustained personal observation, reflection and sketching, students worked individually to inventory, observe, document and analyze a particular theme related to the Campus Creek Corridor. The work seeks to poetically illustrate existing conditions and to identify new design opportunities.

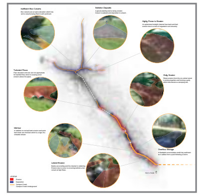

Water Characteristics

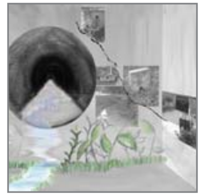

Circulation


Physiography


Channel Shape

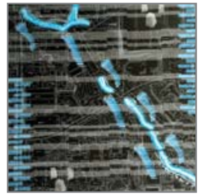

Movement Tracking


Erosion and Sedimentation

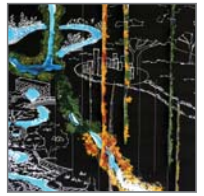

Culverts

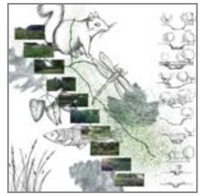

Bridges/Crossings


Activities

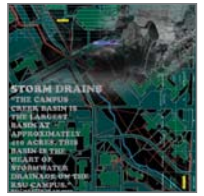

Channel Profile


Bank and Bed


Views

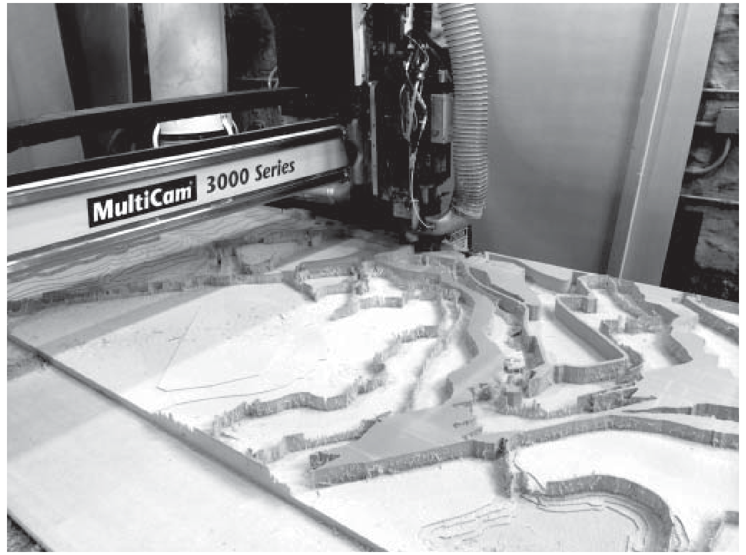

Habitat and Wildlife


Channel Debris


Storm Drains

Studio Activities

To create a longitudinal profile of the creek, we took to the field for data collection. Landscape architecture and engineering students measured stream bed depth and surface water elevation at key locations. Professor Keane illustrated surveying methods, then students took the reins to complete surveying of the entire stream.



A 1″= 20′ site model of the Campus Creek corridor was created by landscape architecture student Wesley Moore and Instructional Technologist Richard Thompson using topographic survey data collected in spring 2014 by instructor Ryan McGrath and civil engineering students. The 16′ long model was milled on the college's CNC router.

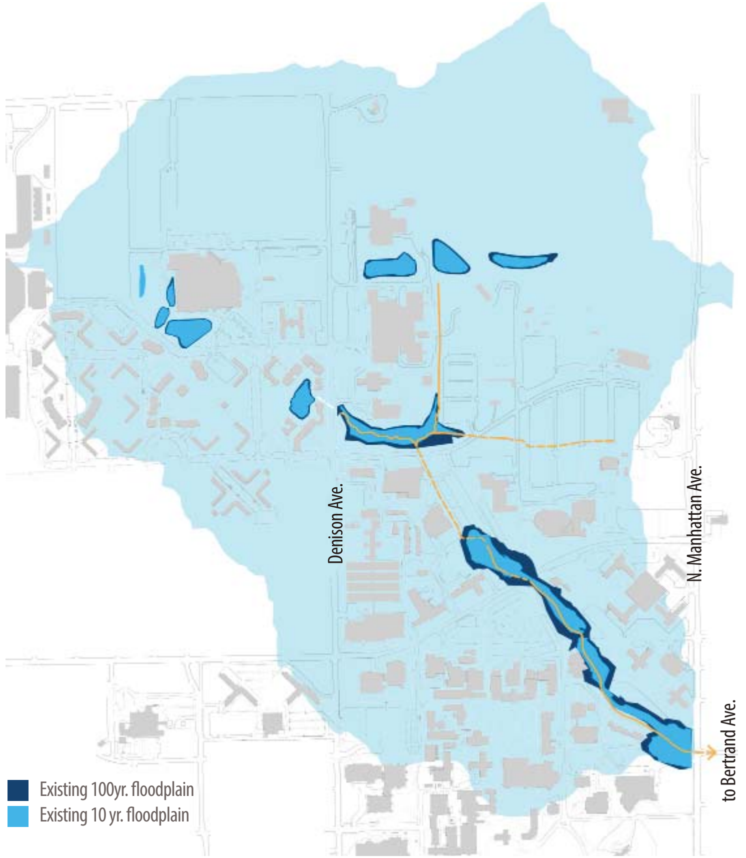
Richard Hansen, artist/maker/landscape architect from Colorado State Pueblo joined us for a three day charrette on design inspiration, ideation, process, and drawing. Students explored initial design ideas for Campus Creek through onsite sketching. On day three everyone pinned-up their work and shared various ideas on how the site could and should be transformed.

Students presented their preliminary design ideas to project stakeholders, including: Ruth Dyer, Senior Vice Provost and Vice President for Academic Aff airs; Ryan Swanson, Associate Vice President of the Division of Facilities; Cindy Bontrager, Vice President for Administration and Finance; and Stephanie Rolley, Professor and Department Head of Landscape Architecture and Regional & Community Planning. Conceptual design ideas were discussed for restoration of the Campus Creek stream channel, overall stormwater management, vegetation and habitat restoration, as well as user experience and amenities.

Existing Conditions

Campus Creek is a significant water transporter for Kansas State University. Unfortunately the creek is prone to overflowing its banks during large storm events. In an effort to protect buildings and infrastructure on campus, there needs to be an increase in storage capacity to allow for flooding to occur safely. Areas along Campus Creek that offer open, vegetated expanses could help direct and control flooding during large storm events.

One of the most serious issues with Campus Creek is flooding. During large storm events the creek will jump its banks and over-top roadways, posing a hazard to adjacent buildings, parked cars, and pedestrians. The stream enters main campus through a culvert under Jardine Drive from the west and from the NBAF site at the north. The stream exits campus through an undersized culvert under N. Manhattan Ave. The stormwater is then carried eastward in a pipe buried underneath Bertrand Ave. The pipe outlets into an open air drainage channel at Tuttle Creek Blvd, which eventually outlets into the Kansas River.



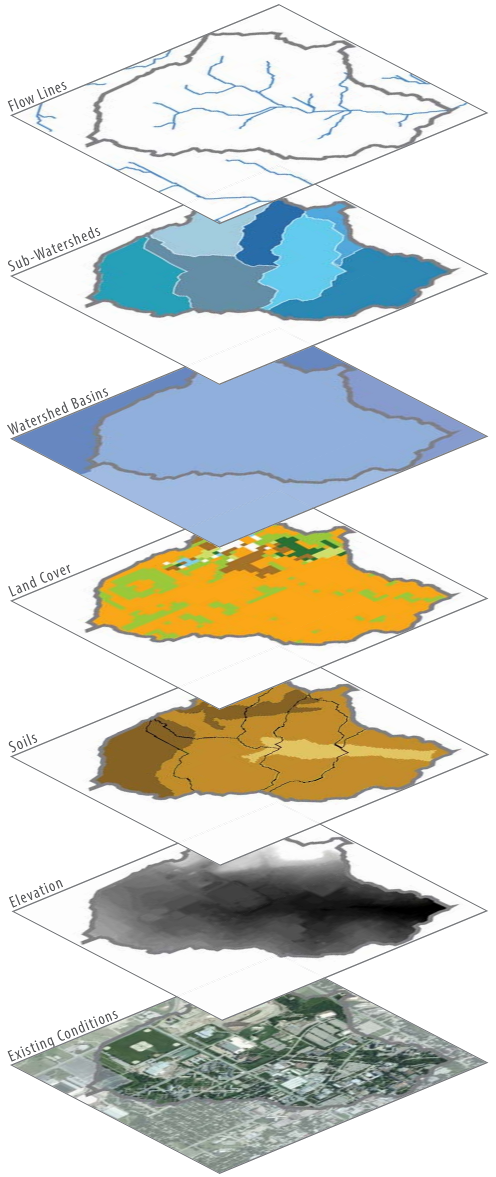
Campus Creek watershed area overlaid onto campus creek map

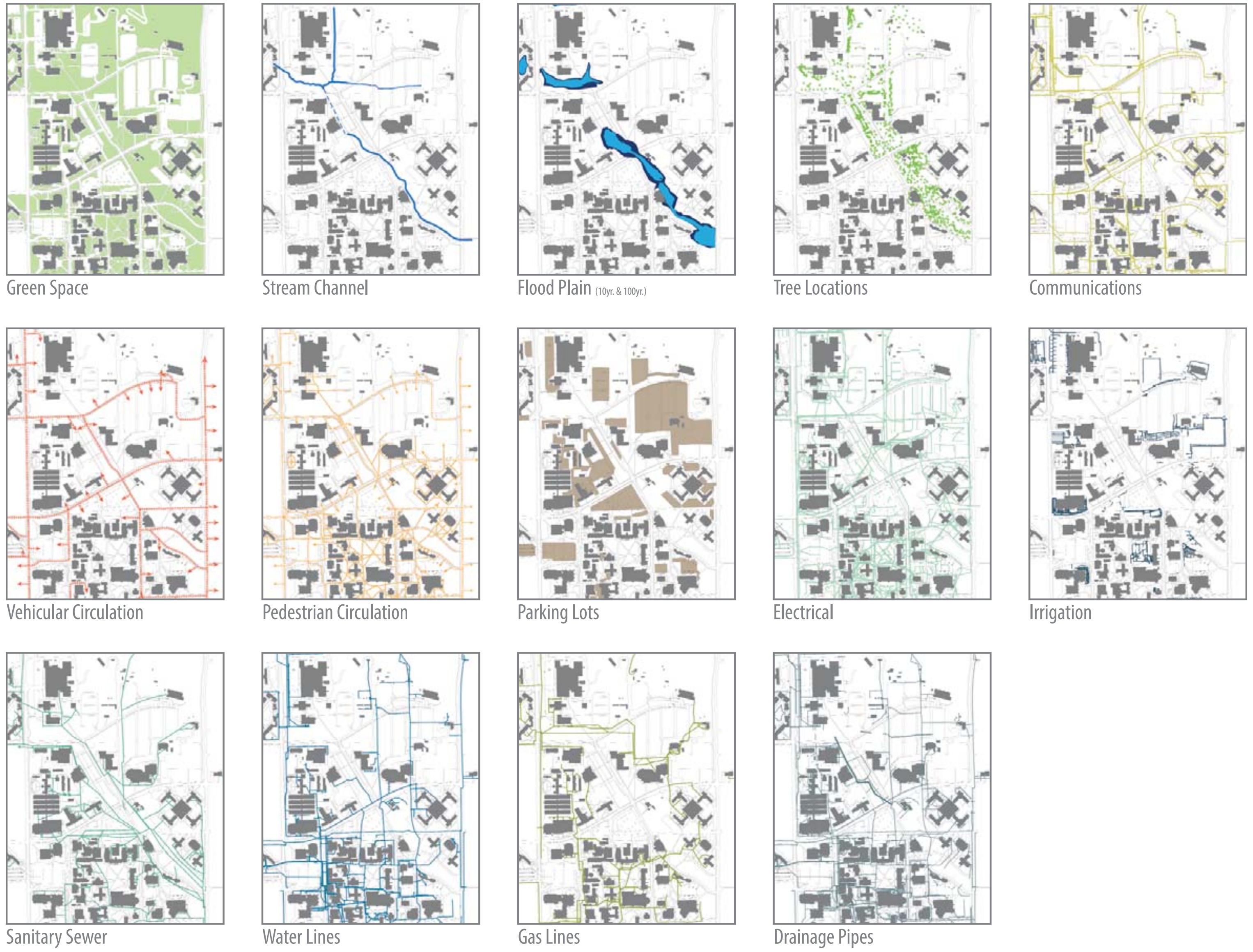

Campus Creek existing conditions 2014

Watershed & Campus Assessment

Currently the creek is not functioning at its full potential, both physically and socially – many improvements can be made regarding stream processes, aquatic and riparian habitat, and social interaction with the stream ecosystem.

Campus Creek, which flows through the heart of campus, has been affected by common urban hydrologic problems, including flashy flood flows, bank erosion, excessive deposition, and altered flow due to buried sections of the channel. The continued addition of buildings within the Campus Creek floodplain has added more stress to the stream in recent years. Furthermore, the Campus Creek Corridor does not present opportunities for human use. A lack of trails, seating, and other recreational and educational amenities leaves the open space area greatly underutilized.





Stream Restoration Approach

Goal: Design a stabilized stream and floodplain system that can safely transport and store water during a 100-yr. storm, as called for in the K-State Stormwater Master Plan.

- Modify the stream channel pattern and profile to more effectively transport flow and reduce erosion.
- Increase flood storage capacity to reduce peak flows and promote natural infiltration.
- Daylight the stream from Jardine Dr. to Claflin Rd. to create a continuous, unrestricted stream channel.

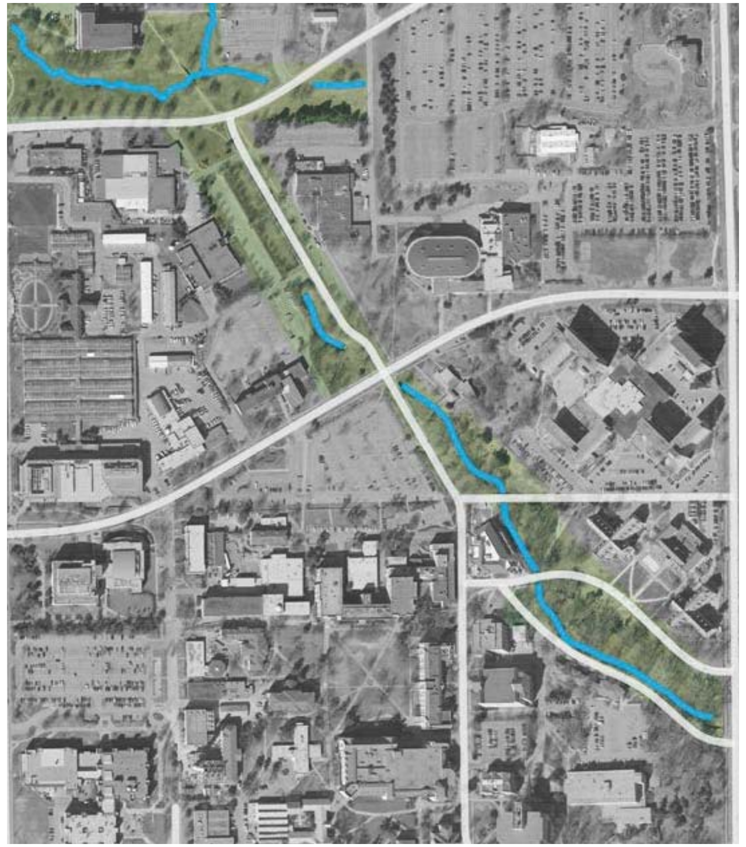
To design a stable Campus Creek, a watershed assessment was first completed. The assessment included measures of long-term suspended sediment, E. coli, temperature, and stream height recordings. Additionally, a longitudinal profile and several cross sectional surveys were completed. These surveys measured the height and distance of important features, including pools, riffles, and stormwater culvert depths and distances, throughout the entire channel. Finally, a hydrology and hydraulic analysis was completed using information from the K-State Stormwater Master Plan and additional information supplied by BG Consultants. This told us how much water was flowing through different reaches, or segments, of the creek from rainfall running off of surfaces and collected in the stormwater pipe network. In total, all of this information helped us quantify how the stream should be designed in accordance with published information on stable reference streams in the Flint Hills. It should be noted that the proposed stream restoration design is based on current watershed conditions. Any new developments on campus should incorporate stormwater infrastructure to prevent sending increased rainfall runoff to Campus Creek, causing the stream to become unstable again.

A reference reach represents ideal conditions for a certain stream type with similar drainage area, vegetation, climate, soils, and topography as a design reach. An inventory of the reference reach riparian conditions was conducted by comparing drainage basin area, utilizing a visual assessment of site photographs, and evaluating species composition data. Four tributaries with drainage basins of similar acreage to Campus Creek were chosen from within the Flint Hills hydrophysiographic province, within which Campus Creek is located. The Antelope Creek tributary, Burnt Creek tributary, Lime Creek tributary, and Little Bloody Creek tributary were selected from Flint Hills streams due to their similarities to Campus Creek. Reference Reach site photographs, observational notes, stream conditions, and a species composition gathered through a site inventory conducted by Dr. Tim Keane of Kansas State University was used for this riparian analysis.

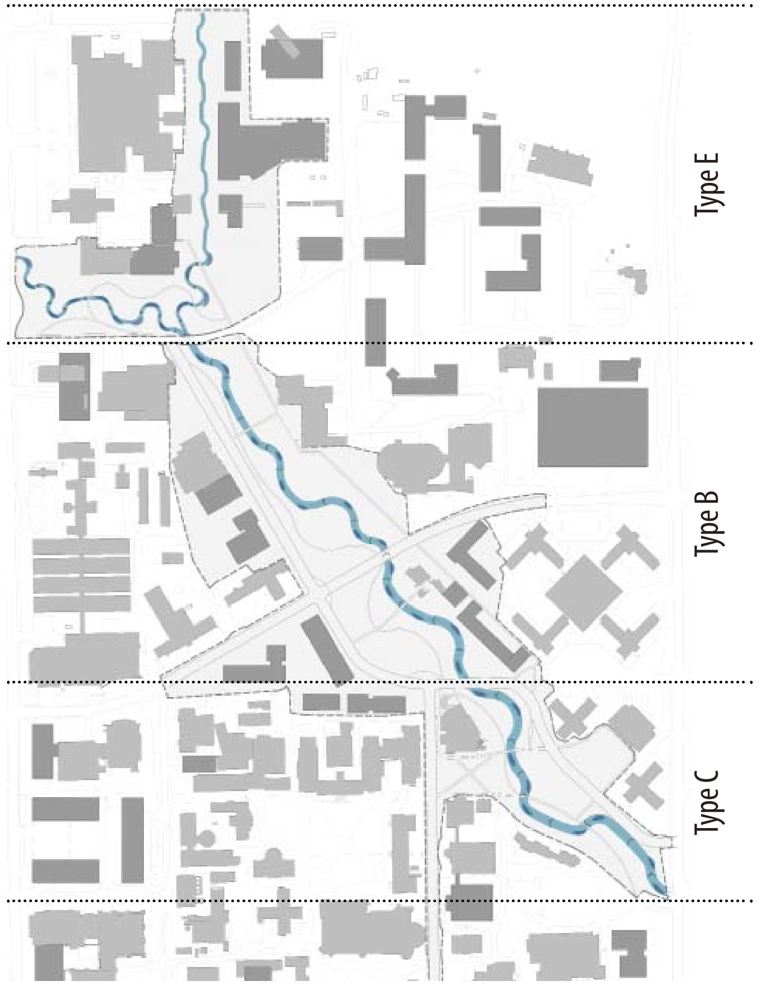
Stream Restoration Methodology

Streams are dynamic systems that continually adjust their channel dimension, pattern, and profile in response to changes that have occurred in the supporting watershed. Campus Creek watershed, which flows through the heart of the Kansas State University campus, has transformed over-time from a native prairie to agricultural fields to an urbanized campus. These changes have increased impermeable surfaces, thus increasing runoff flow into Campus Creek. Because of this, Campus Creek now receives a larger volume of water at a faster rate, causing stream channel instability and incision. Because of this erosional/downcutting process, Campus Creek has lost contact with its natural floodplain.

The floodplain is important in the storage of floodwater and for managing water quality. Without floodplain contact, the channel will continue to erode (as the erosive power of the stream is high) until it has widened itself enough that it can create a new floodplain at a lower elevation. This process of regaining stable dimension, pattern, and profile may take decades, if not longer, assuming that no other changes occur in the watershed. Leaving the channel alone to repair itself also risks damage or loss of civil infrastructure, such as roads, bridges, and building foundations.



Existing stream channel location



Stream Channel Design Concept

Channel Type 'E'

The portion of the restored channel design north of Jardine Drive is considered to be a Rosgen (1996) Stream Classification 'E' channel. An 'E' channel is a stream that is found in a low-gradient and broad valley. Because of the low gradient, this channel type dissipates energy by meandering extensively through the valley and by creating riffles and pools. The level of meandering is measured by sinuosity. Sinuosity is calculated by dividing the distance the fish swims, or channel length, by the distance the crow flies, or valley length. Sinuosity for typical 'E' channels is greater than 1.5, meaning that channel length is typically 1.5 times greater than valley length. Riffles are found at the cross-over reaches between two meander bends, while pools are found along the outside of the meander bends. There are very few depositional features, such as point bars, found in this kind of stream type. An 'E' channel type is typically slightly entrenched, meaning that during flooding events over bankfull stage, the water will be able to spread across the floodplain, dissipating energy, before reaching the valley walls. The bankfull stage is the elevation of the water surface of the stream before it is released onto the floodplain. It is also the stage at which the stream does most of its feature formation. An 'E' channel has a low width-to-depth ratio, where width and depth are measured at bankfull stage. This means that the width and depth of this channel type are very much alike. These channels are considered to be highly efficient in transporting water and sediment and also extremely stable, as banks are typically well-vegetated. Floodplain material usually consists of alluvium, or deposits of sediment left behind following flood events.

Channel Type 'B'

The 1,900 feet of daylighted and restored channel between Jardine Drive and Claflin Road is a Rosgen (1996) Stream Classification 'B' channel. The 'B' channel type is typically found in narrower and steeper valley types, as compared to the 'E' channel type, presented in the previous section. Because of this, these streams are dominated by riffles and dissipate energy by moving sediment within the channel and by meandering through the valley. Sinuosity is typically greater than 1.2, meaning that channel length is at least 1.2 times longer than the valley length. Pools are found in these stream types but are infrequent and randomly spaced. The 'B' channel type is considered to be moderately entrenched, meaning that if flood stage became greater than the bankfull stage, the water would be able to spill out onto a floodplain, but the width of the floodplain would be narrower, meaning that there is less space for water to spread out and dissipate energy, as compared to an 'E' channel type. The width-to-depth ratio is typically greater than 12. This means that width of the channel at bankfull stage is at least 12 times larger than depth at bankfull stage. Because of the greater valley slope, materials found within this stream type are generally of the colluvium origin, meaning that sediment was deposited by the erosion of hill slopes adjacent to the stream channel. This stream type is considered to be very stable.

Channel Type 'C'

A Rosgen (1996) Stream Classification 'C' channel was selected for the 1,400 feet of restored channel along Campus Creek between Claflin Road and North Manhattan Avenue. A 'C' channel type is similar to an 'E' channel type in that it is found in low gradient and broad valleys. Like a type 'E' channel, it dissipates its energy by meandering through the valley and creating riffles and pools. Sinuosity for type 'C' channels is generally greater than 1.2, or channel length is at least 1.2 times greater than valley length. Riffles are found in the cross-over reaches between two meander benders and pools are found along the outside edge of meander bends. During flooding events where flood stage is higher than bankfull stage, water is able to spread across a wide floodplain to dissipate energy, meaning that entrenchment is low. One major difference between Type 'C' channels and Type 'E' channels is that Type 'C' channels have depositional features, such as point bars, on the inside portion of meander bends. Another difference is that these channels have high width-to-depth ratios, where width at bankfull stage is at least 12 times larger than depth at bankfull stage. The soils found in these stream types are of the alluvial origin. Terraces are found with the floodplain. Terraces are abandoned floodplains that were created by degradation, or down-cutting, of the channel over geological time. Type 'C' channels are a stable channel form.

Planting Design Approach

Goal: Create a resilient landscape, informed by native ecosystem types found within the Flint Hills region, to improve habitat value, reduce maintenance inputs, and to create a regionally informed campus aesthetic.

- Restore native plant communities
- Eliminate invasive species
- Reduce maintenance inputs and costs

All existing tree and shrub species in the corridor were inventoried and analyzed in summer 2014 by landscape architecture students Adam Bangerter and Wes Haid. Findings helped to inform which specimens should be preserved (based on ecological and aesthetic value), and which should be removed (due to poor health or invasive qualities).

To coincide with the three restored channel types, three planting zones were developed. Each zone reflects a native ecosystem found within the Flint Hills ecoregion. The chosen ecosystem types correspond to restored stream channel conditions and also respond to campus' contextual constraints.

The northernmost zone is designated as the prairie zone, which will be dominated by a mixture of short grasses and drought-tolerant upland and bottomland grasses. The middle reach of the stream will be re-vegetated as a Flint Hills savanna-type landscape. This landscape will be characterized by a dominance of short and tall grass species, with a mixture of native shrubs and trees as well. Tees will be kept to a minimum in this zone, reflecting native ecosystem conditions. The southern most stream reach will be the woodland zone. The woodland will be populated with a dense, shade-tolerant understory composed of grasses, perennials, ground covers, shrubs and small trees. The canopy will consist primarily of medium- to large-sized riparian tree species that create a dense layer of shade.

When developing the specific species palette for each zone, numerous factors were taken into consideration. First, preference was given to species that are either native or naturalized, which is a typical model for a restoration project where the landscape is being transformed to near a pre-development state. Native and naturalized species can reintroduce and enhance natural ecological function to a site as well. The second factor included physical conditions. Species chosen needed to be well suited for existing soil conditions (soil pH, texture, and drainage properties); climatic factors (sunlight and exposure, exposure to wind, hardiness zones, and precipitation rates); and habitat value (providing food or shelter qualities;. Aesthetic value (form, character, and seasonal interest) and maintenance requirements (irrigation, mowing, pruning, ,etc.) were also taken into consideration.

Planting Design Concept

Amenity Design Approach

Goal: Enhance the overall usability and aesthetic qualities of the Campus Creek Corridor to create a safe, central campus amenity that expands recreation, education, and research opportunities.

- Enhance usability by adding a variety of seating areas that offer contemplation, socializing, studying, and space for classes.
- Increase safety by adding lighting and creating clear sight lines.
- Improve circulation by creating a continuous paved pathway from N. Manhattan through the corridor to Denision Ave. near the Vet Med Complex.
- Promote passive and active recreation opportunities through the addition of a gravel nature trail.

To gain insight about the campus community's perceptions of the current Campus Creek Corridor we conducted an online survey. Through a series of multiple choice and open ended questions, we assessed opinions on the corridor's usability and aesthetics. 315 students, faculty, and staff contributed their thoughts.

Time Spent Outdoors

35% Morning **64%** Afternoon **39%** Evening **15%** Night

Favorite Campus Activities

56% Socializing: being in the company of others.

63% Fitness: walking, running, biking and boarding.

66% Enjoying the Outdoors: relaxing in campus outdoor space.

Opinions of Campus Creek

70% of people surveyed believe that the campus creek is a **beautiful** amenity, while **66%** want to see improvements made to the stream and corridor **aesthetics.**

26% of people surveyed believe the stream is **healthy**, yet **64%** would like to see improvements made to the **environmental health** of the stream and corridor.

What's your favorite outdoor spot on campus?

We asked students to pinpoint their favorite outdoors spots on campus. Old Stadium, Bosco Plaza, the Quad, Anderson Lawn, and the Leadership Studies Building were the most popular sites.

Campus map marked with users favorite outdoor locations.

Proposed Seating Design Concept

03. Re-Envisioned Master Plan

Our design proposal deepens and expands conceptual recommendations proposed for Campus Creek in the Kansas State University 2012 Campus Master Plan Update. In doing so our design focuses on three main issues: increasing flood storage capacity; improving and enhancing the landscape; and, adding new amenities, including seating and trails. Drawing inspiration from the local Flint Hills ecoregion, the re-envisioned master plan proposes a highly designed and engineered multi-functional stormwater conveyance system that looks and functions more like a natural stream. The overall system is divided into three distinct zones: the woodland, the savanna, and the prairie; which collectively will be able to safely convey, and temporary store, flood waters from storms up to 100-yr. events. The re-designed corridor also provides the campus community with new open space areas to recreate, study, gather and enjoy the outdoors. For this multi-functional design proposal to truly be successful, future campus planning efforts need to respect the newly defined flood plain boundary and refrain from adding future structures within the floodplain.

Zone 3: The Prairie
A Living Laboratory
Wet-Meadow Walk

Zone 2: The Savanna
Mid-Campus Crossing
Creek Gallery
Daylighted Stream

Zone 01: The Woodland
The Clearing
The Overlook

Zone 03: The Prairie

Zone 02: The Savanna

Zone 01: The Woodland

Zone 1: The Woodland

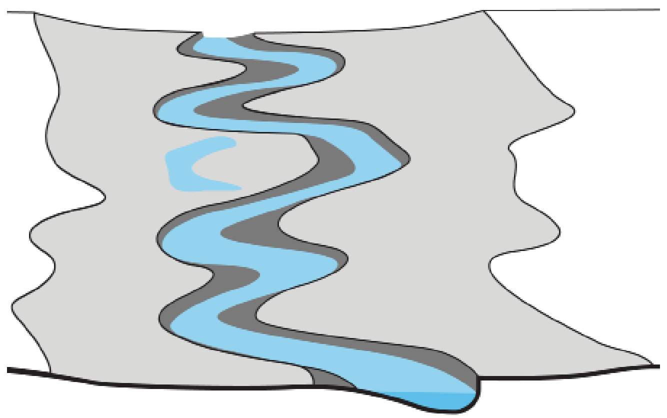
Often found along the edges of large bodies of water and lining stream corridors, woodlands are one of the few places in native Kansas landscapes where a consistent, moderately dense overhead canopy can be found. These ecosystems occur predominantly in riparian areas and offer habitat opportunities for numerous native wildlife species, ranging from macro-invertebrates to large mammals. Within an urbanized setting, woodlands offer a starkly contrasting aesthetic to the built environment. These areas can be utilized to offer spaces for repose and respite within the greater up-tempo urban setting.

Aerial perspective looking north towards Leadership Studies building

Woodland Stream Channel

RESTORED TYPE 'C'

For the length of restored channel between Claflin Road and North Manhattan Avenue, a 'C' type channel (Rosgen, 1996) was selected. This stream type was appropriate given valley gradient and width. 'C' stream channels are meandering, riffle-pool systems common to the Flint Hills on alluvial sediment and stabilized by woodland/gallery forest ecosystems. Gravels and sands are the bed materials providing additional habitat opportunities. Vegetation will consist of native and naturalized riparian trees and grasses, which will assist in bank stability.

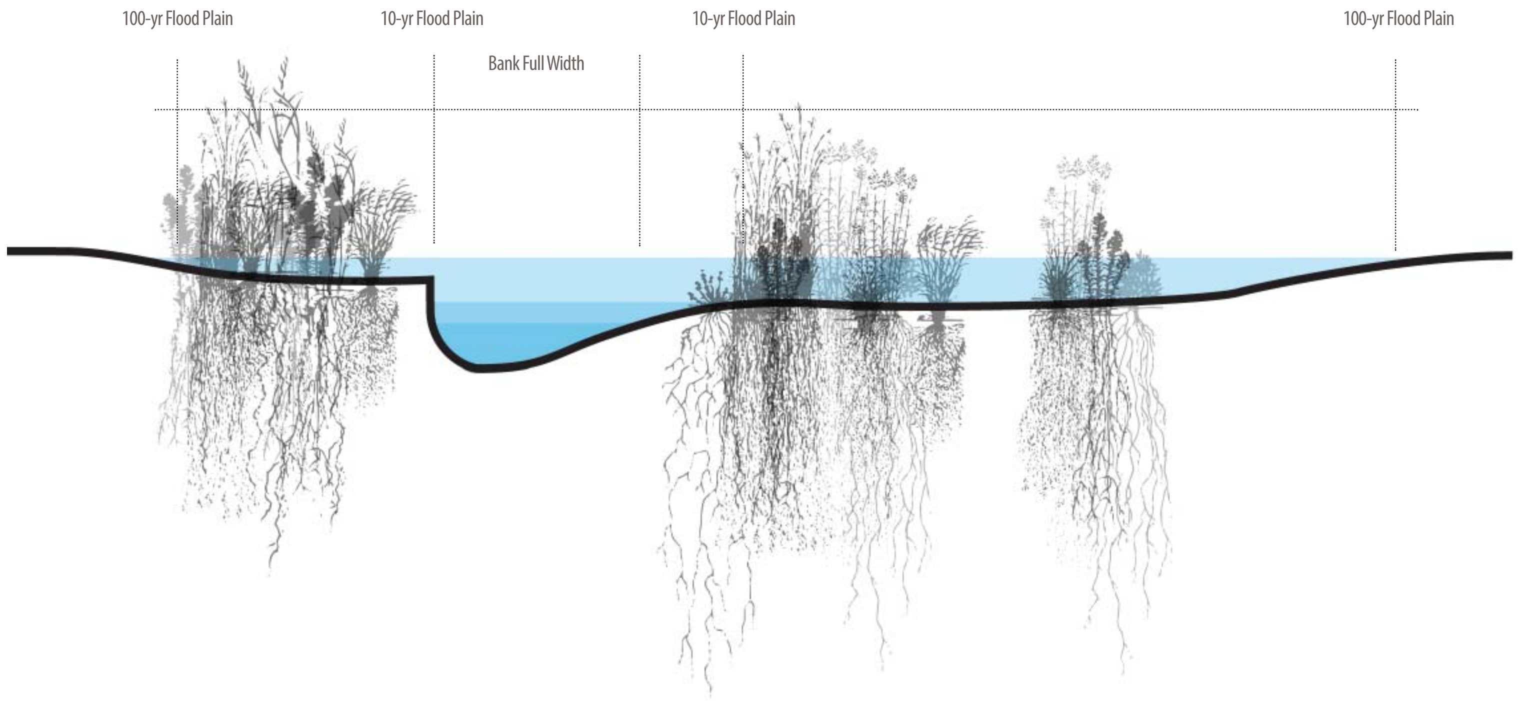


Diagrammatic Perspective

PARAMETERS

Entrenchment Ratio: >2.2 (slightly entrenched)
Width / Depth Ratio: >12 (moderate / high)
Sinuosity: >1.2 (moderately high sinuosity)
Slope: 0.1 - 2.0%

DIAGRAMMATIC CROSS-SECTION



Woodland Plant Palette

MAINTENANCE CONSIDERATIONS

Once established the woodland area should be monitored for proper growth and condition of the woody species and turf grasses or ground covers. Damaged plant should be treated or removed and replaced. As with all of the designed planted areas, invasive species should be monitored and controlled.

Eastern Cottonwood *Populus deltoides*
Eastern Sycamore *Platanus occidentalis*
Silver Maple *Acer saccharinum*
American Elm *Ulmus Americana*
Bur Oak *Quercus macrocarpa*
Common Baldcypress *Taxodium distichum*

Eastern Redbud *Cercis canadensis*
Dogwood var. *Cornus spp.*
Sandbar Willow *Salix exigua*
Common Ninebark *Physocarpus opulifolius*
Buttonbush *Cephalanthus occidentalis*
Liriope var. *Liriope spp.*

Spider Lily *Tradescantia tharpii*
Sedge var. *Carex spp.*
Golden Currant *Ribes aureum*
Great Blue Lobelia *Lobelia siphilitica*
Woodland Phlox *Phlox divaricata*
Common Boneset *Eupatorium perfoliatum*

English Ivy *Hedera helix*
White Avens *Geum canadense*
Jack-in-the-Pulpit *Arisaema triphyllum*
Lesser Periwinkle *Vinca minor*

The Clearing

The Clearing is a grand lawn bordered by tall oak trees and native eastern redbuds. It is envisioned as a "backyard" for students living in nearby dormitories and a place for recreational activities, such as frisbee, soccer, and movies on the lawn, to occur.

A new pedestrian promenade replaces the current vehicular road, as recommended by the Kansas State University 2012 Master Plan. The 30 foot-wide promenade has one lane designated for bicycle traffic and another for pedestrians. A vegetated stormwater swale separates cyclists and pedestrians and helps collect and cleanse stormwater runoff from adjacent paved areas.

The Clearing respects the legacy of the existing Quinlan Natural Area, but expands recreational and educational opportunities and improves comfort and safety by adding bench seating, lighting, and quiet alcove spaces under the trees for relaxing or studying. New trails with permeable paving allow stormwater to soak into the soil below, thereby reducing the amount of runoff that flows directly into the creek.

Seating Nooks
New benches and permeable paving trails help increase usability and activity within the Campus Creek Corridor. New lighting helps increase nighttime safety.

Looking south-west towards Campus Creek

The Overlook

Located south of the Leadership Studies building, The Overlook is a new lawn area bordered by rain garden planters. Stormwater runoff from surrounding surfaces will flow into the planters where it will filter through native vegetation and slowly seep into the soil, helping lessen the amount of runoff that flows directly into the creek. Not only will these planters showcase sustainable design practices to the campus community, their walls will provide comfortable seating that overlooks Campus Creek — a perfect spot for studying, eating or socializing.

To increase flood protection for the Leadership Studies, the stream channel was moved farther away from the building. The expanded floodplain area offers space for a new boardwalk trail next to the building, and enhanced views from the Leadership Studies' second floor balcony and outdoor amphitheater.

A new bridge located north of Leadership Studies will connect pathways, increase walkability, and offer passersby beautiful views up and down the Creek. The large trees will also provide students places to hang a hammock and relax in the shade.

Rain Garden Planters

These features are designed capture stormwater runoff and filter it through native vegetation. After storm events, passersby can watch the stormwater slowly soak into the soil below.

Looking south down Campus Creek, proposed building in background

Zone 2: The Savanna

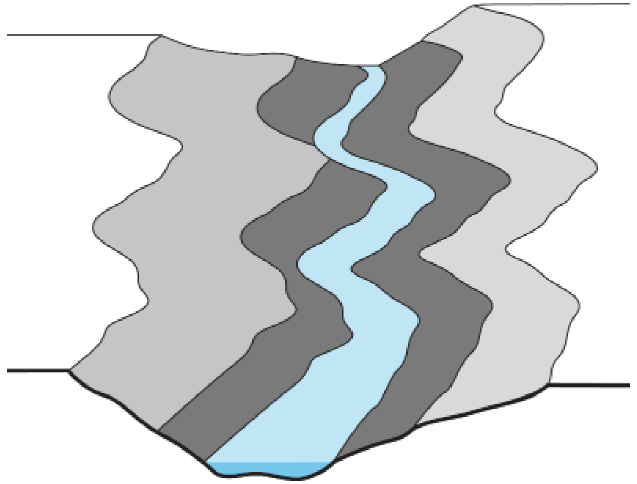
Grasslands populated with scattered trees and understory growth characterizes the savanna ecosystem. Savannas occur in bottomlands and into upland areas throughout the Flint Hills. These landscapes are the model for most urban parks and many college campuses. Utilizing savannas in urban areas creates an opportunity to increase stormwater infiltration rates, reduce pollutant runoff, and increase carbon sequestration. The plantings in savannas consist primarily of shade-tolerant grasses and forbs and native, riparian shrub and tree species.


Aerial view looking north towards Mid-Campus Crossing

Savanna Stream Channel

RESTORED TYPE 'B'

A 'B' type stream channel (Rosgen,1996), common in the upland reaches of the Flint Hills of Kansas, served as inspiration for the reach between Jardine Drive and Claflin Road. This stretch of stream is confined by roads and buildings, leaving very little room for meandering. A gravel and cobble stream bed will provide habitat for a diversity of macro-invertebrates and small fishes, as well as improving water quality and increasing oxygen content. Vegetation along this reach is a mixture of native and naturalized riparian trees and grasses, which will increase bank stability and slow water that flows into the creek.

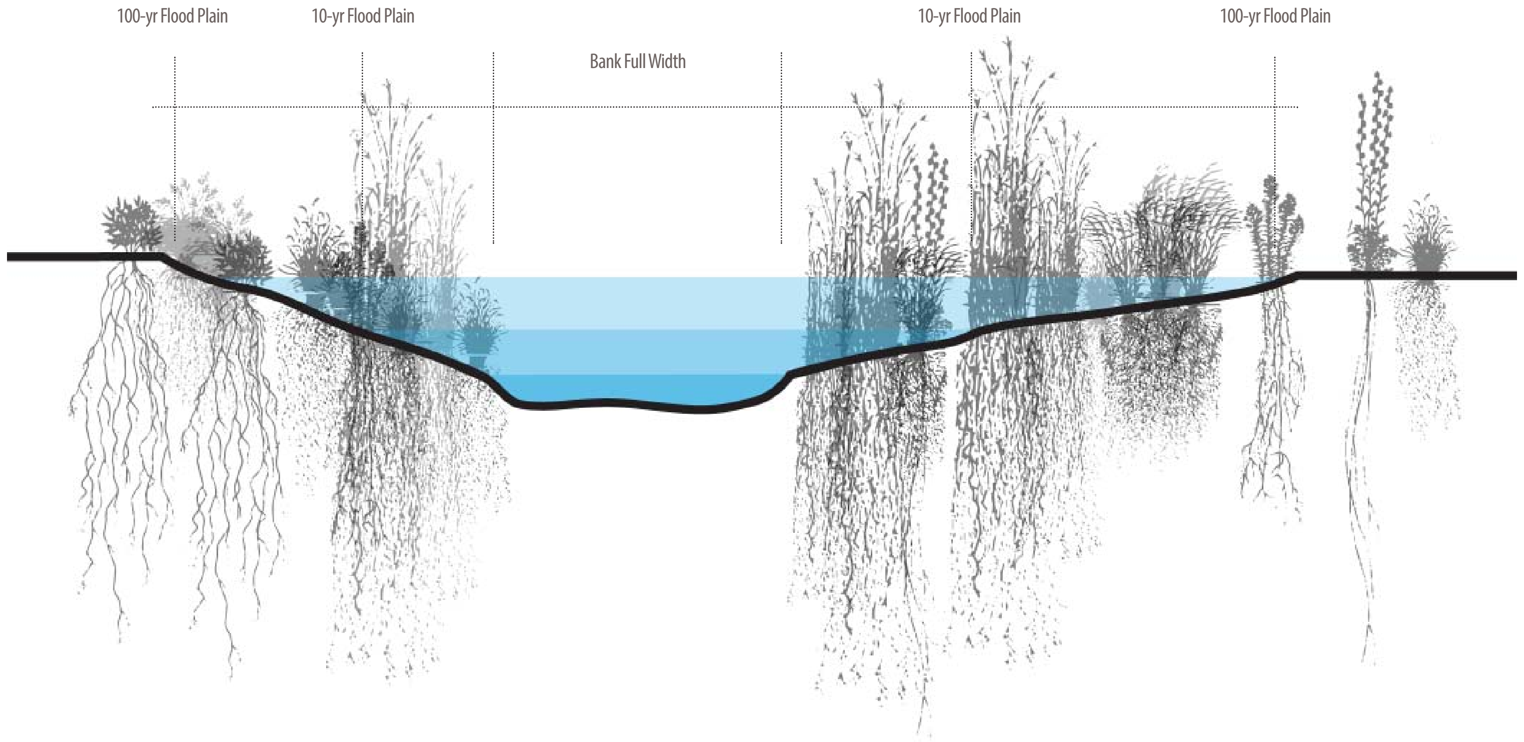


Diagrammatic Perspective

PARAMETERS

Entrenchment Ratio: >1.4 - 2.2 (moderate)
Width / Depth Ratio: >12 (moderately low)
Sinuosity: >1.2 (moderate sinuosity)
Slope: 2.0 - 3.9 %

DIAGRAMMATIC CROSS-SECTION



Savanna Plant Palette

Wester Yarrow *Achillea millefolium*
Milkweed var. *Asclepias spp.*
Blue False Indigo *Baptisia australis*
Purple Coneflower *Echinacea purpurea*
Blue Flag Iris *Iris versicolor*
Roundhead Lespedeza *Lespedeza capitata*

Goldenrod var. *Solidago spp.*
Big Bluestem *Andropogon gerardi*
Grama var. *Bouteloua spp.*
Virginia Wildrye *Elymus virginiaus*
Prarie Junegrass *Koeleria cristata*
Indiangrass *Sorghastrum nutans*

Green Hawthorn *Cratagus viridis*
Common Ninebark *Physocarpus opulifolius*
Chokecherry *Prunus Americana*
Prickly ash. *Xanthoxylum americanum*
American Elderberry *Sambucus Canadensis*
Gayfeather var. *Liatris spp.*

Eastern Redbud *Cercis Canadensis*
Hop Hornbeam *Ostrva virginiana*
Bur Oak *Quercus macrocarpa*
Red Oak *Quercus rubra*
American Linden *Tilia Americana*

MAINTENANCE CONSIDERATIONS

Once established the savanna can be maintained through mowing, and where possible selective burning should occur approximately ever five years. Invasive species should be monitored and controlled.

The Daylighted Stream

The redesigned stream corridor daylights a stretch of Campus Creek that currently flows in pipes buried underground. In keeping with ideas presented in the Kansas State University 2012 Master Plan, the stream will be exhumed and restored to a stable surface flowing waterway between Call Hall and Dole Hall. Seating will be added adjacent to the pedestrian promenade, offering a spot for gathering or resting. The nature trail extends down to the stream bank, providing an opportunity to directly engage with the water. Large limestone "stepping stones" act as a bridge across the stream at low flow.

To increase flood storage capacity, a wet-meadow will be implemented near Weber Hall. This feature, planted with species native to the Flint Hills ecoregion, helps detain stormwater runoff and allows water to infiltrate and recharge soil. Reducing the amount of runoff flowing directly into the stream helps lessen impacts of flooding, including stream bank erosion.

Stepping Stone Crossing
Large stepping stones placed within the creek bed allow pedestrians to cross the stream at low flow.

Looking North-East across the daylighted stream, proposed building in background

Mid-Campus Crossing

An enhanced pedestrian and cycling system allows easier movement through the heart of campus. Located along the northwestern edge of the creek basin, the pedestrian promenade accommodates high volumes of people. For more leisurely strolls, a smaller nature trail winds through the restored prairie landscape within the creek basin. Three new pedestrian bridges span the stream and nature trail.

After a heavy spring or summer storm, the creek basin will temporarily fill to hold flood waters. All features within the basin are designed to withstand floods, and once the waters recede will again be usable. Plants used throughout the re-designed corridor are species found within the local Flint Hills ecoregion and were selected for their hardiness to our local climate, habitat value, resilience to occasional floods and drought, and for seasonal color.

Bridges
The new limestone bridges have been designed to accommodate flood waters during large storm events, and, when at low flow, allow the stream and nature trail to pass underneath side-by-side.

Looking South with Leadership Studies at right, proposed building in background

The Creek Gallery

The Campus Creek Corridor provides a complementary backdrop for several important features along the main pedestrian promenade. A small plaza overlooking the creek offers a centrally-located gathering and meeting place. Large canopy trees create shade and areas for studying or eating. Amphitheater-type terraces cascade down to the nature trail, providing seating areas and teaching spaces with beautiful views of the creek beyond.

To help safeguard future buildings and walkways from seasonal flooding, the creek corridor has been widened by nearly 200 feet. This will create a larger floodplain area, which can double as usable open-space 95% of the year; when not inundated with flood waters.

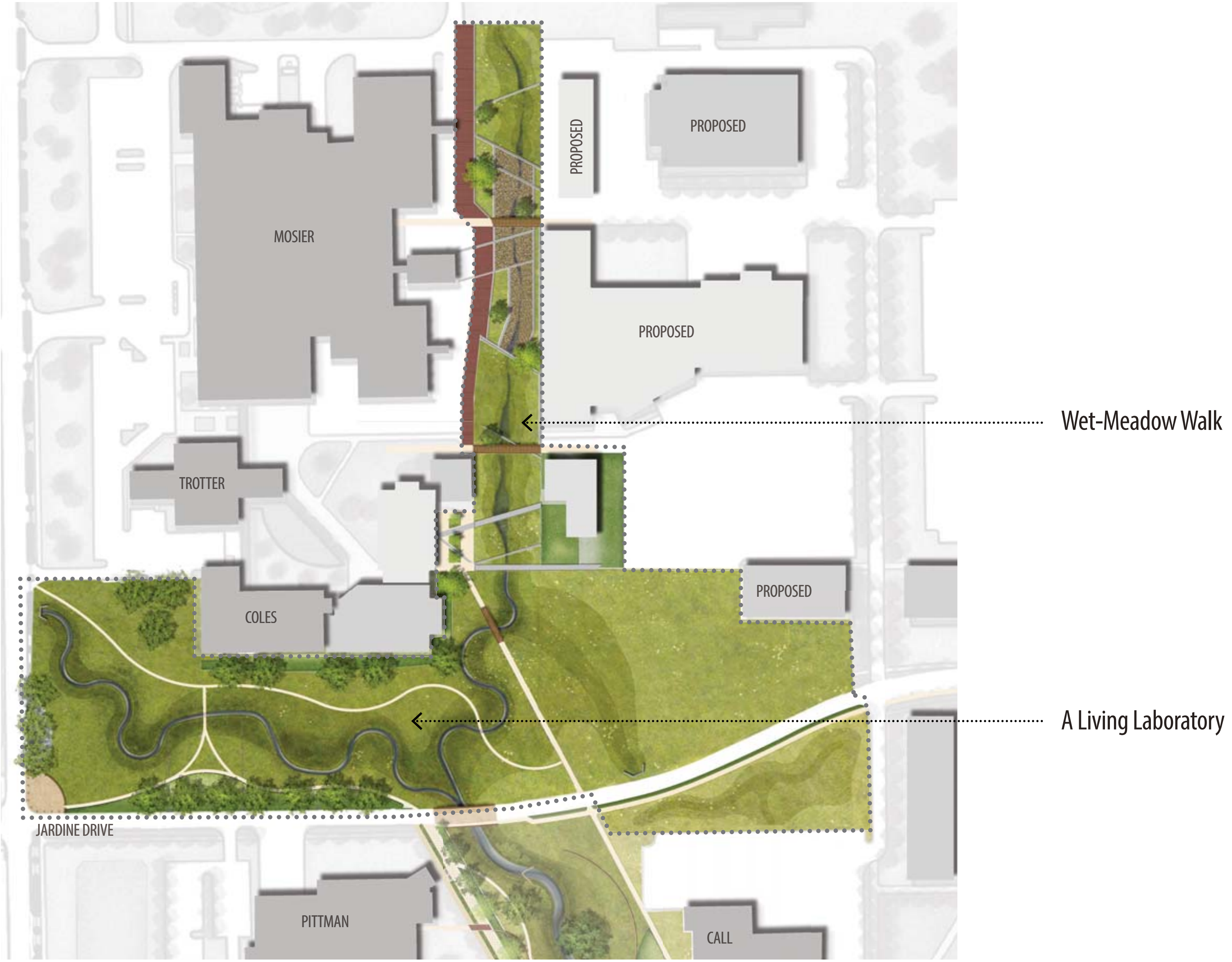
In order to accommodate the wider floodplain, several of the proposed buildings in the Kansas State University 2012 Master Plan will need to be relocated farther away from the creek and outside the new floodplain boundary. Not only will this lessen susceptibility to floods, but it will improve the urban design.

Mid-Campus Plaza
The plaza utilizes permeable paving and structural cells, which allow stomwater to infiltrate directly through the surface and into soil below.

Looking north with new pedestrian promenade at left, stream at right

Zone 3: The Prairie

Perhaps the most iconic of any Kansas ecosystem is the prairie. Characterized by a mixture of drought-tolerant tallgrasses and forbs, prairie ecosystems are found in areas with wide fluctuations of moisture, high winds, and wildfires. The plants and animals that inhabit the native prairie are highly adapted to this increasingly rare environment. The Northern portion of the Campus Creek Corridor will be restored to a prairie environment in order to improve hydrology and to pay homage to the native landscape.

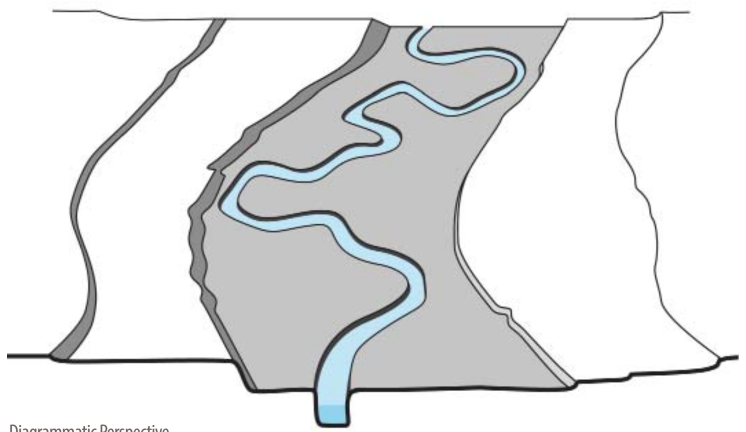


Aerial perspective looking north towards Vet Med Complex

Prairie Stream Channel

RESTORED TYPE 'E'

An 'E' type stream channel (Rosgen, 1996) was selected for the portion of Campus Creek north of Jardine Drive. Given the area's broad, flat expanse, the channel design is modeled after a stream form that likely existed in this area prior to European settlement: a sinuous, narrow channel flowing through native tall grasses whose extensive root systems provide bank stability.

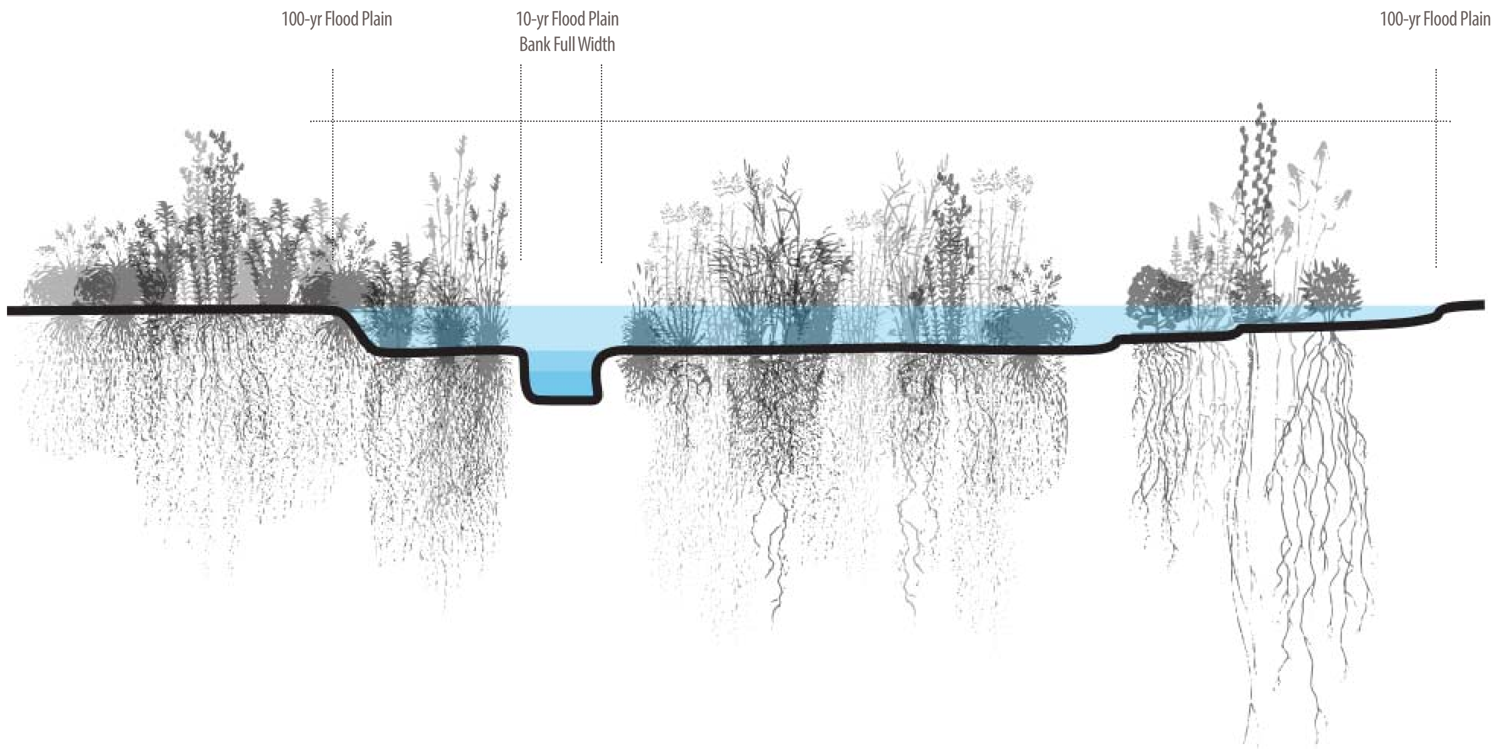


Diagrammatic Perspective

PARAMETERS

Entrenchment Ratio: >2.2 (slightly entrenched)
Width / Depth Ratio: <12 (very low)
Sinuosity: >1.5 (very high)
Slope: 2.0%

DIAGRAMMATIC CROSS-SECTION



Prairie Plant Palette

Wester Yarrow *Achillea millefolium*
Milkweed var. *Asclepias spp.*
Aster var. *Aster spp.*
Blue False Indigo *Baptisia australis*
Prairie Larkspur *Delphinium virescens*
Wild Hyacinth *Camassia scilloides*

Purple Coneflower *Echinacea purpurea*
Roundhead Lespedeza *Lespedeza capitata*
Button Gayfeather *Liatris aspera*
Goldenrod var. *Solidago spp.*
Heather Aster *Symphyotrichum ericoides*
Indiangrass *Sorghastrum nutans*

Prairie Cordgrass *Spartina pectinata*
Little Bluestem *Schizachyrium scoparium*
Big Bluestem *Andropogon gerardi*
Grama var. *Bouteloua spp.*
Prarie Junegrass *Koeleria cristata*

MAINTENANCE CONSIDERATIONS

Once established, the restored prairie areas should be burned every 3-4 years. If burning is not possible, annual mowing should be employed. Invasive species should be closely monitored and controlled.

Wet-Meadow Walk

To accommodate facility expansion around the Veterinary Medical Complex, the Kansas State University 2012 Master Plan proposes burying Campus Creek's northern tributary. However, if designed and engineered in accord with natural systems, this stretch of the stream can become a wonderful stormwater asset, rather than a liability. To increase flood storage capacity and help slow velocity, this area will have a "chain" of wet-meadow infiltration gardens, interconnected by check-dams/weirs. The wet-meadows act as green sponges, capturing and soaking-up stormwater. In large storm events the wet-meadow basins will fill and excess runoff will overtop the check-dams and be slowed before flowing downstream.

A series of boardwalks will span across the wet-meadow basins—uniting existing and future buildings. As students walk from building to building, they will pass infiltration gardens planted with native species from the Flint Hills ecoregion. This stretch of Campus Creek provides excellent opportunities for on-site research, where water quality and infiltration can be continually monitored.

Infiltration Gardens
Planted with native species from the Flint Hills ecoregion, the infiltration gardens are designed to increase groundwater recharge and improve water quality by filtering out excess sediment, bacteria and nutrients.

Looking North between Vet Med. Complex and proposed expansion at right.

A Living Laboratory

The open space immediately south of the Veterinary Medical Complex will provide significant flood storage capacity; lessening downstream flood impacts for the rest of campus. During large storms the basin will fill—holding floodwaters for 100+yr. storm events. As the water level changes passersby may observe natural hydrological processes. To increase infiltration capacity, along with biodiversity and habitat quality, the landscape in this area will be restored with native prairie species, which are tolerant of seasonal flooding and provide visual interest year-round. Removing the existing irrigated lawn will also lessen irrigation and maintenance requirements.

At the intersection of Jardine Drive and Denison Avenue, a gateway plaza frames views of the stream corridor. The plaza mimics the entrance to the Jardine Apartment complex across the street. Passersby can experience this restored prairie landscape as they walk to the Jardine Apartment complex, the Peter's Recreational Complex, or the Synder football s tadium. The new nature trail, made of crushed limestone, follows the meandering path of the stream channel and emulates a Flint Hills hiking experience. Large limestone "stepping stones" act as a bridge across the stream at low flow.

Creek Access
Large stepping stone boulders set within the creek bed allow pedestrians to engage with the stream edge and to cross at low flow.

Looking East towards Jardine, Coles Hall at right

04. Design Benefits

A Re-envisioned Campus Creek Corridor will create many environmental, social, and economic benefits, which will add value to campus and its users. Perhaps most significantly will be the reduction of flood impacts to surrounding buildings and roadways, due to an increase in flood storage capacity. New trails within the corridor will offer pedestrians and cyclists much needed access, traversing uninterrupted from the SE corner of campus to the NE corner. By drawing on local ecosystem types, the regionally inspired plant palette will require less maintenance and be more resilient to periods of flood and drought. Ultimately this multi-functional

Hydrology

Increases Natural Storage Capacity

• Expands natural storage capacity of the Campus Creek stream channel from 932,865 cu. ft. to 1,665,603 cu. ft. to accommodate the 100-year flood.

• Provides flood protection by containing the 100-year flood (926.9 cfs) within the corridor.

• Increases floodplain areas by relocating the channel away from current and proposed buildings.

• Enhances natural stream function and flood storage areas by daylighting 960 feet of the stream and returning it to a surface flowing waterway.

Reduces Erosion

• Anticipates 60% less sediment erosion of Campus Creek stream banks at 170 tons/yr. as compared to the current estimated volume of 585 tons/yr.

Landscape

Reduces Maintenance and Costs

• Reduces overall irrigation requirements and costs by removing non-native lawn and adding native prairie species. Within the first three years of plant establishment, the proposed design will save $17,915 per year in irrigation costs. After three years, the proposed design will save $20,537 per year in irrigation costs.

• Reduces mowing requirements from 64 to 12 a year. 23 of the 30 corridor basin acres will require 51 less mowings each year.

• Reduces fertilizer requirements by 100%. Three tons of fertilizer is currently applied to campus per year, while the future fertilizer needs are expected to be reduced by 600 lbs. per year.

Habitat

Removes Invasive Species

• Eliminates all invasive species within the Campus Creek Corridor and utilizes species found within the local Flint Hills ecoregion.

• Enhances existing tree canopy with native species and establishes a new shrub understory. Trees intercept stormwater, lessen cooling costs to adjacent buildings, sequester carbon, provide habitat, and help control erosion.

Restores Native Plant Communities

• Establishes native plant communities on 23 of the 30 total corridor basin acres. Native species attract a variety of wildlife and are more hardy to periods of drought and seasonal flooding.

• Increases pollinator species. The planting plan proposes over 50% pollinator species. These species attract bees, birds, butterflies and insects, which provide essential pollinator services and help to create a balanced ecosystem.

Open Space

Increases and Enhances Open Space

• Increases usable open space within the Campus Creek Corridor by 13 acres to 30 acres, by removing internal roadways and parking lots, as per the 2012 K-State Master Plan. This will increase the floodplain area.

• Reduces impacts of flooding/protects existing and future buildings and infrastructure by relocating proposed buildings and major circulation routes outside of the corridor basins, thus creating more space for flood inundation.

• Alters existing topography within the basin to allow for a more sinuous and stable stream channel pattern and profile. The redesigned channel takes design lessons from reference streams within the region.

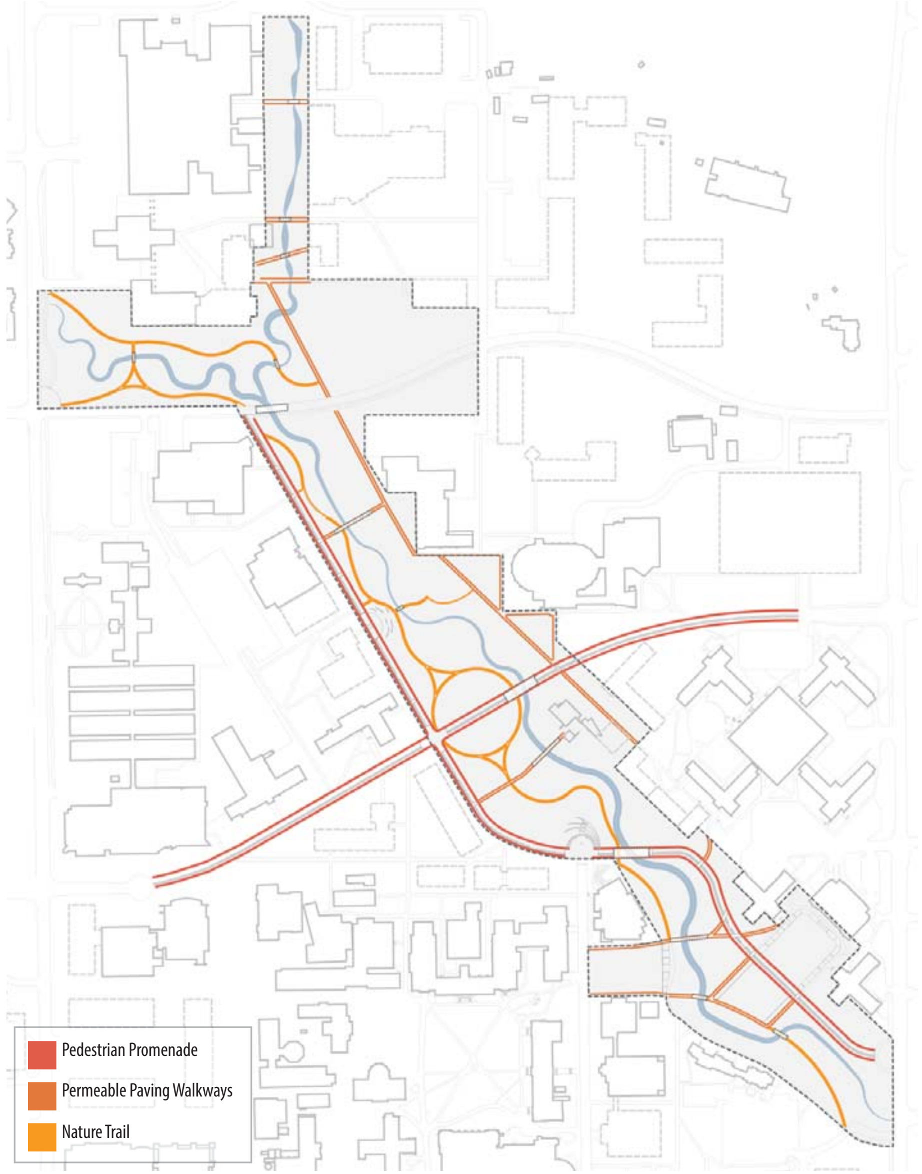
Circulation

Improves and Expands Circulation

• Adds nearly one mile of new walking trails within the basin and provides a direct circulation route, connecting the south-east end of campus to the north-west end.

• Retrofits existing roadways into pedestrian promenades, as per the 2012 K-State Master Plan, creating a circulation spine for pedestrians and cyclists through
the heart of campus. Vegetated bio-swales will be added to the center lane of the promenades to create a buffer between cyclists and pedestrians.

• Provides continuous, uninterrupted circulation within the corridor basin by implementing two new pedestrian promenade bridges, which allow the stream and nature trail to pass underneath.



Amenities

Increases Recreation Opportunities

• Provides opportunities for small events, gatherings, and social interaction in four new plaza areas and designated seating nooks.

• Adds two acres of recreational lawn space for activities such as frisbee.

• Increases seating opportunities by adding 790 linear feet of seating surfaces within the corridor, including benches and seating walls. The new design triples the current amount of seating found across campus.

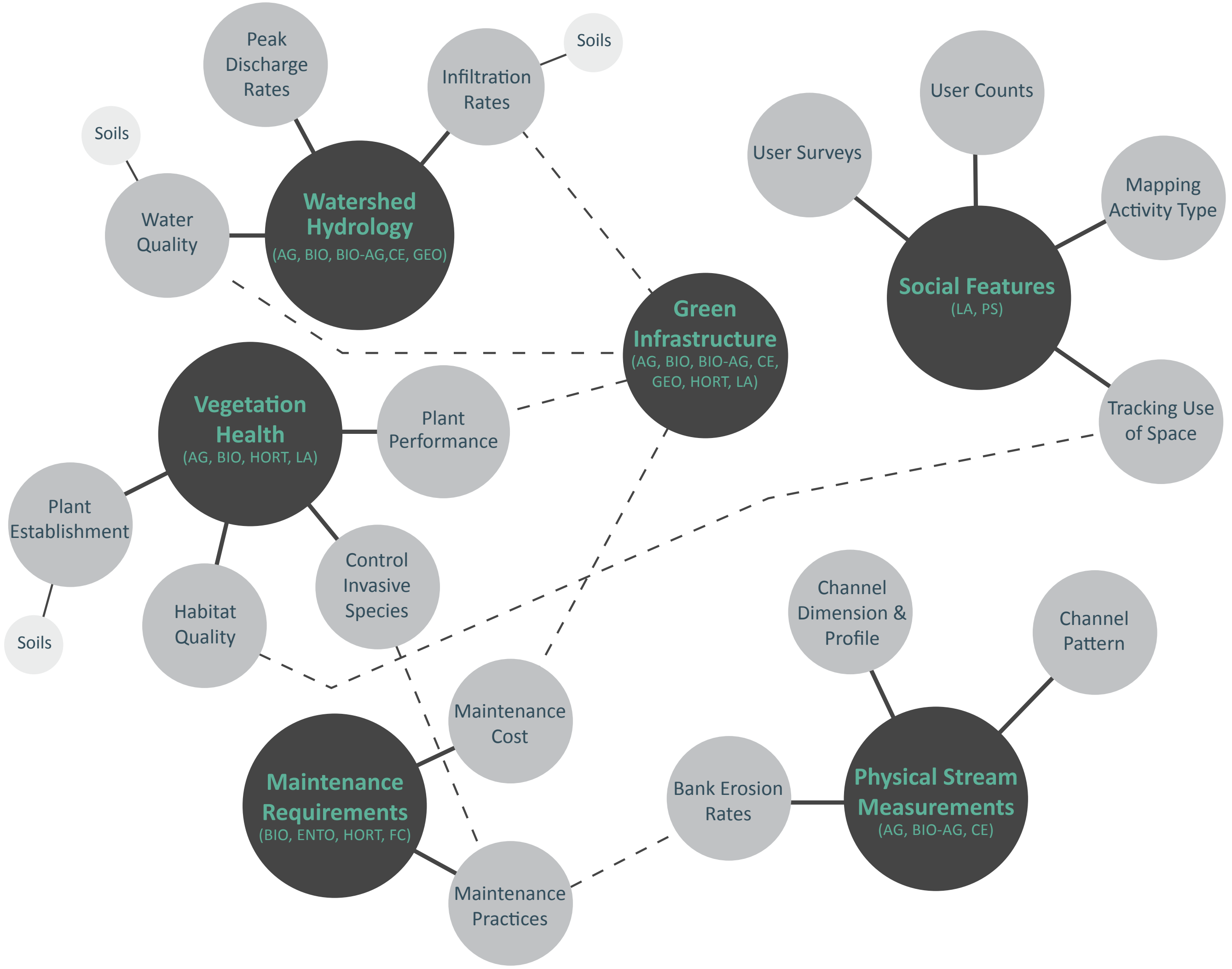
•Improves safety and increases potential nighttime usability by adding lights along the basin perimeter.

Expands Research & Education Potentials

• Creates new interdisciplinary research and learning opportunities to study the restoration and establishment of natural systems, and to monitor green infrastructure applications, including: raingardens, vegetated bio-swales, structural soil cells, and permeable paving.

05. Monitoring

Monitoring of the Campus Creek corridor should begin immediately following construction. The frequency of measurements will depend on the components being monitored. This plan will guide evaluation, as well as document changes in stream dimensions, pattern, profile, water quality, and vegetation health in response to original restoration activities. There will be many opportunities for university departments of Kansas State to get involved in the creek corridor monitoring. This monitoring can further individual research along with general student engagement through classes related to the systems of Campus Creek. This interaction provides students with a living laboratory for them to expand their knowledge regarding urban stream corridor restoration.



Water Quality

Water Quality

Water quality can impact aquatic life, riparian habitat, as well as the health and well-being of ecosystems within the creek corridor. To best monitor the quality of water; the biological, chemical, and physical properties should be assessed. Samples should be taken from the creek monthly or bi-monthly to assess pH levels, water temperatures and dissolved oxygen level. Chemical properties that influence aquatic species are pH, nitrogen, and phosphorus levels. Physical properties can be monitored by assessing the water body's total suspended solids (TSS). The EPA Water: Monitoring & Assessment guide, noted below, can provide further monitoring methods.

EPA Water: Monitoring &Assessment: http://water.epa.gov/type/rsl/monitoring/vms50.cfm.

Peak Discharge Rates

High flows can shape the physical habitat of the stream, so the peak stage which occurs during floods with maximum flow rates in cubic feet per second, is essential to monitor for flood planning and frequency (ex. 2-year, 5-year, and 100-year storm events), floodplain management and protection of nearby structures. The flood plain is land adjacent from the stream and is prone to flooding during high flow storm events, so it's important to keep a healthy functioning floodplain to remove excess sediment, increase groundwater recharge, and prevent flooding to nearby properties. Peak discharge can be monitored by direct observation during high flow events and also by a specialized crest gage. This gage should be placed in a fixed position and in relation to a reference so it can be monitored over time.

Infiltration Rates

Healthy, non-compacted soils are important in reducing erosion and flooding by allowing higher infiltration rates. The soil's structure and texture is key to successful infiltration, so physical soil properties should be monitored over time. Samples can be taken annually to monitor the soil properties and infiltration rates can be measured in the field using infiltrometer rings to see if infiltration rates are being maintained or improving.

Students in the departments of Agronomy, Biology, Biology-Agriculture Engineering, Civil Engineering, and Geology might have interest in measuring these components of the watershed hydrology.

A Field Method for Measurement of Infiltration: http://pubs.usgs.gov/wsp/1544f/report.pdf

Green Infrastructure

If managed and monitored properly green infrastructure can slow water flow and help increase onsite retention and infiltration. The Best Management Practices (BMPs) that should be monitored along Campus Creek are bioswales, raingardens, porous paving, and wetland areas. These infrastructures can reduce maintenance costs, reduce flooding and erosion, create habitats, and increase water quality. A stormwater calculator can be used to measure the annual volume and/or percent of total runoff retained onsite. Below is the link to EPA's National Stormwater Calculator which is a helpful tool to estimate the entire site's runoff based on the total managed area. Also noted below is the link to The Value of Green Infrastructure Guide which provides equations to estimate the runoff volume captured in bioretention and infiltration practices as well as an equation to measure how much runoff can be saved by implementing permeable pavement.

Soils are also a critical component to successful BMPs, if soils are healthy it creates healthy vegetation which contributes to the water-retention capacity and infiltration. These infiltration rates can be monitored in the field using the infiltrometer ring method. To monitor their performances, these BMPs could be measured annually or following high flow events. Departments that might have interest in monitoring green infrastructure are Agronomy, Biology, Biology-Agriculture Engineering, Civil Engineers, Geology, Horticulture, and Landscape Architecture.

EPA National Stormwater Calculator: http://www.epa.gov/nrmrl/wswrd/wq/models/swc

The Value of Green Infrastructure Guide: http://www.cnt.org/repository/gi-values-guide.pdf

Stream Stability

Bank Erosion Rates

By monitoring bank erosion rates, changes in bank geometry can be tracked over time. Two bank erodibility estimation methods that can be used are the Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) that were designed by Dave Rosgen (1996). When using these methods, the bank characteristics and flow distribution will be evaluated to calculate a numerical reach score to rank/predict streambank erosion potential. Another method to monitor bank erosion is to use bank pins which are smooth steel rods four feet long and driven horizontally and flush into the bank to see how much exposure occurs over time (Rosgen, 2006). Erosion rates should be monitored annually and/or following a high flow event.

Channel Dimensions and Profile

Monitoring the channel dimensions tracks the change in a channel's cross-section, which is the shape of the channel at a specific point along the stream. It is common for a stream's geometry and characteristics to change slowly over time, so it's important to monitor these at key points along the stream. In order to monitor change in geometry and characteristics, newly established cross section points should be placed along the stream and surveyed annually after the channel restoration is completed. The cross sections can be placed at various locations along the creek but should be clearly marked and mounted so they can be found each time the creek is surveyed.

The channel's longitudinal profile is the slope and undulation of the streambed along its deepest part and also notes water surface slope. The stream's slope and longitudinal characteristics should be monitored every five years.

Channel Pattern

Streams are rarely straight and tend to follow a meandering course. When looking at a stream from an aerial view, one can analyze the entire channel pattern to observe any changes that might occur in the meander bends over time. The meander pattern can also be monitored through cross section surveys. The pattern shouldn't change drastically but should be monitored every 5-10 years or at signs of erosion. It's important to refer back to the new design of the Campus Creek pattern when monitoring to ensure the channel does not stray from the new designed pattern.

Departments that might have interest in monitoring the physical stream parameter include: Agronomy, Biology, Biological and Agriculture Engineering, Civil Engineering, Geology, and Geography.

Rosgen, D. L. (1996). Applied river morphology. Pagosa Springs, Colo: Wildland Hydrology.

Rosgen, D. L. (2006). Watershed assessment of river stability and sediment supply (WARSSS). Fort Collins, Colo: Wildland Hydrology.

Vegetation Health

Plant Establishment

Plant establishment is critical within the first year or two after construction is complete. One way to monitor the success of plant establishment is direct observation and photographic documentation. Sampling should occur annually during the growing season which is typically from May-October depending on location. Creating vegetation transects and surveying can also be an effective way to monitor plant establishment. These transects should consist of lines stretching through vegetation areas. Such methods with help analyze total coverage of established plants. The link below provides a more detailed list of operating procedures and equipment needed to perform vegetation surveys.

Control of Invasive Species

Eliminating invasive species when they first appear is critical. Monitoring these species will take direct field observations and the knowledge of targeted species and what they look like. Many invasive species populate and distribute quickly so it's important to observe the status and trends of targeted species so they can be eliminated. Measuring the status and trends can be done by gathering inventory from vegetation plots within the Campus Creek corridor. Control treatments for invasive species consist of mowing, herbicides, and burning which helps eliminate large amounts of targeted invasive species at a time. This monitoring should occur annually in order to eliminate unwanted species.

Plant Performance
With the correct plant selection there can be a reduction in water consumption. To monitor the plant performance in conserving water, irrigation usage can be assessed annually to see if native or adapted species are reducing the need for irrigation. Plant performance also contributes to overall biodiversity of the ecosystem along the creek. Creating vegetation transects is a common method to monitor change in plant species and abundance. Transects can be sampled in three ways; line intercepts, quadrants, and points. The below link provides a detailed list of equipment needed and the operating procedures. All three types of transect sampling are useful ways to estimate cover and density. Site visits to take photographs over time is also a method to visually asses the overall plant abundance and performance. Monitoring plant performance can take place once every five years during the growing season which is from May-October.

Habitat Quality
Habitats are areas, both natural or manmade containing the necessary resources and conditions to maximize survival of desired plants and wildlife. Through the design process, quality habitats can be utilized to support greater biodiversity within a functioning and stable ecosystem. The quality of a habitat can be measured through many variables according to desired wildlife species and vegetation dynamics. Using the Plant Stewardship Index (2014), it is possible to monitor the implementation and continued growth of plant communities and habitat units by assigning coefficients of conservatism (or value for conservation specific to the Campus Creek site). A link is given below that provides more information to the Plant Stewardship Index. To determine habitat quality, quadrat plots which are defined areas set up typically in a square frame and can be sampled randomly or along assigned transects. Values collected may include but are not limited to the percent of ground covered by vegetation, the number of species present, percent native species, and the overall prevalence of species within a habitat. Along sampling transects, fluctuations in variables may reflect changes in quality across the site and over time. Collecting habitat monitoring information over time will allow students the opportunity to conduct scientific observations while compiling valuable data on habitat response to conditions within and urban watershed. This type of monitoring should occur at least once every five years, dependent upon desired evaluation intensity and habitat aesthetics.

Students that might have interest in monitoring vegetation health include those in: Agronomy, Biology, Horticulture, Entomology, and Landscape Architecture departments.

Plant Stewardship Index: http://bhwp.org/plant-stewardship-indew.htm

Vegetation Transects and Survey Plot Standard Operating Procedures:
http://www.tidalmarshmonitoring.org/pdf/USGS-WERC-Vegetation-Transects-and-Survey-Plot-SOP.pdf

Use & Activity

Social Performance
With Campus Creek running through the heart of campus, the creek should attract people to use the spaces throughout. To monitor social features, techniques that can be used are user surveys, user counts, observation of activity types, and tracing pedestrian movement through the spaces within and along edges of the creek corridor. Monitoring social features within the creek corridor can determine how people are using the spaces and if the designed areas are serving their purposes. Monitoring groups can use these techniques once every five years to observe the social features. When monitoring user counts, activity types, and pedestrian movement, the observations and data collection should be conducted over a week, three days during the school week and once over the weekend. It should take place in the morning, afternoon, and evening due to the pedestrian traffic changing throughout the day and week (Gehl & Svarre, 2013). Individuals that might have interest in monitoring the social benefits for research projects may come from the Physiological Sciences and Landscape Architecture departments.

User Surveys
Direct surveys can be a viable tool to measure how people use or experience spaces. These direct surveys can be conducted by student monitoring groups to analyze how visitors of Campus Creek use and view the spaces along the creek. Surveys can be sent out electronically to students, faculty, and staff of Kansas State University or can be conducted as an interactive survey with the users of Campus Creek and the students monitoring the social features and activities within the creek corridor. It is important to remember that any surveys or interviews used that involve humans need to be approved by the IRB (Institutional Review Board).

User Counts
Monitoring user counts will require direct observation and site visits by the individual observing the user counts. Individuals from the monitoring group should be placed in different spaces along the creek to keep track of everyone who passes through the area of observation. Counting people can be tracked by writing the total number of people on a note pad or by using a manual hand clicker. User counts should take place at the same place as the first observation session to ensure the best results and provide comparison of pedestrian traffic.

Mapping Activity Type
In order to monitor the types of activities occurring along Campus Creek, the student monitoring groups will need to use direct observations at different locations within the creek corridor. The locations being observed can be anywhere within the corridor but should be predetermined, for example; recreational areas, plazas, along trails, lawn space, major pedestrian promenades, and even within the creek.

Tracing Movement
Monitoring traces of movement is a technique that can simply help show the movement of people traveling through spaces within and along the edges of the Campus Creek corridor to track if the designed paths and spaces are being used as planned. Monitoring groups will need to be present on the site to have direct observation of the movement. The movement can be documented by using a plan view of the site and marking lines where people move through the different spaces within the corridor.

Gehl, J, Svarre, B. (2013). How to study public life. Washington: Island Press.

Maintenance & Management

The redesign of Campus Creek means a paradigm shift for maintenance at Kansas State University. The concept of "mow, blow, and go" is no longer widely applicable. The three major areas of Campus Creek - prairie, savanna, and woodland - present a great change in strategy. Each area requires a different maintenance regime to ensure the beauty of campus.

Woodland
- Prune as needed
- Debris clean up as needed
- Invasive species and weed control

Savanna
- Burned every 5 years
- Mowed twice a year in early summer and late fall
- Invasive species and weed control

Prairie
- Burned every 3 years
- Mowed once a year in late fall or early spring
- Invasive species and weed control

Manicured Turf
- Mowed weekly (or as needed)
- Irrigate as needed
- Other inputs (fertilizer, pest control, etc.) as needed

Creek
- Branch and litter removal as needed

Bridges
- Limestone facade maintenance as needed
- Wood decking replaced as needed

Amenities
- Benches and other furnishings replaced and cleaned as needed

Maintenance Requirements

Institutions set and follow budgets. To help Kansas State University better understand and follow the landscape maintenance budget, maintenance practices and costs should be tracked. Dividing the information into two categories, practices and costs, will help understand the full impact of the Campus Creek Corridor design. Maintenance practices focuses on monitoring tasks that are performed by university employees, whereas maintenance costs considers the overall financial expenditures of Campus Creek. In order to track maintenance practices and costs of the creek, information should be recorded on a log sheet and compiled into an annual report. This report will allow for quick assessment and yearly comparison to ensure that the maintenance plan is being followed and potential savings of the new design are documented.

Maintenance Practices

Monitoring maintenance practices will consist of any task performed by university workers along the Campus Creek Corridor. The monitoring of practices would track such inputs as labor hours, product application (ex: pesticide, fertilizer, etc.), and water usage. The new design of Campus Creek proposes a new maintenance plan with suggestions on how to perform different, individual tasks to maintain newly implemented features. These tasks include, but are not limited to: maintaining the various grassed areas (burning or mowing), weeding, debris and litter clean up, invasive species removal, irrigation winterization, infrastructure and lighting repair, mulching and pruning plants, and snow removal. By monitoring the amount of time required to complete these tasks as well as the necessary inputs will show the effectiveness, or lack thereof, of proposed maintenance practices.

Maintenance Cost

Maintenance costs refer to the dollar spent on Campus Creek. Expenditures will be directly impacted by the performance of the maintenance practices which are listed above. Keeping track of hours spent working and the amount of products used will allow for the overall expenditures to be monitored. If proper systems are implemented into the proposed design, they will help reduce costs in the future as well as the overall dollar amount spent on maintenance of Campus Creek.

University departments and other interested parties may assist in the maintenance monitoring. These individuals may come from Horticulture, Entomology, Biology, and Facilitates.

Phasing

Phasing for Re-Envisioning Campus Creek is recommended to take place in two stages. The division between the two phases is Claflin Road. Phase 1 construction will occur from Manhattan Avenue to Claflin Road and Phase 2 proceeds upstream from Claflin Road toward Jardine Drive and the Veterinary Medical complex. It was determined that Claflin Road was a good point for the phase division due to existing contextual conditions and an opportunity to add a grade check in the stream (creating stability). Circulation and amenities should be added accordingly with each phase.

06. Conclusion

The work presented in the preceding pages represents the efforts of many in conducting inventories, analyses, and assessments. The proposed design for a "Re-Envisioned Campus Creek" arises from creativity informed by an understanding of natural stream processes and how streams interact with urban settings. Our proposal addresses past problems of flooding while looking to create a rich and enduring natural corridor for the future enjoyment of students, faculty, and staff.

The Re-Envisioned Campus Creek Design is much more than an attractive flood management proposal. This design blends natural stream channel restoration with evidence-based amenity design to create an integrated place of natural function and aesthetic pleasure. The Campus Creek Corridor is designed to store (temporarily) a 100-year flood event while providing aesthetic, educational, and recreational enrichment for the campus community during the majority of the time when stream flow is normal. Indeed, the Campus Creek Corridor will become the heart of the campus while leading the way to a more sustainable relationship between cities and streams.

The work presented here would not have been possible without the generous support of: K-State Central Administration, the K-State Green Action Fund, and the K-State Academic Excellence Fund. We look forward to the day when the designs presented here find their way from the drawing boards and computer monitors on to the campus of Kansas State University. It has been our pleasure to begin this process; to gift this work to the University in honor of the 50th anniversary of the Landscape Architecture Program at KSU, and we stand ready to assist the realization of the Re-Envisioned Campus Creek in any way possible.

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