US EPA CAMPUS RAINWORKS

THE UNIVERSITY OF TEXAS AT ARLINGTON

GREEN INFRASTRUCTURE REPORT

Submitted by
One Architecture & Urbanism

In association with
Sherwood Design Engineers
Climate Resilience Consulting

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Cover: CAPPA courtyard (Source: UTA)

EXECUTIVE SUMMARY

On the University of Texas at Arlington campus, investing in green infrastructure is critical for managing stormwater and heat stress today and addressing the emerging challenges caused by a changing climate: shifting precipitation patterns, "cloudbursts" or flash floods, and more frequent and severe extreme heat events.

In 2022, the U.S. Environmental Protection Agency provided technical assistance to UTA as part of the tenth anniversary of the Campus RainWorks Challenge, a national design competition that advances green infrastructure design on college and university campuses across the country.

This report builds on UTA's engagement in the competition and envisions the campus as a model for green infrastructure implementation on campuses nationwide. The report is intended for campus leadership to support the advancement of campus planning, research, curriculum, and community development.

UTA was one of the two institutions invited to participate in the technical assistance pilot because of their extensive past participation in the competition and demonstrated commitment to building a sustainable campus, including managing rainwater where it falls and mitigating heat hazards while enhancing the overall character of its growing campus. The goals of the technical assistance include highlighting the merits of past Campus RainWorks engagement and establishing a framework and priorities for green infrastructure integration into future campus planning and design. It focuses on strengthening communication between campus stakeholders and creating new incentives to enable green infrastructure implementation.

This report builds on a months-long collaboration between EPA and UTA that culminated in a green infrastructure design charrette. Participants, including faculty, students, staff, and government and private sector partners, identified challenges, opportunities, and strategies for implementing green infrastructure on campus. The event also featured an exhibit of recent student projects.

The report includes an analysis of the campus's physical and environmental conditions, documents the ideas that emerged from the charrette, and connects these to a strategic green infrastructure framework and toolkit that UTA could use to guide future investments and planning. The framework identifies both structural and non-structural opportunities for UTA. It leverages a systems-based understanding of watershed dynamics on campus and in the region and can complement campus cloudburst visioning and master planning efforts.

Also included is a prioritization matrix that could inform future decision-making for the strategic siting for new green infrastructure investments on campus, integrating watershed location with ecological, economic, and community considerations.

Together the ideas and strategies presented in this report aim to support UTA's teaching and research goals, improve the environmental and social character of the campus, and further the university's mission to advance knowledge and promote innovation.

Aerial view of the UTA campus
and Trading House Creek
(Source: UTA, 2022)

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INTRODUCTION

The University of Texas at Arlington is a leading research institution with a long history of planning for and investment in campus sustainability. Located at the center of the Dallas-Arlington-Fort Worth metroplex, the UTA campus has expanded rapidly in recent years, adding millions of square feet of built space. UTA has been at the forefront of sustainability in North Texas through the College of Architecture, Planning and Public Affairs (CAPPA).

UTA has participated extensively in the Campus RainWorks Challenge, submitting numerous entries in the campus master plan category over the past decade and engaging continuously with the goals and topics of the competition through its landscape architecture curriculum. Building on this engagement, EPA and UTA held a day-long green infrastructure design charrette in October 2022. The charrette was shaped and organized by a core UTA team that included faculty, staff, students, and City of Arlington partners. It was conceived to build upon the robust body of research and design projects and engage a campus and community stakeholders to advance green infrastructure implementation at UTA. Participants included members of campus leadership, notably UTA's President and Vice President for Administration and Campus Operations.

Charrette participants collaboratively identified strategies that leverage green infrastructure for stormwater capture and storage, pollution reduction, urban heat mitigation, ecological restoration, climate resilience and strengthen the spatial quality, livability, and connectivity of the campus to surrounding areas. They considered ways in which green infrastructure could not only be compatible with and integrated into the physical campus but could complement academic objectives, deepen connections and partnership between students, faculty, staff, and city stakeholders, and contribute to UTA's identity and legacy.

This report provides an overview of the campus context for the charrette, documents the ideas that emerged, and explores opportunities for research, campus visioning, implementation, and leadership. The opportunities relate both to day-to-day stormwater management and managing extreme rain and heat events, linking these to placemaking and connectivity. Drawing on the findings of the charrette, this report elaborates a set of guiding principles for green infrastructure and key opportunities for UTA in several distinct areas, which can inform campus planning and growth.

Investment in green infrastructure can deliver co-benefits for academic programs, campus capital projects, energy demands, culture and aesthetics, and local mobility. This report also includes resources to complement other planning and strategic planning and support decision-making for academics, research, facilities, and engagement with the City of Arlington and the State of Texas, specifically:

- **A strategic green infrastructure framework** with guiding principles and a structure for designing, implementing, and maintaining green infrastructure.
- **A green infrastructure prioritization matrix**, which consolidates technical, ecological, economic, and community considerations to provide a reference and toolkit for future planning.

UTA has an opportunity to leverage green infrastructure planning as it advances its institutional goals and continues to grow its campus. The opportunities, tools, and references contained in this report offer a starting point for ongoing and deepening engagement in the role of stormwater planning and climate resilience at UTA.

Trading House Creek on the UTA campus; creation of Kerby Greenbelt and Short-Term Water Detention (ONE, 2022)

What is green infrastructure?

"Green infrastructure" refers to a variety of practices that restore or mimic natural hydrological processes in the absence of development.[1] While "gray" stormwater infrastructure—systems of gutters, pipes, and tunnels—is largely designed to convey stormwater away from the built environment, green infrastructure uses soils, vegetation, and other media to manage rainwater where it falls through capture and evapotranspiration. By integrating natural processes into the built environment, green infrastructure provides a wide variety of community benefits, including improving water and air quality, reducing urban heat island effects, creating habitat for pollinators and other wildlife, and providing aesthetic and recreational value.

Stormwater runoff and flash flooding present major challenges for urban areas: they carry contaminants, trash, and other pollutants into rivers and coastal waters, contribute to erosion and habitat loss along riparian corridors, and can cause damage to property and infrastructure and put people at risk in extreme weather events. Across the U.S., communities have historically used gray infrastructure to move stormwater away from homes and businesses and toward water treatment plants or directly into local water bodies.

Today, these systems are not only aging but also failing to keep pace with the increasing volumes of stormwater that come with a changing climate. Changing patterns of precipitation, "cloudburst" or flash flooding events, and more frequent extreme heat are the new normal. Green infrastructure can play an important role in addressing these emerging challenges and risks.[2]

While this report employs the terminology "green infrastructure" throughout, this is interchangeable with "blue-green infrastructure" as used by some UTA campus stakeholders.

1
U.S. EPA, "Campus RainWorks Challenge", epa.gov/green-infrastructure/campus-rainworks-challenge-0.

2
Adapted from U.S. EPA, "What is Green Infrastructure?" epa.gov/green-infrastructure/what-green-infrastructure.

EXISTING CAMPUS CONDITIONS

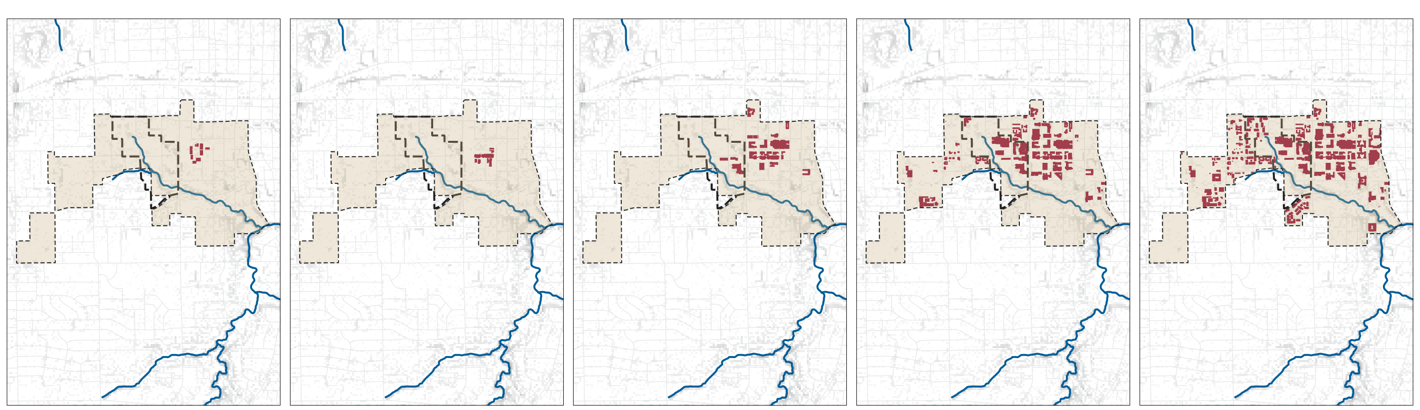
This chapter provides an overview of the UTA campus, ecological and geological systems that inform the behavior of water, current stormwater management practices, potential for green infrastructure and anticipated impacts of climate change. It briefly looks at the community conditions, campus surroundings, and the City of Arlington's characteristics to understand the relationship between the university and the wider context. It also summarizes UTA's past submissions to the Campus RainWorks programs.

COMMUNITY & CAMPUS OVERVIEW

The City of Arlington is located between the cities of Fort Worth and Dallas and forms a major part of the rapidly-growing metropolitan area, with nearly 400,000 residents living across its almost 100-square-mile area. It has expanded hand-in-hand with the university in the decades since World War II.

The University of Texas at Arlington is a public research university founded in 1895 which has occupied its current campus in the southern edge of downtown Arlington since its founding. The university traces its roots back to Arlington college in September 1895, and turned into a public junior vocational college called the Arlington State College (ASC) by 1949. It joined the University of Texas system in 1965 to accommodate expansion and the development of the existing campus which was blocked by the Texas A&M University governing board. As of Fall 2021, Arlington campus enrollment consisted of 45,949 students. Its 420 acre main campus includes the largest branch of public library, city hall, theater Arlington and numerous types of businesses south of the railway line, around which the city of Arlington was established.

Below the campus sits the Barnett shale formation, a natural gas production site. Trading House Creek, a tributary of the Trinity River, runs along the southern portion of the campus. The campus sits within the Trading House Creek watershed , the Johnson Creek watershed, Lower West Fork Trinity River Watershed, and the Trinity River watershed. The green areas of the campus significantly increased in the 2000s with the creation of Greene Research Quad, the 5 acre Green at College Park, a sunken courtyard at Davis Hall, Brazos Park, and the Davis Street west campus edge.



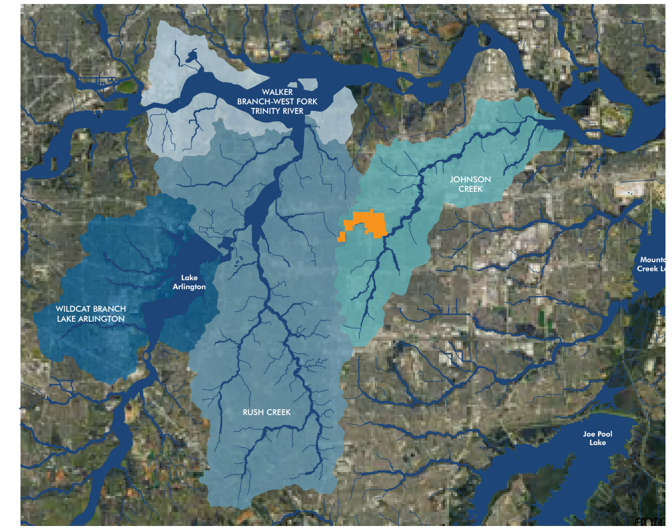
1910
Carlisle Military Academy
Enrollment: 32 Students
1910 Sanborn Fire Insurance Map of Arlington, TX

1930
North Texas Agricultural College
Enrollment: 900 Students
University of North Texas Libraries, Portal to Texas History

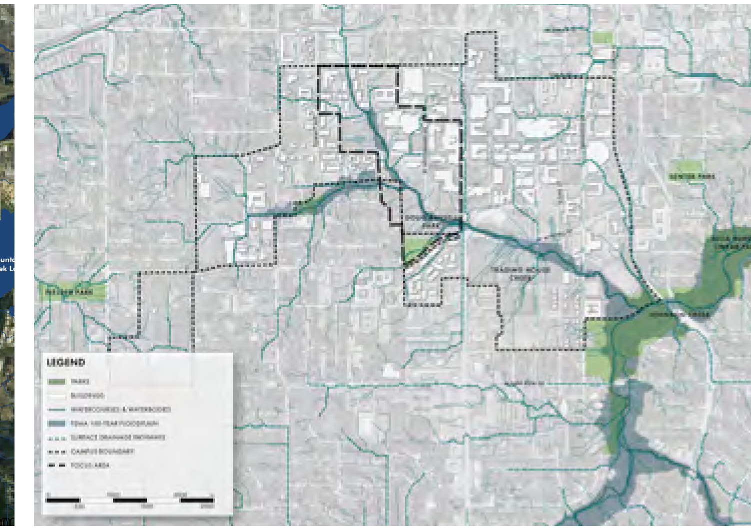
1965
Arlington State College
Enrollment: >11,000 Students
UT Arlington Digital Libraries

1990
University of Texas at Arlington
Enrollment: >25,000 Students
University of North Texas Libraries, Portal to Texas History

2001
University of Texas at Arlington
Enrollment: >41,000 Students
University of Texas at Arlington



Regional Watersheds



Campus Drainage

ENVIRONMENTAL CONTEXT

Any discussion of green infrastructure planning must utilize an understanding of environmental conditions and natural systems. Green infrastructure harnesses plant and soil systems and conditions, therefore, to work effectively, planning must take into account climatic conditions, soil characteristics, and location in the watershed, among other factors. Understanding environmental conditions is critical to optimizing the efficacy of green infrastructure in terms of placement and size.

Watersheds

The context of watersheds and drainage flow paths are critical to understand how water conveys through an area, how much water is reaching any one point on campus, and where pollutants might be expected to accumulate on campus. A watershed (i.e. drainage basin, drainage area, catchment) is an area of land where all surface runoff generated within that area drains to one common point. Watersheds can exist on a variety of scales and depend on which common point is selected for analysis. For example, a location in the northwest corner of campus can be located in a campus-scale watershed and simultaneously the Trading House Creek watershed, the Johnson Creek watershed, the Lower West Fork Trinity River Watershed, and the Trinity River watershed. For the purposes of this analysis, watershed analysis was restricted to campus-scale watersheds.

To understand campus-scale watersheds and their associated drainage patterns, drainage paths of surface runoff and watersheds were generated with GIS based on a Digital Elevation Model (DEM) obtained from the United States Geological Service's online database that was generated via LIDAR Satellite data. Delineated watersheds are based on the topographical patterns of the ground that are represented in the DEM, and not the subsurface stormwater pipe network, but watersheds for pipe networks often align as stormwater pipe networks usually rely on gravity to convey water.

Based on the analysis, UTA is composed of 36 campus-scale watersheds that all drain to Trading House Creek. Generally, most stormwater that falls within these watersheds is intercepted by storm pipes and drains to the creek at point-source outfalls. These pipe interceptions ultimately still convey water to the Creek, but concentrate the points at which stormwater drains to the Creek so that the amount of water reaching the creek at any one time is significantly increased, exacerbating water velocity issues and bank erosion. Stormwater within these watersheds that drains to Trading House Creek is additionally not treated of pollutants before reaching the creek system, disrupting water quality for downstream communities and wildlife.

Soil Conditions

Soils absorb precipitation through the process of infiltration, as part of the natural water cycle. The soil's physical makeup (based on geology) and its degree

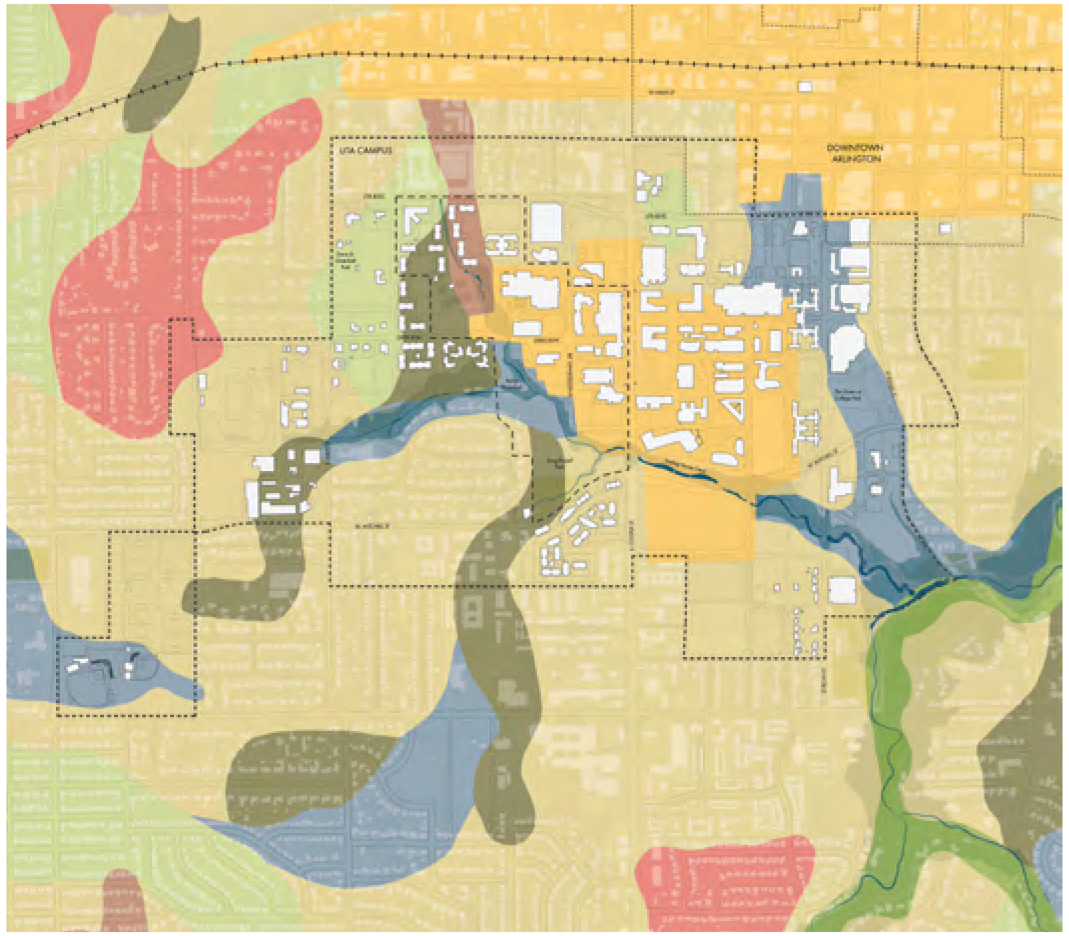
A **watershed** (also called drainage basin, drainage area, catchment area) is: an area of land where all surficial stormwater occurs within that area drains to one common point.

GIS uses the raster of the **Digital Elevation Model (DEM)** to detect the differences in relative elevation between each cell of the raster, and formulates vectors that show how surface water conveys on the land based on elevations in the topography, known as surface drainage flow paths.

Delineated watersheds and stormwater pipe networks are typically highly correlated, since subsurface networks generally leverage gravity to convey water (instead of pumps).

opposite:
UT Arlington campus growth, 1910 - 2001 (Source: UTA student work)

above:
UT Arlington watershed context and drainage pathways (Source: Sherwood)



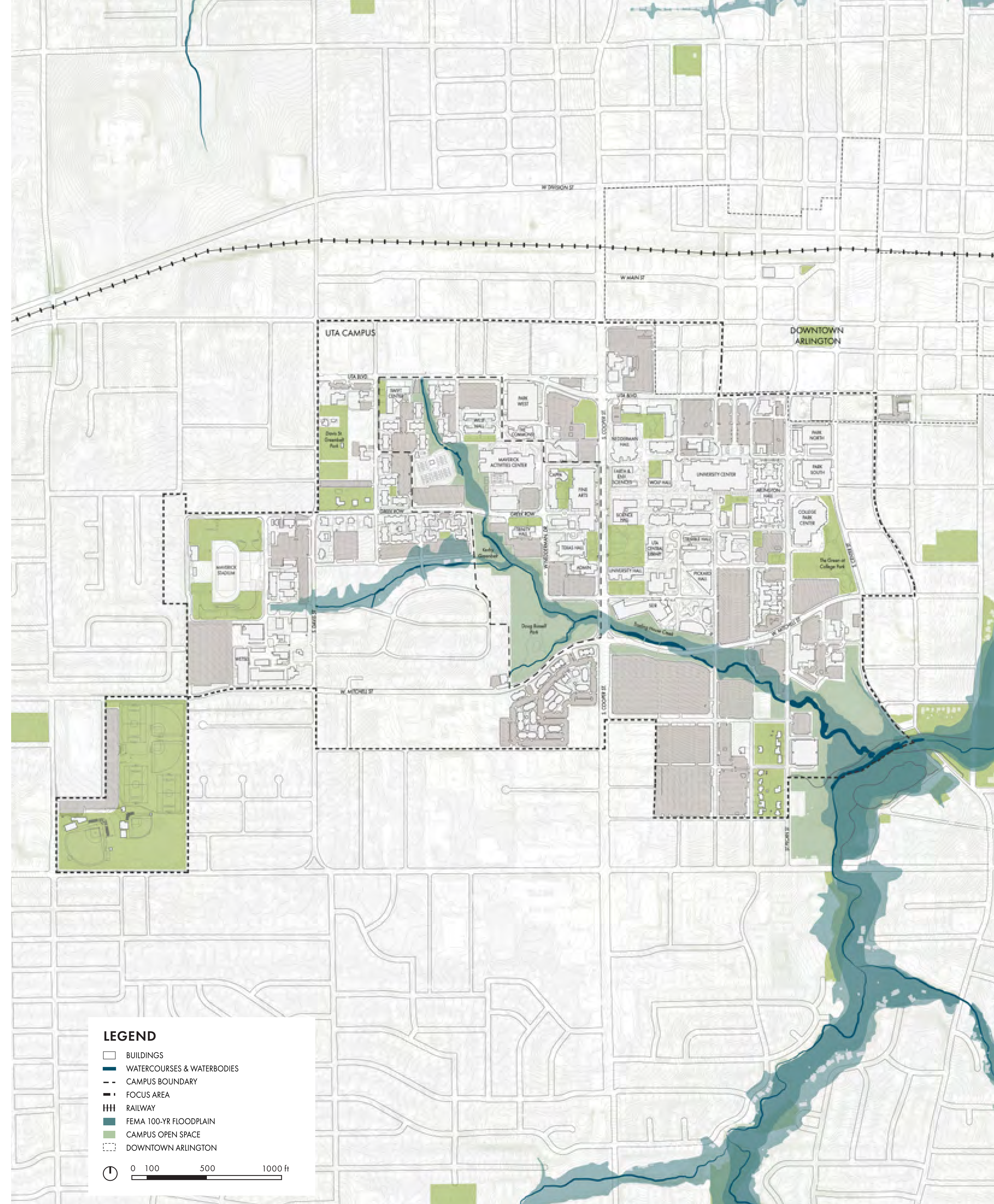
UTA area soil types; the campus is primarily urban land - Rainsboro complex. Refer to Appendix for full legend. (Source: USGS).

of saturation from groundwater both impact the ability of soil to infiltrate water at a given location. Soil conditions and records can give clues as to infiltration capacity. Generally, soils in the lower portions of watersheds are fully saturated and therefore have limited capacity to infiltrate any stormwater. Due to the need for infiltration in green infrastructure practices, green infrastructure projects often include the replacement of soil underneath with high-infiltration soil or are sited in areas of naturally occurring high-infiltration soil whenever possible.

At UTA, soils on campus generally have a low to medium capacity to infiltrate stormwater runoff, resulting in additional stormwater that cannot be absorbed and remains on the surface. This is largely due to the soil's physical makeup predominantly composed of clay, which is a soil type characterized by minimal infiltration capacity. These clay particles can also often be suspended within moving water when clay is exposed to the surface, resulting in additional sediment pollutants in Trading House Creek and downstream water networks.

Soil erosion is a minor concern on Campus where there are mild slopes with the exception of the Trading House Creek banks where slopes range between one to eight percent. This is especially a concern in the immediate aftermath of heavy rain events where concentrated flows convey to the creek banks, especially at points of concentrated conveyance near stormwater pipe outfalls.

Built Environment & Impervious Area
An impervious surface is any material that prevents or significantly hinders the infiltration of water into soil below. Impervious surfaces include asphalt and concrete and are commonly found as roads, buildings, driveways, parking areas, etc. The incorporation of impervious surfaces on the natural landscape decreases the available landscape for stormwater to naturally infiltrate, increasing the amount of stormwater that exists above ground and disrupting the natural water cycle. Unable to infiltrate, water on impervious surfaces convey towards the lowest point, transporting any pollutants (e.g. dirt, fertilizers) on the impervious surface along until it reaches a water body. In



opposite: University of Texas at Arlington campus map (Source: UTA / ONE) contrast, a pervious surface is a surface that facilitates the infiltration of water and is commonly seen as grass or other natural surface material. Pervious surfaces can facilitate infiltration to varying degrees, depending on the material.

Within the UTA Campus, 83% of the Campus is classified as Impervious Area. The majority of contiguous pervious areas are in locations of previously demolished buildings characterized by heavily compacted soils that inhibit the infiltration of water and is hostile to the majority of ecological character. With this in mind, any future design considerations for the Campus should aim to maximize the amount of pervious area in order to optimize stormwater infiltration, facilitate additional room for habitat and ecology, and also mitigate the urban heat island effect that is exacerbated by heat reflection off impervious surfaces.

Tree Canopy

Trees provide valuable ecosystem services, which are the benefits that society reaps from the processes that occur in nature, including shade cover from sun, infiltration of water by plants and soil to mitigate flooding, and the purification of air through photosynthesis, among others. Preservation and restoration of tree canopies can enhance ecosystem services provided to campus, while destruction reduces provided services.

Historically, the UTA campus straddles the intersection of two major ecoregions of Texas: the Crosstimbers ecoregion to the West and the Blackland Prairies ecoregion to the East. The Crosstimbers area was once heavily forested timber areas with dense vegetation. The Blackland Prairies were historically prairie grasses with deep, fertile black soils that were resource-rich areas for habitat. Both ecoregions have changed drastically with development and lost many of their core characterizations, both with the rise of impervious area and the increased presence of fill soil that changes the soil characteristics.

Tree canopies have declined through the increase of development as trees have been either removed or hindered from growing in places of impervious area or have died. Currently, UTA has a tree canopy that spans 21% of the Campus, with a majority of the trees being large, mature species of shade trees. Habitats produce an increasing value of ecosystem services with time through establishment, so preservation and restoration is best done earlier to allow time for value accrual.

Climate Change Context

Understanding how the campus climate will change in the coming decades is critical when planning for resilient green infrastructure, as all campus planning and investment should be designed with awareness of present and future conditions. The UTA campus is especially vulnerable to increasing average annual temperatures, extreme heat, and more intense rainfall events, even as total rainfall remains similar. Changes in climate have already begun to impact the campus in recent years, as the area has experienced record summer temperatures and torrential rain events that cause flash flooding and street closures. Recognizing these threats, how they are projected to change in the future, and integrating adaptive thinking into campus planning and investment is imperative to ensure a good user experience on campus.

On the UTA campus and throughout the region, increases in average yearly temperatures are expected to cause more frequent and intense heat waves. In 2020, there were only 7 days on record that were above 102 degrees Fahrenheit in a year, but it is expected that it will be around 38 days in the year 2050 (ClimateCheck). In addition to negatively impacting campus livability and causing to heat-related illnesses, these temperature increases will likely cause an increase in vector-borne diseases as well as result in water scarcity, demanding additional groundwater pumping. This change in temperature is also projected to change the types of flora that will thrive in these conditions, so any plantings in green infrastructure and additional landscaping must take this into account.

Precipitation events are also expected to decrease in frequency, but increase in intensity, resulting in a larger volume of precipitation falling on the campus at any one time. The decrease in frequency of rainfall events will result in more frequent and severe droughts, affecting

ClimateCheck bases projections on an RCP8.5 (business as usual) scenario and assigns ratings for each property relative to the rest of the contiguous United States. A rating of 1 represents the lowest risk; 100 is the highest. Data sources: flood risk – NOAA (2017) and USGS digital elevation models; precipitation – LOCA Statistically Downscaled CMIP5 Projections for North America; heat – LOCA Statistically Downscaled CMIP5 Projections for North America, Multivariate Adaptive Constructed Analogs (MACA) downscaled Global Climate Models. www.climatecheck.com. Regional climate projections reference Dupigny-Giroux, et al., 2018: Northeast. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 669–742. doi: 10.7930/NCA4.2018.CH18

opposite:
UTA charrette visit to Trading House Creek (ONE, 2022)

flora on the campus and causing soils to be less stable, exacerbating soil erosion issues. Even in pervious areas, there are limits to how much precipitation can be infiltrated by the soil. During extreme rain events, stormwater volumes are likely to overwhelm existing infrastructure capacities, causing flooding and severe damage to infrastructure and assets as well as impacting human safety – as the campus community has already experienced. This increase in stormwater volume may be especially problematic for areas of campus that are lowest in elevation and nearest to Trading House Creek, as stormwater runoff elevates water levels, reduces the capacity of stormwater outfalls, and causes backups in nearby stormwater infrastructure.

Awareness of these projected trends and the impacts they will have on campus is of special importance for this campus so that proactive management of these threats can be implemented before conditions exacerbate. By investing in proactive disaster management and incorporating resilience into recovery from climatic threats today, adaptive capacity is created that will minimize future disturbances as threats increase. Creating adaptive capacity for these threats will avoid unmitigated disturbance impacts that will cause greater harm to Campus infrastructure and users.

To provide this adaptive capacity in preparation for climate change, campus planning can incorporate features that address both heat and flood-related conditions. Heat conditions can be addressed through intentional plantings of drought-tolerant plants, increase in shade-providing trees and landscaping, stabilization of stream banks with plantings to mitigate erosion, and the inclusion of shade structures into any future infrastructure. Flood conditions can be addressed by using green infrastructure in alignment with natural drainage patterns to capture and treat rainwater where it falls, as well as through the increase of pervious area to optimize stormwater infiltration and groundwater recharge, and the restoration of natural creek banks to augment flood storage and mitigate erosion.

Campus Green Infrastructure Features & Stormwater Management
UTA's campus contains a range of green infrastructure features, including bioretention areas, green belts, parks, creeks, and permeable pavements. Over the last decade, several efforts were made to expand these features by reducing the impervious areas on campus to increase stormwater capture and infiltration for flood protection, maximizing groundwater recharge, reducing pollutant runoff into the creeks and mitigating erosion along

Aerial view of Trading House Creek (Source: UTA, 2022)

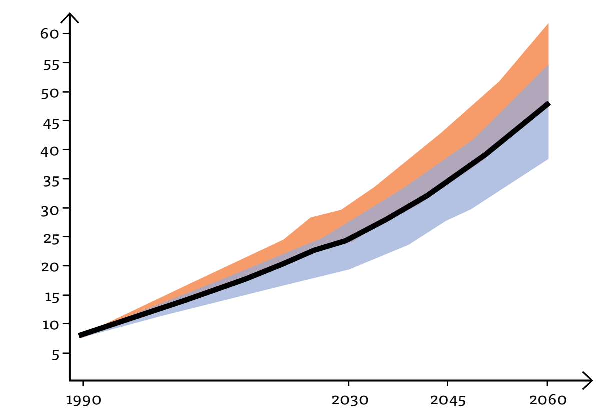
Extreme heat and rainfall will increasingly affect Arlington in the coming decades.

Historically (1981-2005), Arlington had an average of about **7 days** per year where temperatures reached above 102 °F (39 °C). In 2050, in the Arlington campus:
- ~ **38 days** in an average year will reach above 102 °F, and
- ~ **7 days** per year will reach above 107 °F (42 °C).

Historically (1981-2005), rainfall exceeded 1.0 inches in about **11** 48-hour storms per year (average of ~ 1.6" per storm). In 2050, storms will be larger and more frequent:
- ~ **11** 48-hour storms per year, averaging about 1.6" per storm.
- Rainfall events are projected to become flashier across the U.S. (see notes)

PROJECTED ANNUAL EXTREMELY HOT DAYS (1990-2060)

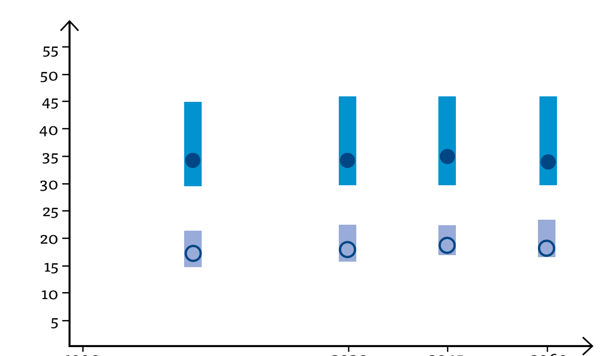
	Threshold	1900	2030	2045	2060
Arlington	102.1°F	7	24	34	47
TX*	100.5°F	7	26	38	54
U.S.*†	94.1°F	7	23	33	46



* Colored area represents 25th-75th percentile estimate for Texas and U.S. Table shows 50th percentile.
† Population in 48 conterminous U.S. states.

PROJECTED ANNUAL RAINFALL (1990-2060)

	1900	2030	2045	2060
Annual Rainfall (Arlington)	34.5"	34.5"	35.2"	34.2"
Extreme Rainfall (Arlington)†	17.2"	17.9"	18.6"	18.0"
Annual Rainfall (Region)	30-45"	30-46"	30-46"	30-46"
Extreme Rainfall (Region)†	15-21"	16-22"	17-22"	17-23"



* Average for 1980-2005 across ensemble of climate models.
† Average annual rainfall in all events that exceed this location's threshold in a 48-hour period.
‡ 25th-75th percentile for Texas region

Extreme heat and rainfall projections for the UTA campus for Representative Concentration Pathway 8.5 (RCP8.5 greenhouse gas concentration trajectory). (Source: ClimateCheck)

Source: Li, Z., Gao, S., Chen, M. et al. The conterminous United States are projected to become more prone to flash floods in a high-end emissions scenario. Commun Earth Environ 3, 86 (2022). https://doi.org/10.1038/s43247-022-00409-6 these watercourses. In 2018, UTA won a prestigious Excellence in Sustainability Award from the National Association of College and University Business Officers for establishing the Sustainable Sites Initiative™ voluntary guideline for sustainable land design at UTA's College Park Center and The Green at College Park. Other interventions include:

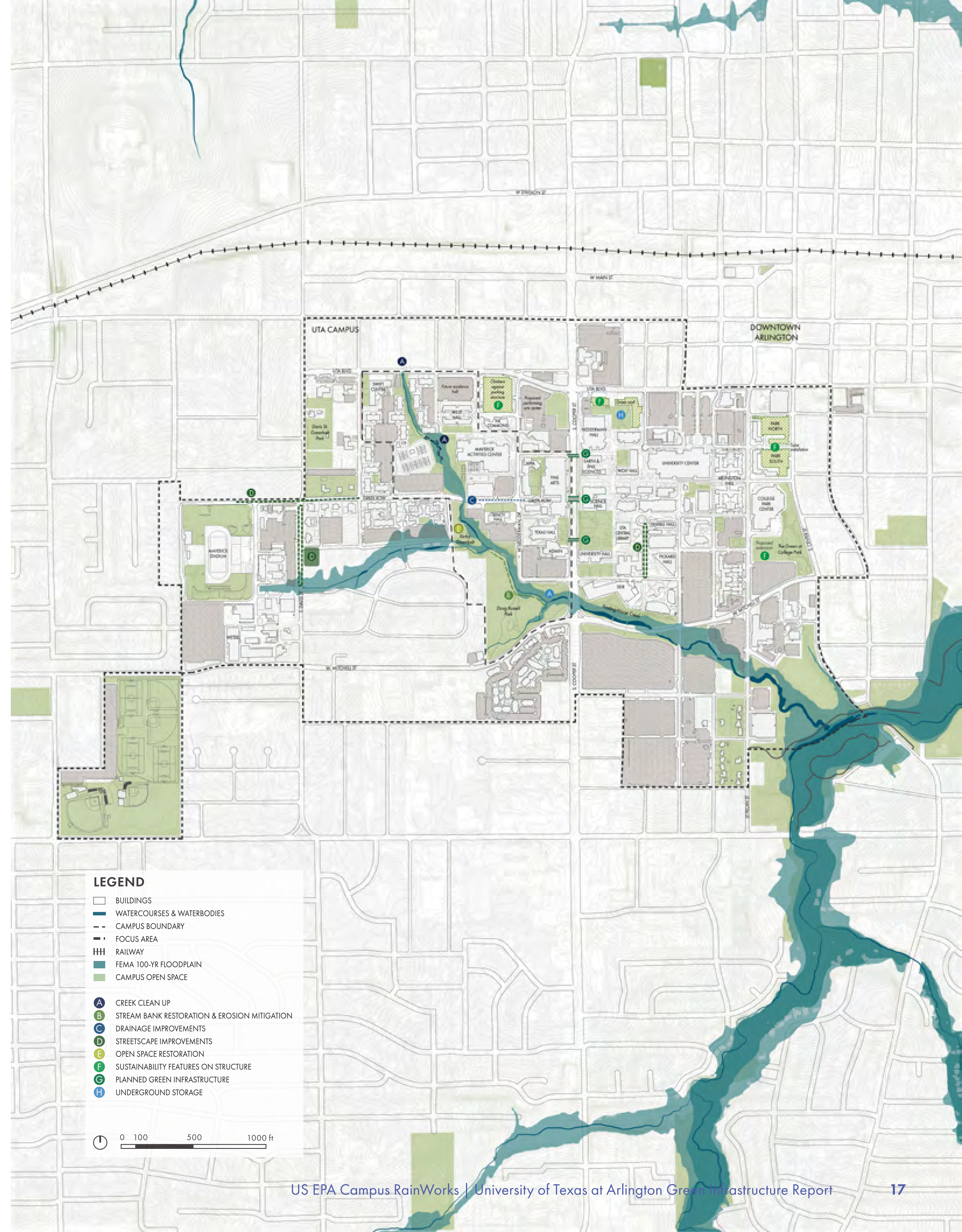
- Removal of several buildings and complexes built on flood plains to expand the campus greenbelt and water detention areas
- Removal of large sections of concrete and abandoned sidewalks to create a larger greenbelt
- Creation of Kerby Greenbelt and Short-Term Water Detention Area by removing five residential homes in the floodplain to tackle heavy rain events
- Creation of the Green at College Park for water detention to prevent flooding at apartment complexes during heavy rain events
- Creation of Arbor Oaks Parking Lot green belt that acts as a detention area to slow water flow into Johnson Creek
- Flooding corrections across bridges and roads

Furthermore, UTA is actively working to address a range of stormwater management challenges, heat stress effects, and related planning objectives on campus. These include:

- Increase presence of native trees for carbon sequestration to mitigate Air Pollution
- Restore native flora throughout campus to mitigate Urban Heat Island Effect
- Augment contiguous planting areas to restore natural habitats and ecosystems
- Restore natural creek banks and increase plantings of banks to mitigate erosion
- Maximize pervious area where possible to optimize infiltration capabilities
- Restore soils, in non-developed areas to reduce compaction and optimize infiltration
- Increase infiltration opportunities to maximize groundwater recharge
- Align stormwater infrastructure with natural watersheds to optimize drainage patterns
- Treat/clean runoff through GI before draining to Creek to mitigate water pollution for downstream users
- Restore creek with naturalized banks to augment flood storage and reduce erosion

Greek Row flooding corrections – stormwater contained largely in right of way after improvements (Source: UTA)

opposite:
UTA existing green infrastructure (Source: discussion with UTA team; ONE / Sherwood)



CAMPUS RAINWORKS ENGAGEMENT

UTA students have participated in the Campus RainWorks Challenge with 17 entries in the campus master plan category since the inception of the competition a decade ago. Refer to the appendix to see all submissions. Highlights include:

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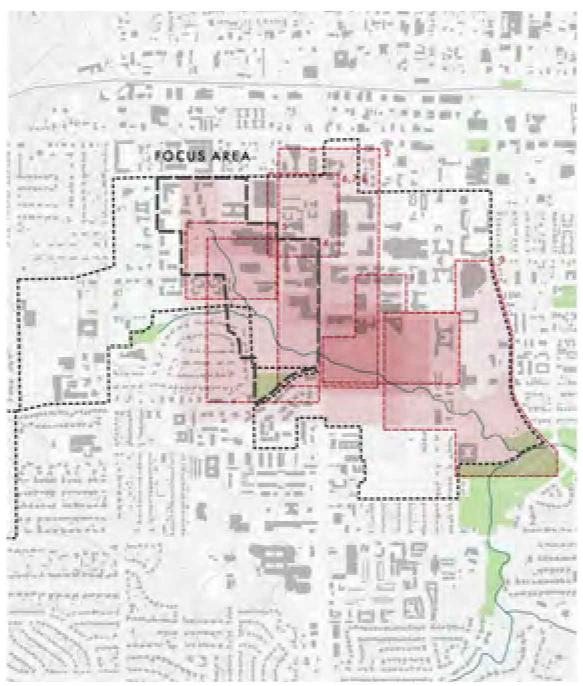
UTA CAMPUS VISION 2020 - 21



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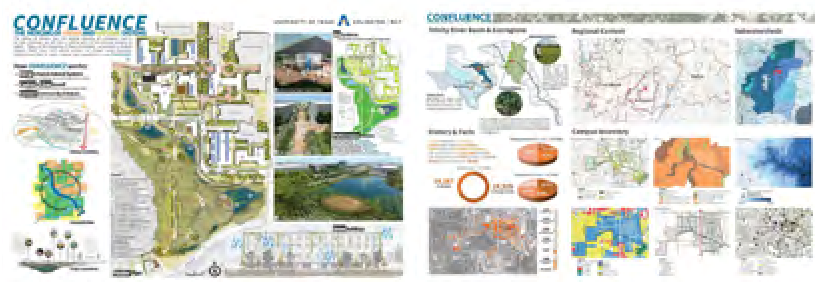

UTA CAMPUS VISION 2019 -20

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UTA CAMPUS VISION 2018

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UTA CAMPUS VISION 2017 -18

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UTA CAMPUS VISION 2016 - 17

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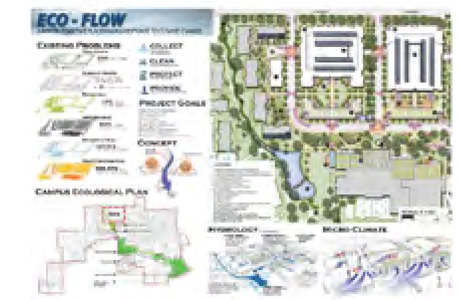
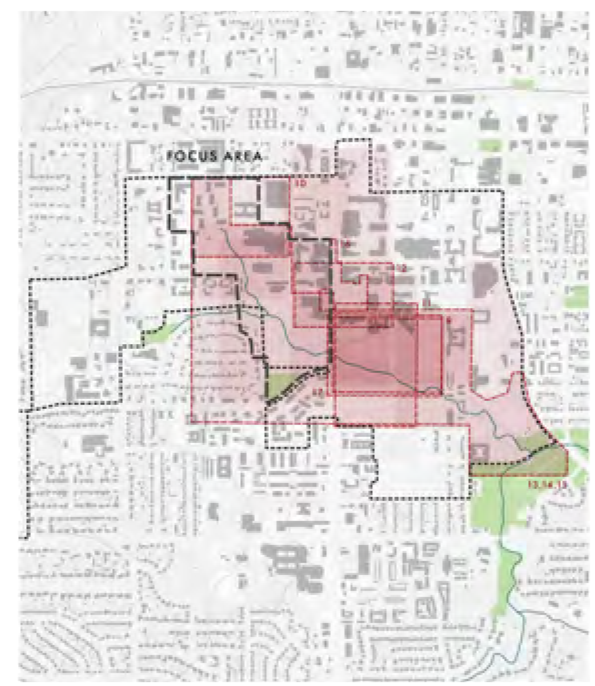


UTA CAMPUS VISION 2015



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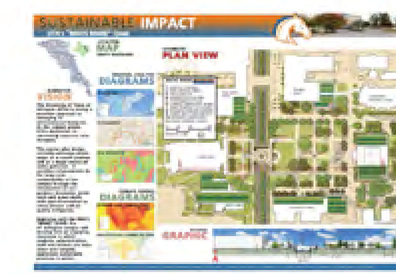

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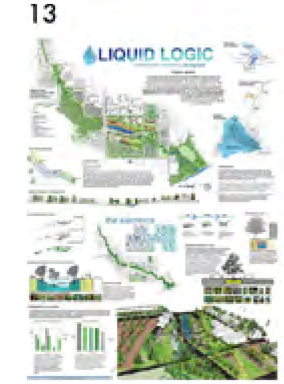

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UTA CAMPUS VISION 2012 -13

RAINWORKS CHARETTE

This chapter provides an overview of the Campus RainWorks design charrette at UTA, including goals, activities, key topics and ideas that emerged during the breakout sessions.

CHARRETTE OVERVIEW

The Campus RainWorks Charrette was a day-long event held in October 2022. It brought together UTA campus leadership with faculty, staff, students, and key stakeholders to discuss green infrastructure and water planning on campus, linking it to climate change, connectivity, livability, open space design and environmental quality. Participants toured the campus, learned about campus leadership as well as recent and ongoing university and City planning efforts and sustainability initiatives, and reviewed RainWorks entries by students as well as their current research on green-blue infrastructure. Working in groups, they explored opportunities for watercourse restoration, watershed management, and biodiversity, with a focus on Trading House Creek and its surroundings. Participants learned from expert presentations, engaged in small group discussions, identified opportunities and strategies for future campus planning, green infrastructure implementation and education.

UTA campus tour (UTA, 2022)

CHARRETTE OBJECTIVES

The UTA Core Team articulated a set of objectives for the RainWorks charrette:

- Establish a framework, goals, and objectives to guide upcoming campus planning and design efforts, including responding to the climate emergency, addressing climate change impacts, elevating the place of green infrastructure on campus, and linking it to connectivity, livability, open space design, and environmental quality.
- Build consensus among campus, City, and community stakeholders around shared goals, values, and opportunities for watercourse restoration, watershed management and biodiversity, with a focus on Trading House Creek.
- Establish priorities and direction for future green infrastructure research and campus projects that are eligible for State or Federal funding.
- Identify opportunities for academic research, programs, campus pilot projects, and coursework.
- Showcase campus leadership and student work on green infrastructure, water planning, and sustainability projects and efforts to encourage future adaptation and/or implementation.
- Equip UTA as an Urban Lab for the Dallas-Fort Worth metropolitan region in green infrastructure, climate sensitive design, and sustainability education, research, and implementation.

BREAKOUT DISCUSSION STRUCTURE

The charrette's breakout discussions focused on identifying and analyzing challenges and opportunities presented along Trading House Creek, including flooding challenges, campus needs, and recent / planned development. The second session focused on discussing green infrastructure objectives and articulating potential design strategies and principles for the focus area that serves climate adaptation and other environmental and social impacts. Participants were divided into four groups, each with a specific prompt. Under each prompt, the groups developed and presented a final design proposal.

Healthy water, healthy creek
Trading House Creek and its surroundings. The focus was on identifying opportunities to daylight the creek and establishing design strategies for stormwater sewer outfalls that address erosion and help with water quality issues.

Climate resiliency on campus
Areas in and around campus. The focus was on identifying green infrastructure opportunities and other green measures that could be incorporated into new buildings, paths, roads, parking lots and structures, and recreational facilities.

Connecting communities
Areas of transition and adjacent to the campus. The focus was on the interconnection between the campus and adjacent neighborhoods, exploring green infrastructure initiatives on campus and linking them to city infrastructure and communities in adjacent neighborhoods.

Trails for people and nature
The focus was on combining green infrastructure with pedestrian movement across campus and beyond, along the creek, on both trailheads and along the trails.

UTA charrette presentations and collaborations, October 7, 2022 (UTA and ONE, 2022)

UTA aerial views and charrette campus tour photos, October 7, 2022 (Source: EPA, UTA, and ONE, 2022)

CHARRETTE OUTCOMES

Breakout groups identified design principles, challenges, opportunities, and strategies for working with green infrastructure and water planning on UTA's campus and in surrounding neighborhoods. These ideas were shared through sketches, sticky notes on maps, and commentaries delivered back to the full group.

Charrette working materials: climate resiliency on campus breakout group

Breakout 1: Healthy water, healthy creek

Principles
- Interventions should not cause problems downstream or upstream
- Increase & improve riparian buffers
- Strengthen & expand vegetation on campus
- Support pedestrian mobility & access

Challenges
- Flooding
- Poor water quality
- Lack of access
- Stream bank erosion

Opportunities
- Daylight the creek; remove culverts (e.g., under the Pecan St bridge)
- Focus on fewer, larger pedestrian crossings
- Remove constraints for people and the creek
- Replant and redesign riparian zones to mitigate erosion and create buffers
    - Include native grasses
    - Modify creek bank slopes
- Expand tree canopy & planted areas
    - Plant two for every one removed
    - Manage invasives with a monitoring system

Area specific notes
- Pecan Street bridge: low point on campus where culvert creates a bottleneck
- UTA Blvd area: poor water quality
- Greek Row: outfall causes damage
- Below Greek Row: vulnerable riparian areas, poor water quality, erosion management needed
- West St bridge: flooding, access issues
- Trading House Creek & Johnson Creek confluence: flooding issues

Breakout 2: Climate Resiliency on Campus

Principles (heat, rain, population / new development)
- Address stormwater, heat, and mobility together
- Align conveyance routes: paths for people and water systems together
- Increase permeability to reduce nuisance flooding
- Integrate detention with placemaking (combine recreation with water squares)
- Build awareness and knowledge through strategic communication
- Leverage graywater for beneficial reuse (e.g., from rooftops to irrigation)

Challenges
Climate
- Extreme heat
- Extreme rainfall events (cloudbursts)
- Quantity of impervious surfaces
- Standing water from irrigation

Population
- Rapid campus expansion & construction
- Demand for parking
- Accessibility challenges
- Lack of shaded areas for walking and gathering

Opportunities
Technical
- Replace impervious surfaces with permeable solutions, especially parking lots
- Leverage new buildings and infrastructure to expand GI on campus
    - New green roofs
    - Retrofit roofs and buildings
    - Improve coordination between LEED buildings program and campus landscape
    - Rework drainage structures to incorporate green infrastructure
- Improve connectivity of water systems
    - Connect landscapes upstream and downstream to improve watershed health
    - Connect water conveyance infrastructure
- Enhance creekside with trees, planted buffers, and bioswales
- Build rain roads for mobility and conveyance
- Pathways as design opportunity; improve shade between buildings
- Recreation & stormwater opportunities combined – water squares, etc.
- Open space / placemaking with GI (requires educational signage)
- Expand tree planting on campus for shade and retention (root systems)
- Create no noise zones linked to education signage

Social
- Engage interested students in sustainability and resiliency work
- Expand interdisciplinary and interdepartmental collaborations and education
- Expand collaborations between students, faculty, and facilities staff
- Incorporate green legacy projects to attract donors

Strategies
- Combine [permeable] service roads with conveyance infrastructure & swales
- Create shaded routes to campus – addressing heat for pedestrians along paths
- Link city to campus with paths
- Rethink campus mobility networks and access
- Build structured parking to reduce the total footprint on campus
- Retrofit surface parking on campus to introduce more green and permeability
- Retrofit roofs for detention
- Utilize pilot projects to improve collaboration and learn about maintenance
- Integrate strategies into masterplan

Breakout 3: Connecting Communities

Principles

- Facilitate connections between the campus & surrounding areas
- Seek to provide experiences for UTA students & the whole Arlington community
- Enhance the experience of green infrastructure and the experience along the creeks

Challenges

- Cooper Street design (not pedestrian friendly; lack of connections above / below)
- Constrained and localized flow of water in creeks; flooding (e.g. west of Mitchell)
- Plastic and other debris in the creek
- Silt infill inhibits green infrastructure function
- Erosion issues along creek, e.g., at Doug Russell Park
- Safety and access issues along creek and at culverts
- Lack of connectivity between parks and neighborhoods
- Large areas of surface parking
- Performance of current planting strategies; grass lawns
- Lack of native species
- Maintenance practices are not cognizant of green infrastructure needs

Overarching opportunities

- Break down barrier between students and residents
- Focus placemaking efforts at campus edges; rethinking transitional places where people enter campus and reimagine surface parking
- Make campus an attractive place to spend time (not just for students)
- Cooper Street as innovation hub; redevelop the north section of Cooper
- Engage campus trails as a part of the city park trail system
- Create a walkable / bikeable corridor between UTA and downtown Arlington
- Bring infrastructure & retail into campus
- Emphasize engaging the street in campus architecture
- Manage and treat stormwater coming into the campus, with a focus on the upper watershed (pollution and contamination from brownfields and surrounding areas)
- Rewild the campus with native plantings to filter pollutants, mitigate soil erosion, create pollinator habitats, and add ecosystem value
- Introduce community gardens

Trail network opportunities

- Rethink plantings; use signage to explain plantings
- Trails as site to test new practices and ideas
- Protect the creek with development setbacks; create a protection zone
- Link the movement of water to the movement of people
- Create an integrated approach to (trail) signage for city and campus

Area-specific opportunities

- *Brownfield transect*: focus on permeability, biofiltration, and bioretention in parking areas and walkways; install oil/grit separator and underground filter under parking area; expand the tree canopy.
- *Residential transect*: rainwater harvesting for irrigation, sunken planters and stormwater detention vaults; add canopy trees, educational signage, and native, deep-rooted shrubs and grasses along the creek; introduce a seat wall at creek for gathering
- *Campus transect:* restore the stream and introduce stormwater wetlands; revegetate where possible and expand green roofs. Seek opportunities for better footprints, ecosystem and biodiversity (insects).
- *Cooper transect*: rewild the creek corridor and adjacent parks, create a walkable innovation zone where mixed-use buildings demonstrate a new development paradigm: integrate solar with water detention on roofs, plan for water collection in pocket park, and create green alleys between buildings.

Breakout 4: Trails for people and nature

Principles

- Align trail network to watercourses
- Encourage access to the water
- Improve accessibility for all users
- Preserve the right of way and enhance crossings
- Value the trees already on site

Challenges

- Planning efforts for the open space network and natural resources have not been well coordinated with campus building / capital program. (Areas indicated for trails now have buildings in them)
- Planning has not kept up with the pace of development
- Lack of public transit – largest city without transit in the US
- Accessibility issues along watercourses due to very steep slopes
- Trail discontinuities (e.g., no sidewalk and connection on Mitchell)
- Lack of wayfinding
- Erosion issues on creek embankments
- Limited tree canopy; shadefinding needs

Opportunities

Near-term:

- Connect discontinuous trail segments and expand the system with paths and sidewalks
- Create varied experiences (overlooks, get downs, trails) along creek
- Integrate landscape buffers along trails for biofiltration and erosion management
- Wayfinding to promote access and use
- Improve lighting and signage

Long-term:

- Expand crossings for pedestrians; create accessible, pedestrian-focused stream crossings with new bridges
- Reconstruct and right-size culverts
- Improve both retention and detention along banks of creek
- Expand tree canopy especially along trails

Area-specific opportunities

Section A – east of Cooper St

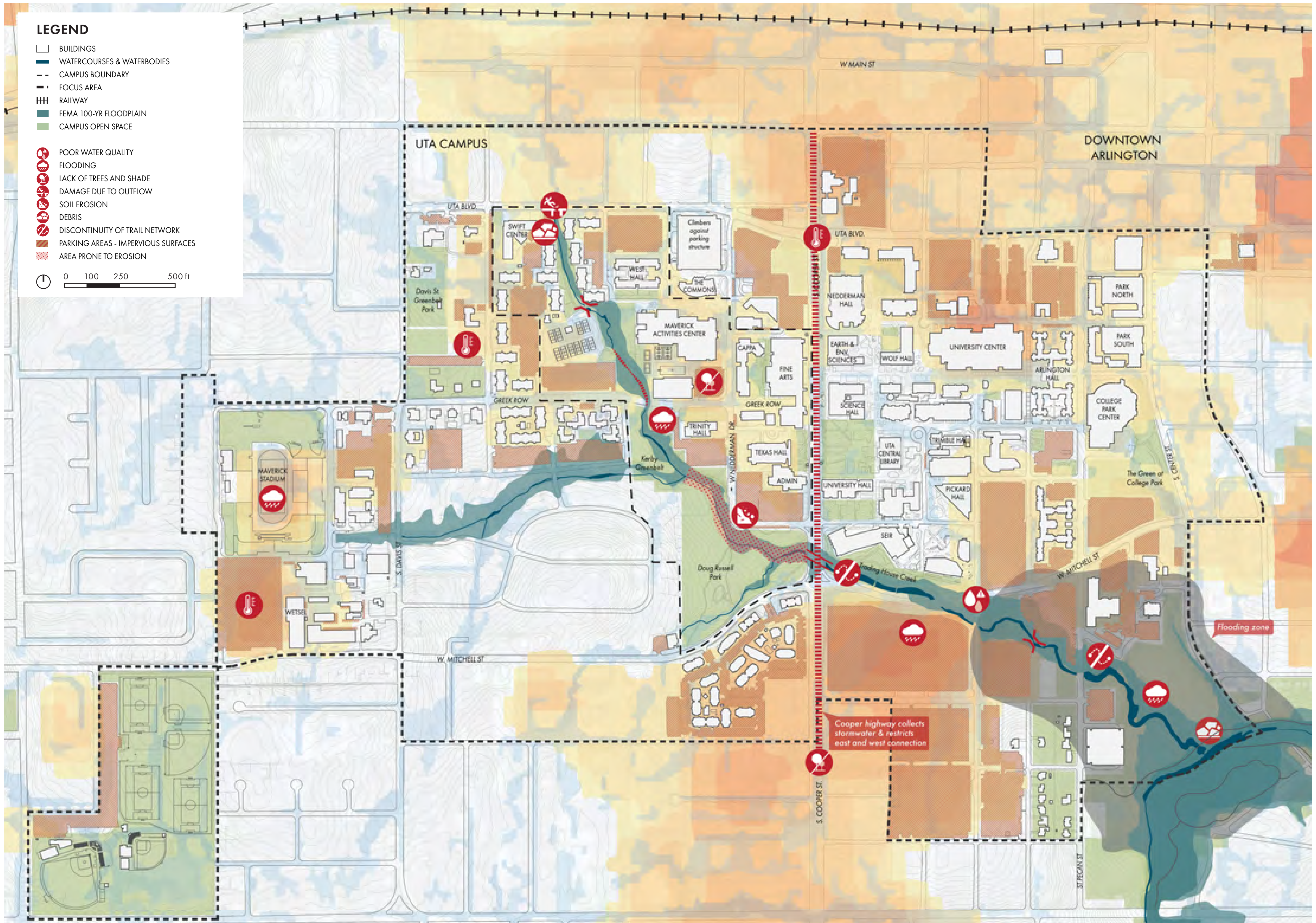
- Build a new trail south of the creek (east of Cooper)
- Add biofiltration strip able to withstand periodic inundation
- Install oil/grit separate in parking lot
- Long term:
    - Improve connection across Cooper
    - Create additional, accessible crossings
    - Expand tree canopy

Section B – Nedderman St

- Create semi-private overlooks for gathering & down to the water access
- Excavate to expand channel capacity
- Naturalize and stabilize the channel with planted slopes, coir logs, and trees

Section C – above Greek Row

- Allow sheet flow into Creek
- Ensure wet weather access
- Improve accessibility of trail

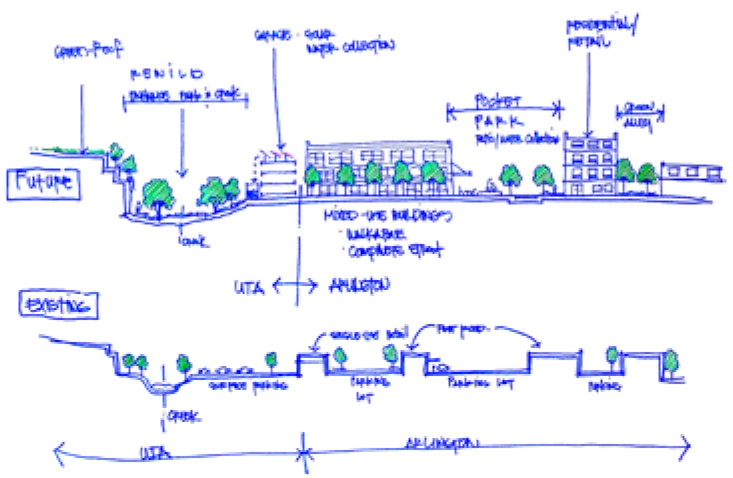



Erosion along Trading House Creek (Source: ONE)

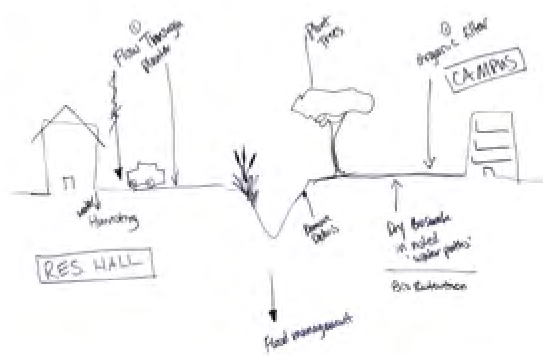
CHARRETTE OUTCOMES: OPPORTUNITIES

Many of the breakout groups illustrated their proposed design interventions with sketches and diagrams, a selection of which are included here.

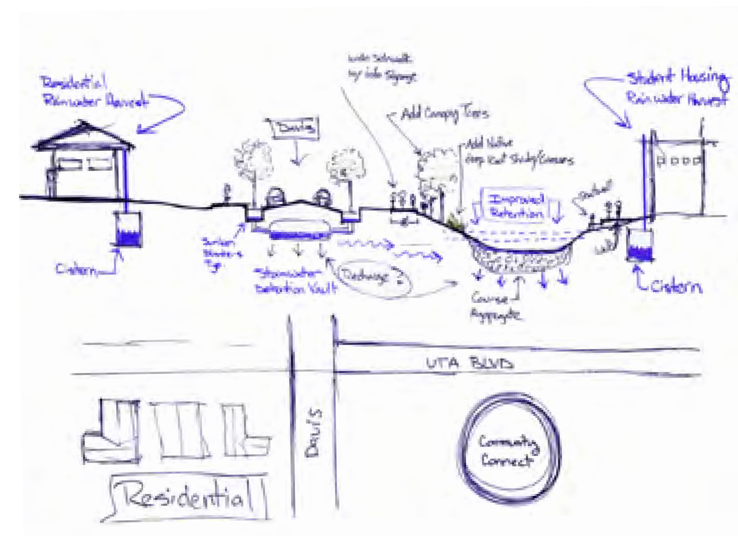
COOPER TRANSECT



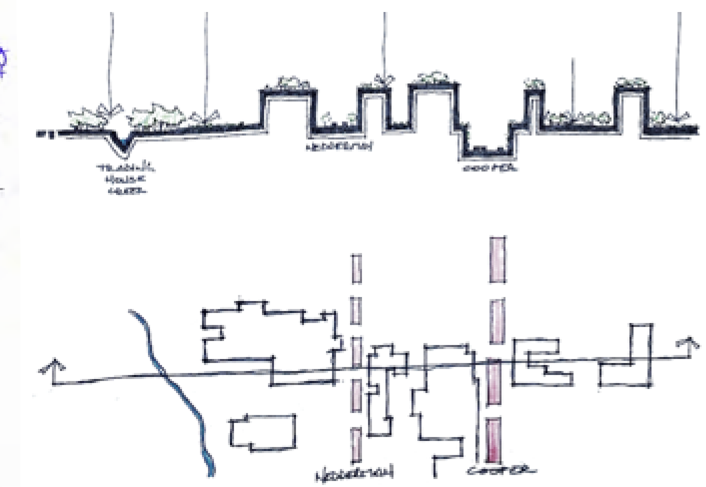
RESIDENTIAL TRANSECT



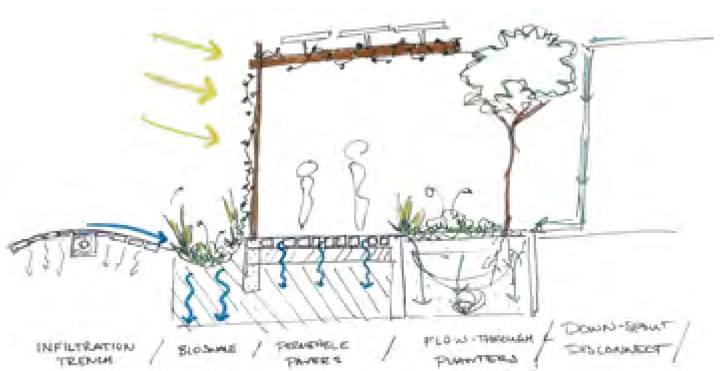
UTA BLVD TRANSECT



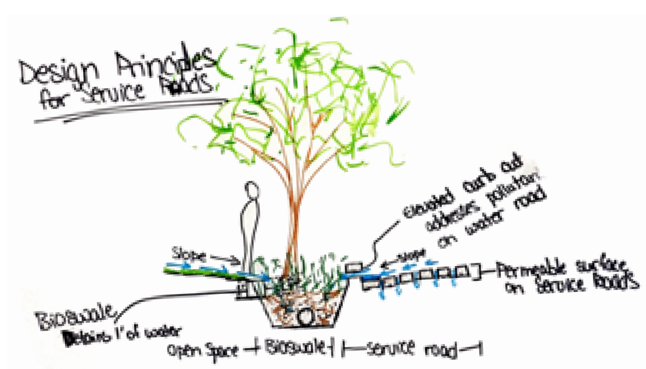
CAMPUS TRANSECT



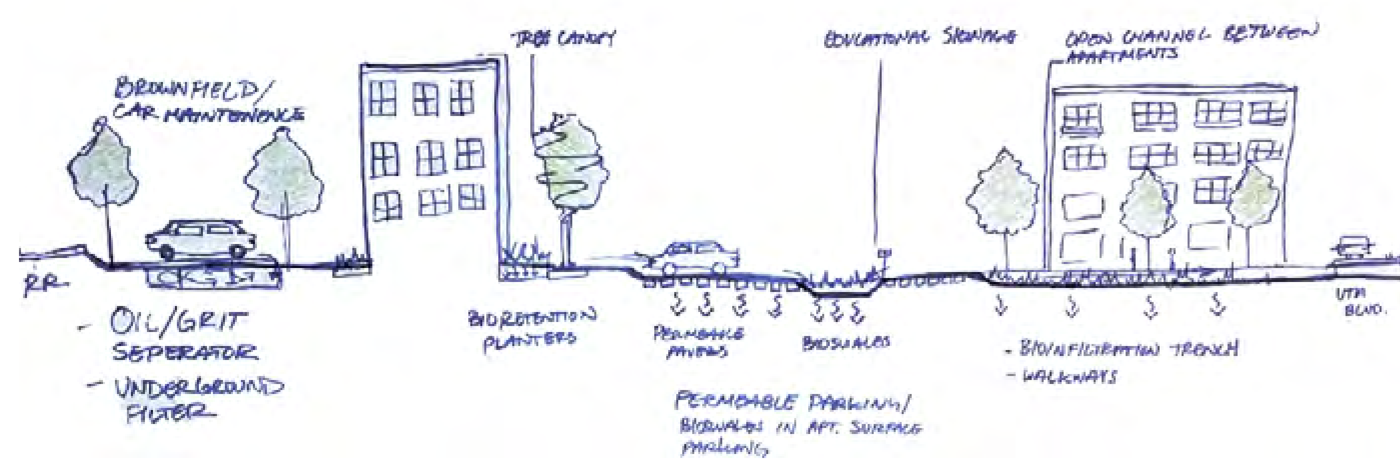
GREEK ROW SECTION



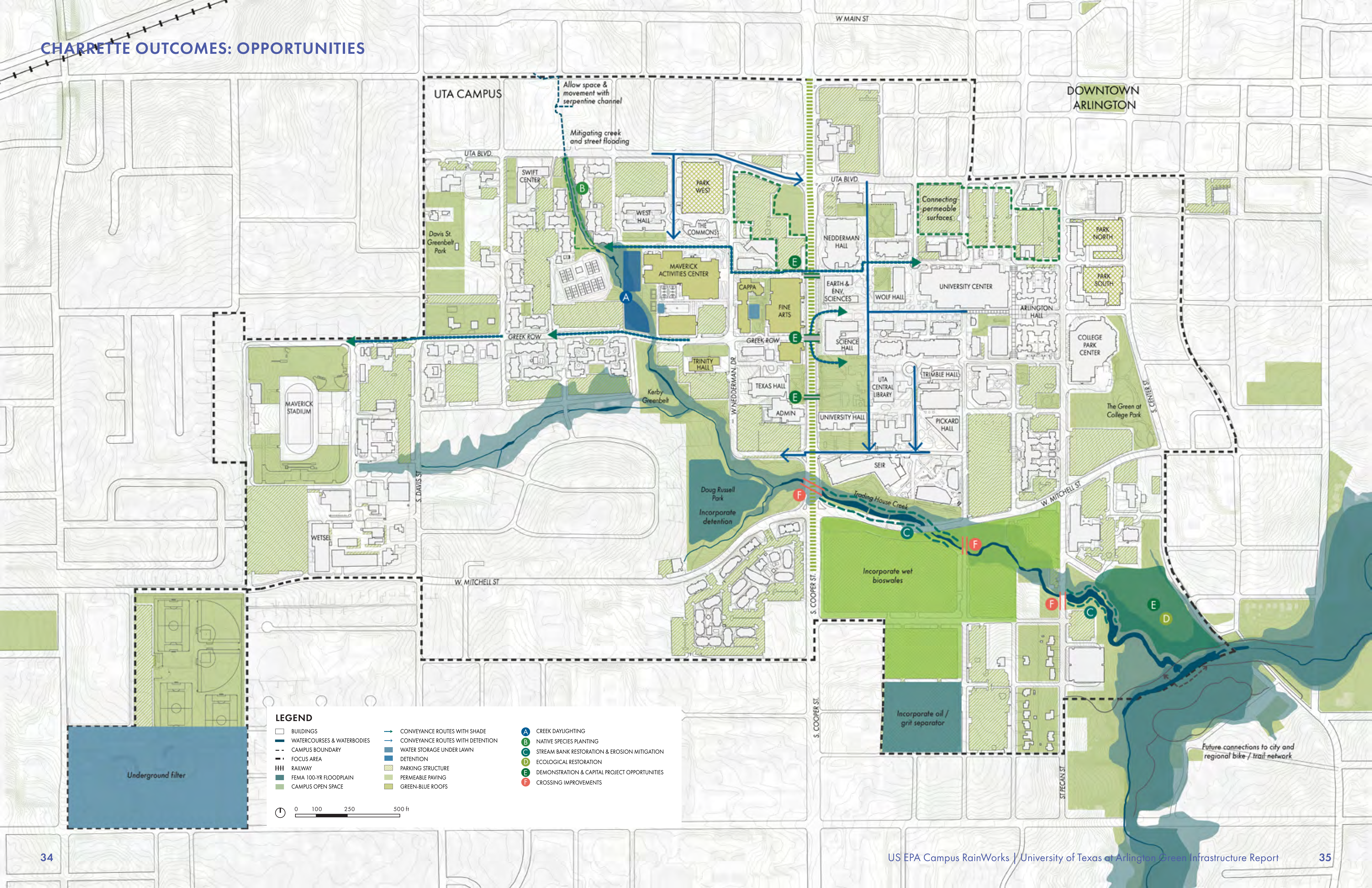
SERVICE ROAD SECTION



BROWNFIELD TRANSECT



CHARRETTE OUTCOMES: OPPORTUNITIES



STRATEGIC GREEN INFRASTRUCTURE FRAMEWORK

This chapter offers a conceptual and spatial approach and direction for considering the integration of green infrastructure on UTA's campus. It starts with a set of guiding principles for green infrastructure planning and describes a methodology that can lead to identifying specific measures and strategic siting or positioning from a functional perspective.

GUIDING PRINCIPLES

The following principles for green infrastructure planning emerged through conversations with the core team, UTA students, faculty, staff, and other stakeholders leading up to and during the charrette. It is anticipated that these offer a starting point for further conversations that will take place during the campus master planning process in the coming year:

- **Put knowledge to practice**
  Build on existing academic work and knowledge to shape campus green infrastructure, sustainability planning, and facilities management; leverage campus capital projects for research and knowledge development.

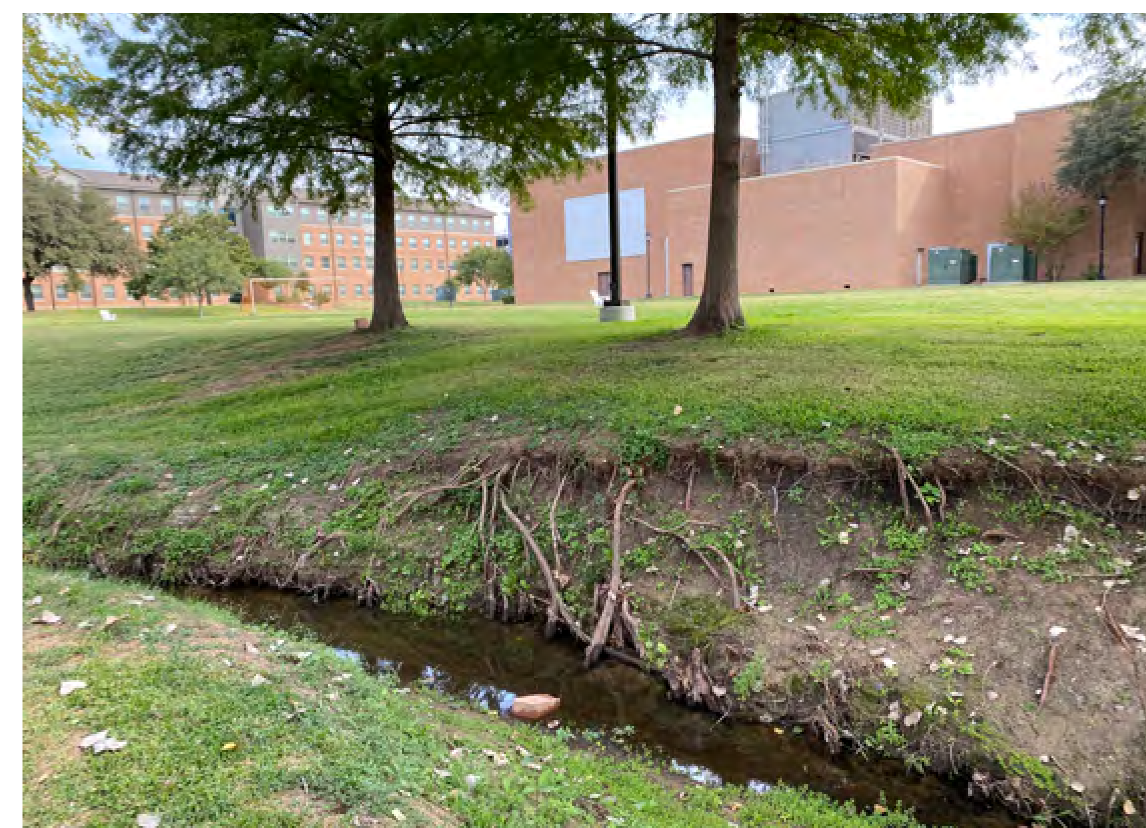
- **Seek multiple benefits**
  Green infrastructure solutions should be integrated with other planning initiatives and placemaking on campus, e.g., creek restoration, trail improvements, recreational amenities, gathering spaces, and building energy performance.

- **Connect communities**
  Enhance and restore connections between campus and city through urban design, recreational trails, and (dry & wet) ecological networks. Consider universal access and the flow of water together to improve accessibility for all users.

- **Align campus planning with natural systems**
  Prioritize naturalized conveyance flows for water and people and locate buildings and infrastructure accordingly. Focus new build areas on higher grounds to avoid flooding and locate the buildings to take advantage of passive shading. Leverage green infrastructure opportunities to store and convey water for placemaking and campus identity.

- **Follow the rain**
  Link green infrastructure interventions to location and function in the watershed; link upper, middle, and lower watershed landscapes to improve ecological health, avoid damages caused by flooding, and deliver co-benefits.

- **Build adaptive capacity for a changing climate**
  Employ an integrated and forward-looking approach to green infrastructure to advance stormwater management, mitigate heat and drought, and improve campus access and experience for today's climate and the future.



Trading House Creek
(Source: ONE / SDE)

VISION FRAMEWORK

A campus framework for designing, implementing, and maintaining green infrastructure for the greatest benefit requires an integrated understanding of the technical optimization of green infrastructure practices to capture and detain stormwater as well as the multiple benefits that the infrastructure provides to campus beyond stormwater management. The framework must draw on and reference the existing environmental constraints and incorporate the opinions and needs of key campus stakeholders: UTA's staff, faculty, students, and visitors.

Watershed analyses are critical to properly locate and size green infrastructure measures and ensure their technical optimization. Individual measures have different intended designs that work in tandem to mimic the water cycle and range between infiltration of water into ground, conveyance of water throughout the watershed, and absorption/storage. These intended designs should be sited across the watershed based on what is naturally happening in the water cycle.

Location in the watershed generally dictates the sizing of green infrastructure interventions. As drainage pathways follow gravity and water seeks the lowest point, what begins as many small streams at the top of a watershed will continually combine and converge, picking up more water along the way until they reach one common study point. This phenomenon explains why watersheds are characteristically large at the top and smaller at the bottom and results in areas of lower watersheds with larger volumes of water and correspondingly larger green infrastructure measures.

When visioning for green infrastructure, location and existing built context (buildings and roads) should be taken into account to understand built impacts on drainage patterns and determine the prioritized design function and size of the green infrastructure, and how much water is expected to reach the feature. In addition to technical optimization, green infrastructure should also be evaluated for its capacity to deliver co-benefits to the campus community.

Intended green infrastructure benefits should be agreed upon and prioritized by key stakeholders during a visioning process to ensure that future green infrastructure designs work in alignment with the desired outcomes. Discussing both the technical and non-technical implications of green infrastructure measures during visioning ensures that the greatest benefit is attained.

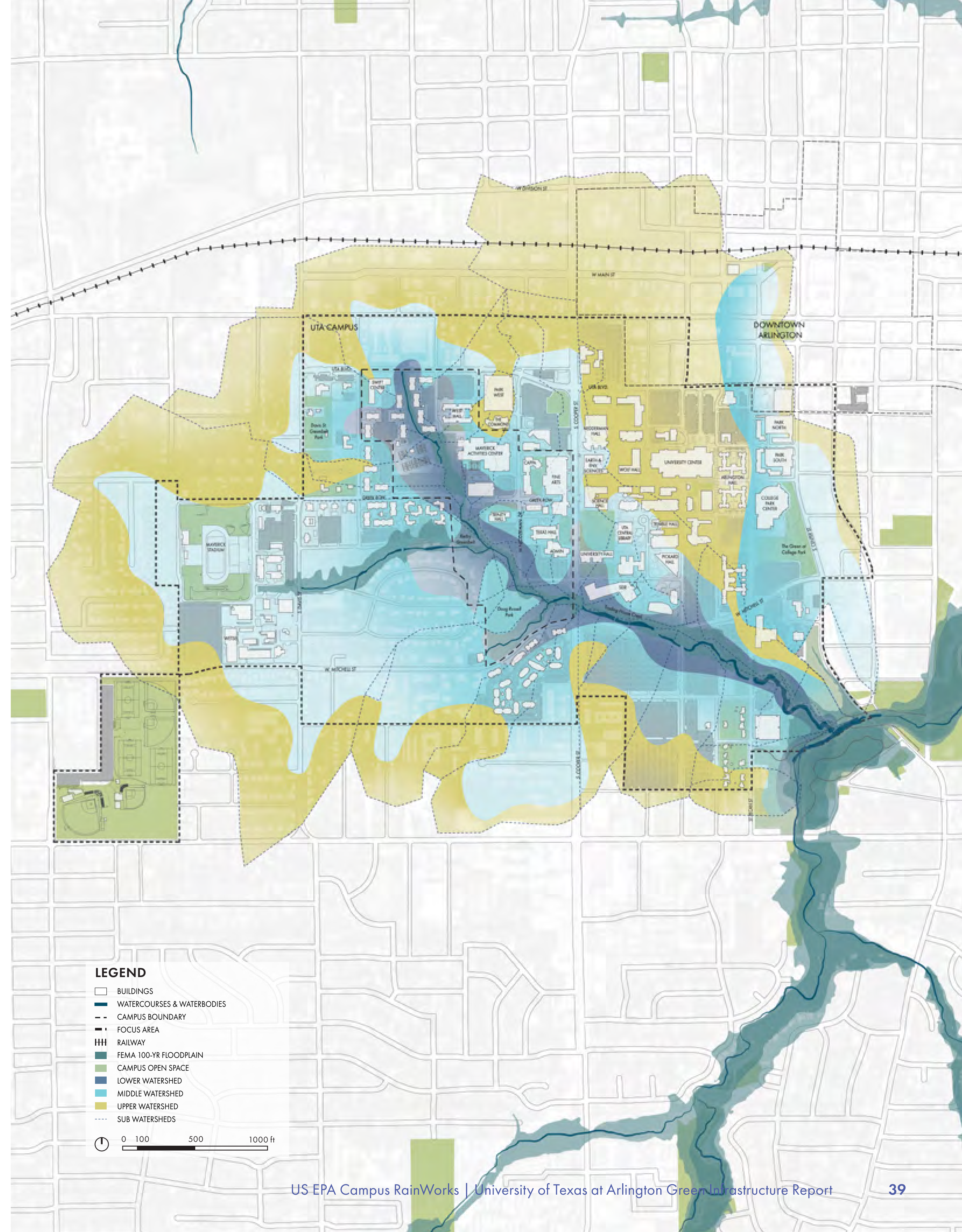
A watershed is typically thought of in three portions, organized by function and each with distinct priorities:

Upper watershed: infiltrate
Infiltration of stormwater into the ground via green infrastructure should be prioritized to mitigate runoff in the upper portions of the watershed and reduce the volume of runoff that reaches the lower portions of the watershed. Conveyance of water to the lower portions of watershed should also be prioritized to mimic surface runoff to lower portions.

Middle watershed: slow & store
As stormwater conveys towards inlets for existing stormwater infrastructure ("gray infrastructure"), stormwater should be slowed down via vegetated waterways, stormwater inlet optimization, and pockets of temporary storage (e.g. cisterns, bioretention areas with outlets). By slowing down the rate at which stormwater reaches this gray infrastructure, stormwater can be more safely conveyed from the upper portions towards the lower portions while mitigating the rate and frequency that infrastructure is over-capacitized.

Lower watershed: restore
Lower portions of watershed should be restored to exhibit the natural drainage patterns and ecological patterns of the area to re-establish the storage capacity and flood-tolerant vegetation that once mitigated further flooding downstream. This is especially important in areas where one waterway has a confluence with another waterway where the confluence of the two waterways may cause additional backups of water due to hydraulic interactions.

opposite:
UTA campus hydrology and conceptual watershed maps (Source: ONE / Sherwood)



GREEN INFRASTRUCTURE MEASURES & CONSIDERATIONS

The following pages offer an approach to identify and compare potential green infrastructure measures for their applicability and compatibility with campus conditions. The reference and approach can complement other campus planning activities and ongoing facilities investments.

A green infrastructure prioritization matrix can support future campus planning activities and offer a reference to summarize the design criteria of various green infrastructure measures as they relate to ecological, economic, and community considerations. The intent of the matrix is to provide campus stakeholders a starting point to consider and evaluate common green infrastructure approaches based on their suitability to site conditions, in order to advance implementation of green infrastructure on campus. The matrix describes a way to compare green infrastructure strategies and provides select technical criteria as a starting point for analysis. All measures are either mentioned specifically in non-jurisdictional Integrated Stormwater Manual by the North Central Texas Council of Government (NCTCOG) or are industry-standard practices. Guidance for industry-standard practices are taken from the Georgia Stormwater Management Manual (GSMM), which is considered by EPA as one of the leading guidance documents for green infrastructure in the nation, in the absence of specific EPA guidance. Specific approaches or footnotes are listed below the table, where applicable.

Ecological Considerations characterize design criteria and recognize the importance of co-benefits for the natural environment. They include position in the watershed based on the framework of general applicability or specific applicability to the upper, middle, or lower watershed. This category also gives an indication of the ecological co-benefits that green infrastructure can deliver, including making a contribution to the restoration of the natural environment or the provision of habitat.

Economic Considerations evaluate the relative cost for both one-time installation and recurring maintenance costs. Cost data were based on guidance provided by both NCTCOG and GSWMM, with preference to the NCTCOG guidance where available. Unit costs are relative due to uncertainty around site-specific conditions and the changing fiscal context, driven by inflation and supply-chain operations. Still, green infrastructure interventions are generally found to be cheaper to maintain than traditional "gray infrastructure" solutions (i.e. subsystem pipe networks) due to the self-sufficiency of the vegetation within green infrastructure.

Community Considerations evaluate the societal implications of green infrastructure, including the impacts that interventions have on the campus's integration with surrounding neighborhoods, the collective campus's environmental stewardship, contiguous campus character, compliance with governmental regulations. Evaluation of considerations related to permitting/coordinating correspond to the level of inter-organizational coordination and scale of the project. Metrics that are evaluated in this category, with their associated considerations, include:

- <u>City-Campus Integration</u>: The degree to which the green infrastructure facilitates benefit to surrounding neighborhoods or provides connections between the Campus and neighborhoods
- <u>Environmental Stewardship</u>: The degree to which an intervention contributes to the Campus's overall sustainable use and protection of the natural environment
- <u>Aesthetic Value & Placemaking Opportunity</u>: The degree to which green infrastructure offers additional benefits to the Campus in terms of improving aesthetics, facilitating continuous Campus character, and orienting infrastructure around the Campus employees and students.
- <u>Permitting/Coordinating</u>: The degree to which extensive permitting or inter-organizational coordination is necessary, as a result of the scale or complexity of the measure.
- <u>Benefit to MS4 Compliance</u>: The degree to which the green infrastructure advances the Campus towards MS4 compliance by either reducing the amount of impervious area that exists or by increasing the amount of impervious area runoff that is treated by green infrastructure (less relevant for UTA).

Technical Criteria (see appendix) outline the physical requirements for the range of green infrastructure measures. Wherever possible, they reference guidance provided by the NCTCOG Transportation Integrated Stormwater Manual. In the absence of explicit guidance from NCTCOG, guidance references the Georgia Stormwater Management Manual, known as one of the most reputable and comprehensive stormwater design manuals in the nation.

Green infrastructure strategies are evaluated based on their relative benefit to the campus or surrounding communities.

Stormwater Management & Cloudburst Mitigation
The strategies that apply to managing moderate rain events can also apply to managing cloudbursts, or extreme rainfall events. A layered approach that introduces a hierarchy of flooding can ensure capacity for a range of rainfall volumes. For example, measures such as green roofs and infiltration trenches can hold a certain amount of water as rain accumulates, and as they reach capacity, stormwater could flow to and be detained in larger areas (e.g., bioretention features, detention ponds, flood management areas).

Application of the Matrix
The matrix is deliberately non-determinant; it is a tool that could be used alongside and in concert with other technical and value-based evaluation frameworks and inputs to explore the range of green infrastructure strategies that might be suitable for a given location on campus. The utility of the matrix builds on the cloudburst visioning process, which remains the fundamental step to envision the benefits and scale of green infrastructure projects.

After the visioning process, this green infrastructure prioritization matrix can be referenced as an interim step to further define and understand the applicability of green infrastructure measures to the site-specific conditions of the campus. The assessment of constraints can help guide the selection of which interventions should be further evaluated for construction. The matrix does not replace the need for more detailed site analysis, engineering, and design to select a green infrastructure approach and develop a detailed design concept.

GREEN INFRASTRUCTURE MATRIX

MEASURE NAME	ECOLOGICAL CONSIDERATIONS		ECONOMIC CONSIDERATIONS		COMMUNITY CONSIDERATIONS				
	Location in Watershed	Ecological Co-Benefits	Relative Initial Cost	Relative Maintenance Cost	Integration with Neighborhoods	Environmental Stewardship	Aesthetic Value & Placemaking Potential	Permitting / Coordination Complexity	Benefit to MS4 Compliance
	Upper, Middle, Lower	Low, Medium, High	$ / $$ / $$$	$ / $$ / $$$	Low, Medium, High	Low, Medium, High	Low, Medium, High	Low, Medium, High	Low, Medium, High
Green Roofs	All	Medium	$$$	$$$	Medium	Medium	High	Medium	Medium
Rainwater Harvesting	All	Low	$$	$	Medium	High	Medium	Medium	Medium
Oil Grit Separator	All	Low	$	$$	Medium	Medium	Low	Medium	Low
Downspout Disconnect	All	Low	$	$$	Medium	High	Low	Low	Low
Site Reforestation / Revegetation	All	High	$$$	$	High	High	High	Low	High
Infiltration Trench	Upper	Medium	$	$$	Low	Medium	Medium	Low	Low
Permeable Pavers / Surfaces	Upper	Medium	$$$	$$	Low	Low	High	Medium	Medium
Organic Filter	Upper	Medium	$$	$$	Low	Medium	Low	Low	Low
Surface Sand Filters	Upper	Low	$$	$$	Low	Low	Low	Low	Medium
Bioretention	Upper/Middle	High	$$$	$$	Medium	High	High	Medium	High
Flow-Through Planters / Landscape Infiltration	Upper/Middle	Medium	$$	$	Medium	Medium	High	Low	Medium
Dry Well	Upper/Middle	Medium	$$	$$	Low	Low	Low	Medium	Low
Dry Bioswales	Middle	Medium	$$$	$$	Medium	Medium	High	Medium	Medium
Wet Bioswales	Middle	Medium	$$$	$$	Medium	Medium	High	Medium	Medium
Dry Detention Pond	Lower	Medium	$	$$	Low	Medium	Medium	Medium	High
Extended Dry Detention Pond	Lower	Medium	$	$$	Low	High	Medium	Medium	High
Wet Pond	Lower	High	$	$$	Medium	High	Medium	High	High
Pocket Pond	Lower	Medium	$	$$	Low	Medium	Medium	Medium	Low
Underground Filter	Lower	Low	$$	$	Low	Low	Low	Medium	Medium
Flood Management Area	Lower	Low	$	$	Low	Medium	Medium	Medium	Low
Stormwater Wetland	Lower	High	$$	$	High	High	High	High	Medium
Pocket Stormwater Wetland	Lower	Medium	$$	$	Medium	High	Medium	Medium	Low
Stream Restoration	Lower	High	$$$	$	High	High	High	High	Low

Notes

Watershed location:
Based on the priorities listed for each portion of watershed. Upper Watershed: Infiltrate, Convey Downstream; Middle Watershed: Slow Water Flows through storage, Divert Flows from Problem Areas, Convey Downstream; Lower Watershed: Absorb and Store.

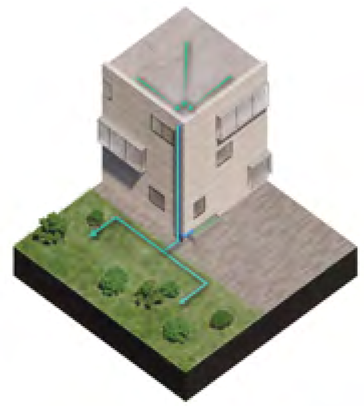
Ecological co-benefits:
Evaluation considers the ancillary benefits associated with the incorporation of green infrastructure on campus, including the provision of habitat within the green infrastructure and the mitigation of Urban Heat Island Effect through the decrease of impervious area or the increase of tree canopy.

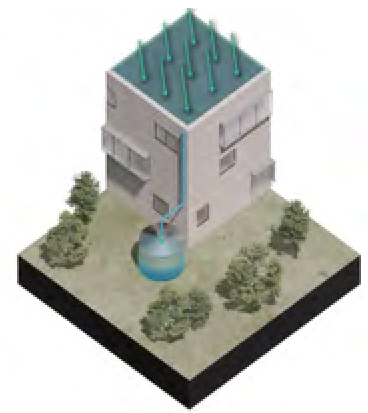
Costs:
Due to the unavailability of data from the Integrated Stormwater Manual, costs were taken from Volume 2 of the Georgia Stormwater Management Manual (2016) and NOAA Guidance for Cost Estimations of Nature Based Solutions (2020). Costs are considered in terms of price per square foot (SF) that is treated by the measure.

Permitting:
Evaluation based on the degree to which the GI either reduces the amount of impervious area or treats the stormwater that generates from impervious area on campus.

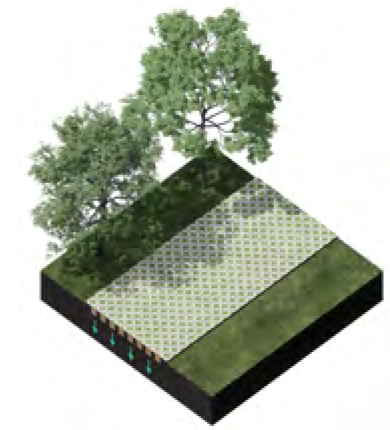
GREEN INFRASTRUCTURE MEASURES

Upper watershed strategies
Middle watershed strategies
Lower watershed strategies

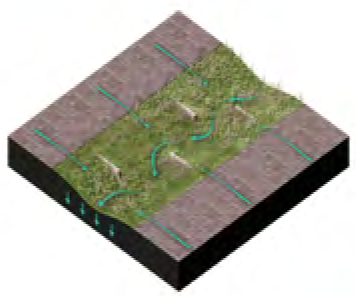

Downspout Disconnect

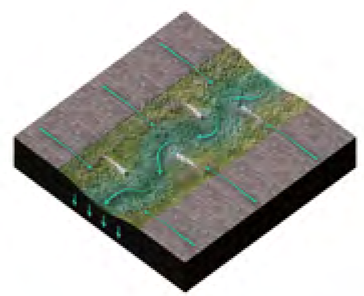

Rainwater Harvesting


Green Roofs


Permeable Pavers / Surfaces


Flow-Through Planters


Dry Bioswales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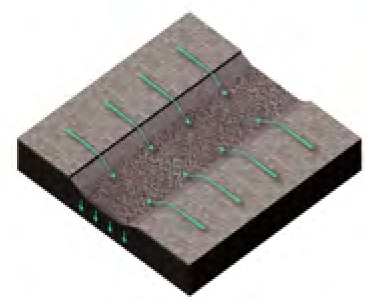
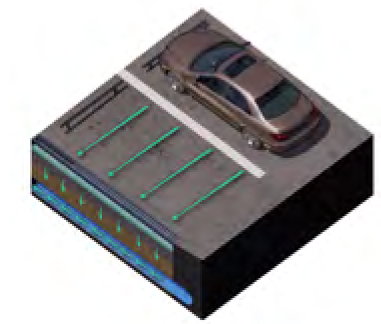

Infiltration Trench


Oil / Grit Separator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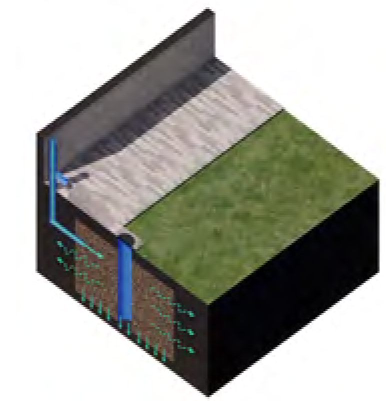
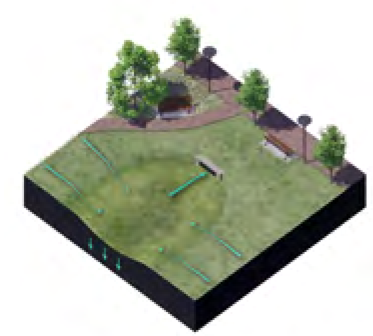

Dry Well

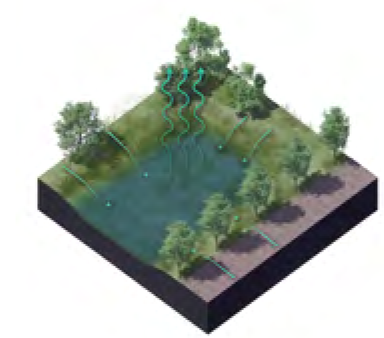

Bioretention


Organic Filter


Surface Sand Filters

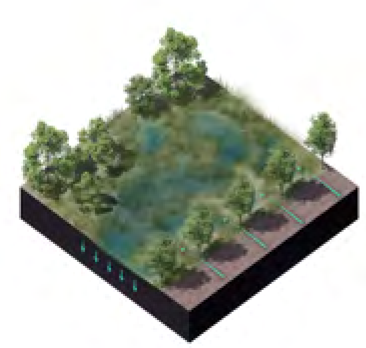

Dry Detention Pond


Extended Dry Detention Pond


Wet Pond

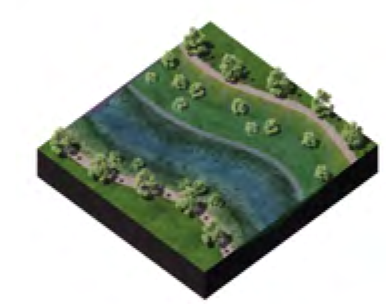

Pocket Pond


Pocket Stormwater Wetland


Stormwater Wetland


Site Reforestation / Revegetation


Stream Restoration


Flood Management Area

GREEN INFRASTRUCTURE OPPORTUNITIES

The following pages elaborate the key opportunities for climate-responsive campus green infrastructure that emerged during the charrette process, building upon existing campus planning concepts, initiatives, the previous Campus RainWorks entries, and charrette discussions as applicable. In addition, several non-structural opportunities have been identified.

Campus Collaborations & Research

Green infrastructure research and implementation can be a source of motivation to strengthen existing and explore new collaborations across UTA. These projects can expand interdepartmental collaborations and education, both across the design, planning, and engineering disciplines and the wider university. They can also represent a venue for faculty and staff to collaborate as well as offer research design and learning opportunities for students at all levels. Monitoring and adaptive management of campus green infrastructure can support long-term research trajectories and hands-on experience on campus and in partnership with the city.

Cloudburst Vision Development

A cloudburst vision is a comprehensive strategy for extreme precipitation events that describes where stormwater should and can be detained, conveyed, or stored and infiltrated. A vision requires a detailed understanding and modeling of campus physical and ecological conditions to describe a range of strategies working in concert to manage stormwater during a flash flood. The cloudburst project could be an excellent opportunity for students and faculty from multiple departments (landscape, engineering, planning, architecture) to collaborate with facilities and maintenance staff to develop research on existing conditions and projected climate scenarios and build toward a comprehensive strategy for campus water management and planning, connecting adjacent neighborhoods to campus facilities, landscape, and watercourses. It also supports incorporating a wider cloudburst strategy into subsequent projects to ensure they work toward the broader goal of a climate resilient campus.

UTA as Green Infrastructure Urban Lab

As a leading research institution with a rapidly growing campus, UTA is well-positioned to become a laboratory for green infrastructure research and design and resource to the whole region. The Urban Lab can bring together research, curriculum, and the physical campus in a single home that facilitates interdisciplinary connections and cross-campus collaborations. The Lab could support, facilitate, and formalize the following activities, among others:

- Research support and coordination
- Interdisciplinary course development
- Interdepartmental relationships
- Student and faculty engagement in facilities master plan
- Design of pilot projects
- Climate action and adaptation leadership
- Input into implementation of capital projects and integration of green infrastructure components
- Monitoring and adaptive management of campus green infrastructure

Identity & Placemaking

UTA has demonstrated a commitment to sustainability on campus, and green infrastructure implementation can become a tangible extension of this leadership. Stormwater management can be combined with recreational spaces such as water squares, outdoor theaters, or sports facilities, while green infrastructure features with their natural shading capacities can enhance walkways and open spaces for the UTA community and campus visitors. These measures can contribute to managing extreme weather in a changing climate. A paradigm shift toward native plantings may require education, signage, and new maintenance practices to be successful. Over time, green infrastructure can become a key feature of UTA's image and identity, even becoming attractive to campus donors interested in green legacy projects.

Communication & Education

UTA can also endeavor to raise the visibility of green infrastructure that is already existing on campus. These projects often serve multiple goals: managing stormwater, improving water quality of runoff for low-intensity rainfall events, and holding water to mitigate extreme storms as well as contributing to placemaking, urban design, and public health. During cloudburst events, storage is key. Identifying areas of campus where storage is already taking place can help communicate the intentional design of these spaces and encourage campus stakeholders to see their value.

Campus Buildings

There are opportunities to embed green infrastructure in buildings through campus capital projects for renovation as well as new construction. As a starting point, assess the feasibility of retrofitting existing structures for detention with green and blue roof systems. New construction projects can be designed to incorporate green roofs, provide detention tanks for gray water systems, or connect drainage systems to utilize gray water for landscape irrigation. In conjunction with cloudburst vision development, the campus capital program can establish stormwater management standards and targets for new buildings, starting with pilots and then expanding across the campus.

Paths & Open Spaces

Campus sidewalks and path networks are a design opportunity to address stormwater and heat together as well as encourage pedestrian mobility while reinforcing campus identity. Tree planting efforts along pedestrian routes and pathways can provide shade and mitigate summer heat and sun exposure while improving retention (via root systems). Shade structures such as pergolas are a shorter-term solution than trees to provide much-needed shade along key routes, and they can host climbing plants linked to bioswales. Meanwhile, impermeable surfaces can be redesigned with more permeable solutions, and native plants and bioswales along these routes can further improve retention and infiltration.

There are also opportunities for campus open space design, notably investing in the tree canopy and shifting the planting paradigm. While UTA has a robust canopy, there are gaps to fill and opportunities to do so with tree species that provide shade to mitigate summer heat while being resilient to drought and cloudburst conditions. Investment in campus landscapes can prioritize native plantings and strategically rewild the campus, considering use, history, and culture.

Campus Roadways

As explored during the charrette, the road network within and around UTA's campus represents a critical opportunity to integrate green infrastructure and holistic thinking about stormwater management for ecological value, improved access, and climate resilience. Roadway interventions can build on an overall campus cloudburst vision. For example, rain roads can combine mobility and conveyance, utilizing a convex grading profile to holds and convey water during cloudburst events. Service roads or other low-traffic routes can combine conveyance with retention, including permeable pavement, roadside plantings, and bioswales to slow the flow of water. More generally, revisiting campus roadway widths can lead to the identification of opportunities for road diets and free up space for green infrastructure.

Parking

Parking demand has soared as the campus has grown in recent decades. The construction of surface lots has converted a significant fraction of campus lands to expanses of asphalt with limited if any planted areas. Going forward, a shift to structured parking can reduce the total footprint on campus, while surface lots can be greened with plantings and trees and retrofit to incorporate more permeability. Treating rainwater where it falls with biofiltration and bioretention can help reduce runoff and pollution flowing into the creek, while tree planting can improve the performance and comfort of these spaces during hot summer months.

Trading House Creek

The Creek is a major feature and implicit boundary of UTA's campus, and planning for its restoration represents a key opportunity to reconnect campus built with natural systems. Daylighting the creek within the campus can help reduce severe erosion and safety issues during flood events, while river corridor and riparian zone restoration with stormwater wetlands, revegetation and regrading of the lower slopes, and native plant buffers can support creek habitat development. Creekside trails can be more deliberately integrated to improve watercourse ecology with bioswales and planted buffers to detain stormwater entering the creek, improve biofiltration, and manage erosion. An expanded tree canopy can provide shade and improve retention. All interventions along the creek can serve the dual goals of improving natural ecology and enhancing recreational potential, reinforcing Trading House Creek as a celebrated asset and core aspect of the campus identity.

Trail Network Opportunities

The city and campus trail systems can be unified, both with physical links to connect discontinuous trail segments, improved connectivity especially where trails cross roadways, and integrated communication approaches such as a wayfinding system to improve navigation, provide educational assets, and give the system a recognizable identity. Investments in the trail experience can focus on spaces for access and gathering, safety (both lighting and protecting users from steep embankments), as well as amenities such as seating along the route. Trailheads, overlooks, and get downs are examples of pausing and gathering spaces that can integrate green infrastructure with education (through signage, monitoring, etc.) and recreation. Over the long term, the focus can shift to expanding the system, including creating paths on both sides of Trading House Creek and ensuring the trail is accessible for all users.

Campus-City Connectivity

While the city grid extends seamlessly from downtown Arlington onto the campus to the north and east, the vehicle-oriented design of the roadways plus threshold spaces occupied by parking lots create an implicit barrier between city and university. To the south and west, the diagonal trajectory of Trading House Creek interrupts the street grid and results in few access points between city and campus. Within the campus, the six-lane highway of Cooper Street cleaves east campus from west, with few bridges to link across. Strategies to overcome this barrier, such as adding bridges or decking over, can improve inter-campus mobility and access.

Placemaking efforts can begin by rethinking the campus edges and transitional spaces. Expanding the number of pedestrian connections across Cooper Street and Trading House Creek is another important aspect. Finally, designing for pedestrian and bicycle mobility first could help encourage mode shift for campus commuters and area residents.

Aerial views of the UTA campus and Cooper Street (below) (UTA, 2022)

NEXT STEPS: IMPLEMENTATION, MAINTENANCE & FUNDING

Implementing green infrastructure at UTA will be an ongoing process as the campus continues to grow and evolve. This chapter provides a starting point for exploring and evaluating green infrastructure measures relevant to UTA's campus and an overview of the time frames, partners, and potential funding sources for future work.

QUICK WINS

The charrette underscored UTA's commitment to continuing to implement and expand the use of green infrastructure on campus in keeping with its environmental commitments. The measures outlined in the matrix vary in how easily they can be integrated into the existing campus context and the level of planning and coordination required for implementation.

There are, however, some measures that may be relatively simpler to integrate into the existing campus context in the near term while adding value for stormwater and heat mitigation. These are typically green infrastructure strategies that increase permeability and stormwater reuse at a small scale. Examples of potential quick win projects include:

Small-scale revegetation of open spaces
Removing turf lawns and reintroducing native plants and grasses can increase on site stormwater retention and infiltration while increasing the habitat value of an area. Revegetation projects require, however, an understanding of the historic / cultural significance and functional needs of campus spaces.

Small-scale rainwater harvesting
These systems put rainwater to use for landscape applications, typically offsetting the use of potable water for irrigation purposes. They could be implemented at a range of locations on campus where landscape features and a need for additional irrigation already exist. These systems only require cisterns and connecting downspouts from roof to landscape and are limited in scope of impact to the roof of whichever building the rainwater is collected.

Increasing permeability & vegetation in parking areas
Swapping out impervious materials can incrementally improve the performance of campus open space through the increase of available space for runoff infiltration. Bioswales, planted areas, and permeable pavers require routine maintenance to perform, so this measure must be supported by the establishment of a green infrastructure maintenance program.

CAMPUS RAINWORKS ENGAGEMENT

The Campus RainWorks competition represents a continuing source of engagement and motivation for UTA faculty, facilities staff, and students to advance green infrastructure research, planning, design, and engineering. Many of the ideas and topics that emerged from the charrette can become topics or issues for future semester projects, capstones, and competition submissions. These include, among other topics:

- Continuing engagement with the restoration and integration of Trading House Creek into the UTA campus as an invaluable asset for ecological restoration, recreational value, campus identity, water management, and climate resilience.
- Green infrastructure strategy and site design for new buildings on campus as well as restoration/ retrofit projects for buildings and open spaces.
- Initial groundwork to develop campus planning initiatives, such as examining green infrastructure as part of open space and recreation, mobility, or climate action and resilience visions.
- Develop modeling and decision support tools for campus and community stormwater management projects.
- Applying open-source tools and resources, such as EPA's Storm Water Management Model (SWMM) software.
- Piloting and documenting maintenance and stewardship initiatives to support ongoing student engagement in green infrastructure installations on campus.

Ongoing participation in Campus Rainworks provides a venue, framework, and motivation to engage further with existing campus constraints and opportunities. For example:

- Providing research and other groundwork in support of future green infrastructure grant applications.
- Establishing engineering criteria or exploring alternative design concepts to jump start or advance campus capital projects.
- Exploring and testing design strategies for campus buildings, roadways, open spaces, and natural resource management to be incorporated into campus master planning initiatives.
- Reinforcing communication and expanding collaborative relationships between students, faculty, staff, and community stakeholders.

Competition submissions can equally be unique projects or multi-year research initiatives, building a deeper understanding of the campus context, needs, and site/engineering analysis.

UTA CAMPUS MASTER PLAN

UTA completed its most recent campus master plan in 2005, and has been growing rapidly in the years since, adding millions of square feet of buildings and parking facilities (see page 8). Its upcoming master plan will guide the next decade of growth and strategic investment; it is a key opportunity to connect water planning and management to the university's growth strategy.

Integrating green infrastructure in the vision for the campus and giving consideration to watersheds and underlying natural systems is critical to improve the resilience of campus buildings, infrastructure, and open space and ensure adaptive capacity in a changing climate. As described throughout this report, green infrastructure can also support efficient use of resources, improve livability and especially help manage extreme rain and heat events, reinforce campus identity and placemaking, and link to mobility and circulation strategies.

Developing and applying a set of principles for buildings, roads, trails, and open spaces in the master plan can establish a structure and direction to guide subsequent capital projects.

STRATEGIC PATHWAYS

The upcoming campus master plan will be an important opportunity to integrate and address many of the ideas that surfaced during the design charrette. However, there are many ideas and recommendations that could be further developed independent of a master plan – even during the coming academic year, as faculty and staff capacity allows.

Immediate / Near-Term (1-3 years)

- Campus master plan: establish a direction and agenda for later work
- Focus on initiatives and projects that build consensus around a campus vision for green infrastructure, water planning, and climate resiliency
- Seek partners and collaborators in the work at a local, city, and regional scale.

Mid-Term (3-5 years)

- Focus on program development
- Master plan implementation – capital projects
- Campus capital projects: pathways, roads, buildings, parking, open space
- Placemaking & connectivity between City and campus
- Trail system improvements and expansion (UTA & City partnership)
- Trading House Creek restoration (UTA & City partnership)
- Laying the groundwork for longer-term stewardship of natural resources on campus and citywide.

Long-Term (5 plus years)

- UTA established as academic leader in green infrastructure and water planning and urban lab for the metropolitan region
- Ongoing support for upscaling of best practices and knowledge development in the region

GREEN INFRASTRUCTURE MAINTENANCE

Maintenance demands are an important consideration, given the potential impact of green infrastructure on facility teams and recurring budgets. While green infrastructure is often thought of to be a less time-intensive, more cost-effective solution as compared to traditional "gray" stormwater infrastructure, maintenance of these systems, and in some cases, adaptive management strategies are key to ensuring performance over time. Maintenance efforts vary by green infrastructure typology, but usually include efforts to remove accumulated sediment and pollutants, clean out underdrains (where these have been installed within measures to ensure conveyance), and remove trash/debris. Intervention-specific maintenance requirements for each green infrastructure typology should be referenced in jurisdictional stormwater guidance documents during master-planning to ensure feasibility within constraints of economic and staffing capacities.

FUNDING FOR RESEARCH AND IMPLEMENTATION

Funding Considerations

Funding mechanisms are a primary avenue for overcoming monetary constraints related to implementing green infrastructure projects and corresponding initiatives on campus. Such funding can be awarded to facilitate either the construction of green infrastructure or the operations of a recurring program such as research, maintenance, or facilitation of watershed awareness programs.

Local, state, or federal agencies, as well as private funders, offer various types of funding throughout different phases of project development, including planning, engineering design, and construction. Obtaining funding from these sources usually requires an application that includes a narrative component and additional documentation such as letters of support and cost estimates. Considering the following factors can help to filter through opportunities and identify the most suitable ones:

<u>Co-alignment with Funder: Do the intended project outcomes align with the mission of the grant and the funder?</u>
Consider both the primary and ancillary benefits that the project's impacts could have on the community to maximize eligible funding opportunities, such as regional flood resilience, the creation of open space/trails, and the provision of jobs in the local economy.

<u>Funder Giving History: Is the funder's giving history indicative of meeting funding needs?</u>
Evaluate the funder's giving average/median, preferred areas of focus, and historical trends, which are typically made publicly available via tax forms and can be referenced by grant writers.

<u>Desired Level of Risk: What level of risk is the applicant willing to take when applying for grants?</u>
Is the grant applicant in the position to accept a higher level of inherent risk and apply to only one grant that addresses all portions of the project, or are they better suited to apply for multiple grants that each satisfy different components of the project to reach complete funding? Is the grant applicant in a position that is better suited to apply to large funding programs where awards are typically larger but there are a higher number of competitors or is a local fund with smaller rewards better suited for the project?

<u>Logistical Feasibility: Does the applicant meet all logistical prerequisites to be eligible for the grant?</u>
The project and applicant must meet the following common prerequisites: minimum funding match requirements from the applicant, project completion timelines, and monitoring/reporting requirements. The following describes a general approach and steps to identifying funding opportunities.

<u>Project Documentation</u>
Before applying for funding, the applying party should evaluate and document the logistics and guiding principles of the project (e.g. project mission, desired project impacts, desired timeline, what would be funded and how much is needed, etc.). This helps the applicant envision project impacts, identify the needed funding sources, and focus funding pursuit towards concerted efforts.

<u>Opportunity Query</u>
Query postings from available funding databases (local, state, federal, and private) based on applicable funding caps, funding needs, project location, and fields of work. States and federal agencies usually have funding databases on government websites that can be leveraged for holistic-level query functions. Private funding opportunities are typically decentralized in postings, but subscription databases can compile them.

<u>Initial Filter</u>
Conduct a first filter of all opportunities queried in the first round to identify the opportunities that are most logistically feasible based on eligibility criteria (e.g., type of applicant, type of project, funding deadline). Consider application requirements, as many projects limit eligible applicants to government jurisdictions. An application could be submitted as a partnership between UTA and an eligible applicant.

Funding Program	Eligible Projects	Purpose of Fund	Application Deadline
TCEQ Nonpoint Source Grant Program	Initiative Planning Programs; Capital Project Implementation or Restoration Project, Community Outreach/ Education Programs	To fund projects that provide any of the following: education and outreach designed to motivate changes in behavior that reduce non-point source (NPS) pollution; Implementation of both technology-based and water quality–based management measures to address NPS pollution; and protection of unimpaired waters.	Annually in Fall
US EDA Public Works and Economic Adjustment Assistance Programs	Engineering Design, Capital Implementation Project	To fund projects that lead the Federal economic development agenda by promoting innovation and competitiveness and address the following priorities, among others: Equity, Recovery & Resilience, Environmentally Sustainable Development.	Rolling
US NFWF America the Beautiful Challenge	Initiative Planning Program, Engineering Design, Capital Implementation Project	To fund projects that enable applicants to implement on-the-ground conservation activities or otherwise lead to on-the-ground implementation that benefits habitat connectivity, strengthening of ecosystem services, expansion of community access to nature, and facilitation of community resilience.	Annually in Summer
EPA & NFWF Five Star and Urban Waters Restoration Grant Program	Restoration Projects; Community Outreach/ Education Programs	To fund projects that develop community capacity to sustain local natural resources for future generations by providing modest financial assistance to diverse local partnerships focused on improving water quality, watersheds and the species and habitats they support.	Annually in Winter

above: grant programs to consider

Secondary Filter
Conduct a secondary filter of all opportunities to identify the most competitive grants based on the co-alignment of the project mission's with funder's giving history.

With the pursuit approach in mind, the following information outlines the types of opportunities available, categorized by type and their suitability for different project types.

Grants
Grants can be either one-time or recurring funding that is awarded following a successful application. Grants are typically best suited for funding isolated construction projects, including engineering design and construction fees, or for recurring operational costs, such as maintenance, planning, and program operations. Usually, grants require some matching funds, which the applicant must provide to meet a percentage of the funding awarded.

To identify projects that are eligible for grant funding, it is essential to identify those that offer multiple benefits and address various campus priorities simultaneously. These ancillary benefits can range from providing placemaking opportunities to reducing costs elsewhere in the infrastructure network.

Based on the funding considerations above, the table outlines some funding opportunities that UTA could utilize. Note that this is not an exhaustive list, and not all of these opportunities may be suitable for all project types, but are popular funding sources that can meet eligibility criteria (see table above).

Some addition potential grant funding sources to explore include:

- NTCOG – clean air, water, trails, and sustainability grants
- City of Arlington utilities department
- TexDOT – linking to transportation projects
- FEMA – technical assistance grants
- USACE – opportunities to fund research

Additional Funding Opportunities

Low-interest loans are commonly provided by government entities and can offer larger amounts of funding at advantageous interest rates for large-scale infrastructure projects (e.g. stormwater pipe network retrofits). An example of a low-interest loan that could be applicable for UTA stormwater infrastructure is the Texas Water Development Board's Clean Water State Revolving Fund which aims to provide low-cost financial assistance for planning, acquisition, design, and construction of stormwater infrastructure, with subsidized costs for green components.

Campus-community partnerships can be successful for isolated projects on campus with high-visibility or a framework for project collaboration between UTA and community members. These types of partnerships are typically most successful for isolated projects on campus with high-visibility (e.g. a rain garden) or a framework for project collaboration between UTA and community members/ campus alumni. Action items would likely be oriented around areas where the campus and community intersect with support given through volunteer hours and small-scale funding.

Industry partnerships can provide additional funding to undertake research and give students and faculty additional funding. This type of work must be oriented around projects that could be of benefit to the funding industry, whether the project impacts the industry's community, or provides research findings that are valuable to the funding industry. This type of partnership can also benefit UTA beyond actual project research as this is an unique opportunity for students to facilitate connections with industry professionals.

Conclusions
A strategic approach to funding is vital to implement green infrastructure visions and initiatives on campus. Funding opportunities are wide ranging in nature and completing applications can be cumbersome, so identifying the opportunities to pursue is just as critical as filling out the applications themselves. Third-party grant writing services or organizations experienced in preparing funding strategy frameworks can be especially helpful organize efforts and facilitate the process.

Funding strategies are critical for ensuring that project teams are aligned in vision, next steps advance the project's mission, and funding opportunities are optimized. Combining several funding sources to fund the totality of a project cost is helpful, where feasible, to minimize the level of risk taken with success for funding, as is submitting multiple applications for different portions of a project. Contingencies for each funding application should be recognized when combining multiple funding sources.

Successful funding administration typically requires sufficient staff allocation to ensure the campus meets all regulatory requirements as stipulated by the funder's policy and what was promised in the application. Most opportunities outline monitoring and reporting requirements that must be followed during the project's performance period.

POTENTIAL IMPLEMENTATION PARTNERS

The following are established and potential knowledge, funding, and implementation partners in green infrastructure work:

Federal	US Environmental Protection Agency US Forest Service US Army Corps of Engineers
State	Commission on Environmental Quality Department of Transportation (TXDOT) Parks & Wildlife Department (TPWD) Texas Water Development Board Trinity River Authority
City of Arlington	City Manager Department of Planning & Development Services Department of Public Works & Transportation Department of Parks & Recreation Office of Strategic Initiatives Department of Economic Development Arlington Housing Authority
UTA Stakeholders	College of Architecture, Planning and Public Affairs Center for Metropolitan Density (CfMD) UTA Office of Facilities Management UTA Office of Sustainability
Regional organizations	North Central Texas Council of Governments
Local consultants	KFM Engineering Di Sciullo-Terry, Stanton & Associates, Inc Dunaway Associates Studio Balcones Halff Associates, Inc. AquaGreen Global, LLC Westwood professional services TBG Partners MBL Inc MMA Inc TNP
Local elected officials	Mayor City Council members

West Street greenbelt
(Source: ONE, 2022)

RainWorks charrette site visit by Trading House Creek (EPA, 2022)

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GLOSSARY

Green Infrastructure
also called blue-green infrastructure
Green infrastructure refers to a variety of practices that restore or mimic natural hydrological processes. While "gray" stormwater infrastructure is designed to convey stormwater away from the built environment, green infrastructure uses soils, vegetation, landscape forms, and other media to manage rainwater where it falls through capture, storage, and evapotranspiration. By integrating natural processes into the built environment, green infrastructure provides a wide variety of community benefits, including reducing stormwater flooding impacts, improving water and air quality, reducing urban heat island effects, creating habitat for pollinators and other wildlife, and providing aesthetic and recreation.

Multi-benefit Infrastructure
Multi-benefit infrastructure is gray infrastructure whose primary use is not for preventing flooding, but helps during a storm event to temporarily store or convey stormwater. Examples are streets, sunken playgrounds, and parking lots.

Retention System
Retention systems store water on a more permanent basis, for example in ponds, reservoirs, and brooks.

Detention System
An area that stores water temporarily and eventually drains into the sewer system, such as green roofs, green-blue roofs, park space, bioswales, berms, sunken basketball courts, and sunken playgrounds.

Conveyance System
Conveyance systems direct water to flow to a site that can handle the stormwater, such as permeable surfaces, detention or retention sites, or rivers. Conveyance systems are systems such as stormwater pipes, gutters, swales, streets and streams.

Stormwater Flooding (pluvial)
Stormwater flooding is flooding from rainwater run-off from buildings, yards, streets, squares, and parks when it rains harder than the stormwater sewer can handle resulting in sheet flow flooding from direct rain or back up flooding from the stormwater sewer. Stormwater flooding is caused by extreme precipitation events, tropical storms and hurricanes. This is also called pluvial flooding.

Direct Rain
When it rains harder than what the stormwater sewer has been designed for, rainwater cannot enter the storm sewer and will create sheet flows on streets, yards, and other hard surfaces. Flooding risks to adjacent or downstream properties and especially to low lying areas will then occur when the surfaces do not have enough space for the sheet flow. In addition to the challenge that, due to climate change, extreme rain events, hurricanes and tropical storms will increase in amount of rain, challenges further include the need to incorporate sheet flows from offsite areas and the lack of capacity in the receiving streams.

Stormwater Sewers Backup and Overflow
The campus has a separated sewer system that segregates rainwater and sanitary sewer flows. An overflow in the rainwater sewer system will not create a back-up in the sanitary sewer system. The underground rainwater sewer system, however, can be blocked, resulting in sheet flow and surface flooding in the area.

Sanitary Sewer Overflow
A sanitary sewer overflow is a backup and discharge of raw wastewater that can contaminate water, cause property damage, and threaten public health. The most common causes of sanitary sewer overflows are blockages (caused by grease & wipes), wastewater line breaks, and flooding (stormwater overloads the wastewater system by fluvial flooding).

Riverine (Fluvial) Flooding
Riverine or fluvial flooding occurs when the water level in a watercourse rises and overflows onto the surrounding land. It is caused by upstream precipitation or upstream release.

Groundwater
Groundwater is the water found underground in the tiny spaces (pores) between rocks and particles of soil. If you dig into the ground and find water welling in the hole, you have reached the groundwater table. The depth of the groundwater table varies.

Watershed
also called drainage basin, drainage areas, or catchments
Watersheds are areas of land where all surface runoff that is created within that area drains to one common point. As water that is draining towards the ocean and is always conveying towards the lowest point in elevation, water will start in a large number of small streams at the top of watersheds ("tributaries"), and streams will continually combine and become rivers as the streams pick up more water along the way.

Watersheds are defined on the borders by "ridges" or hills where if a raindrop falls on the point, both elevations on either side are lower than the high point and water could drain to either side. Areas in the lower part of watersheds will have larger volumes of water in higher concentrations of volume as water accumulates as it moves toward the ocean. As watersheds are defined by the drainage area that reach one specific point, watersheds can be defined on several scales, depending on which common outlet point is picked for analysis.

Every point on Earth is part of several watersheds, depending on what common outlet point is analyzed to determine what land drains towards it. For example, a location in the northwest corner of campus would be located in a campus-scale watershed and simultaneously the Trading House Creek watershed, the Johnson Creek watershed, the Lower West Fork Trinity River Watershed, and the Trinity River watershed.

Water Quality
Water quality is a measure of the suitability of water for a particular use based on selected physical, chemical, and biological characteristics. Water quality is among others affected by temperature, erosion, contaminants (such as pesticides but also medicines) and decaying organic materials. The water quality is important for use of drinking water and health.

Aerial view of UTA campus (Source: Taner Ozdil / UTA).

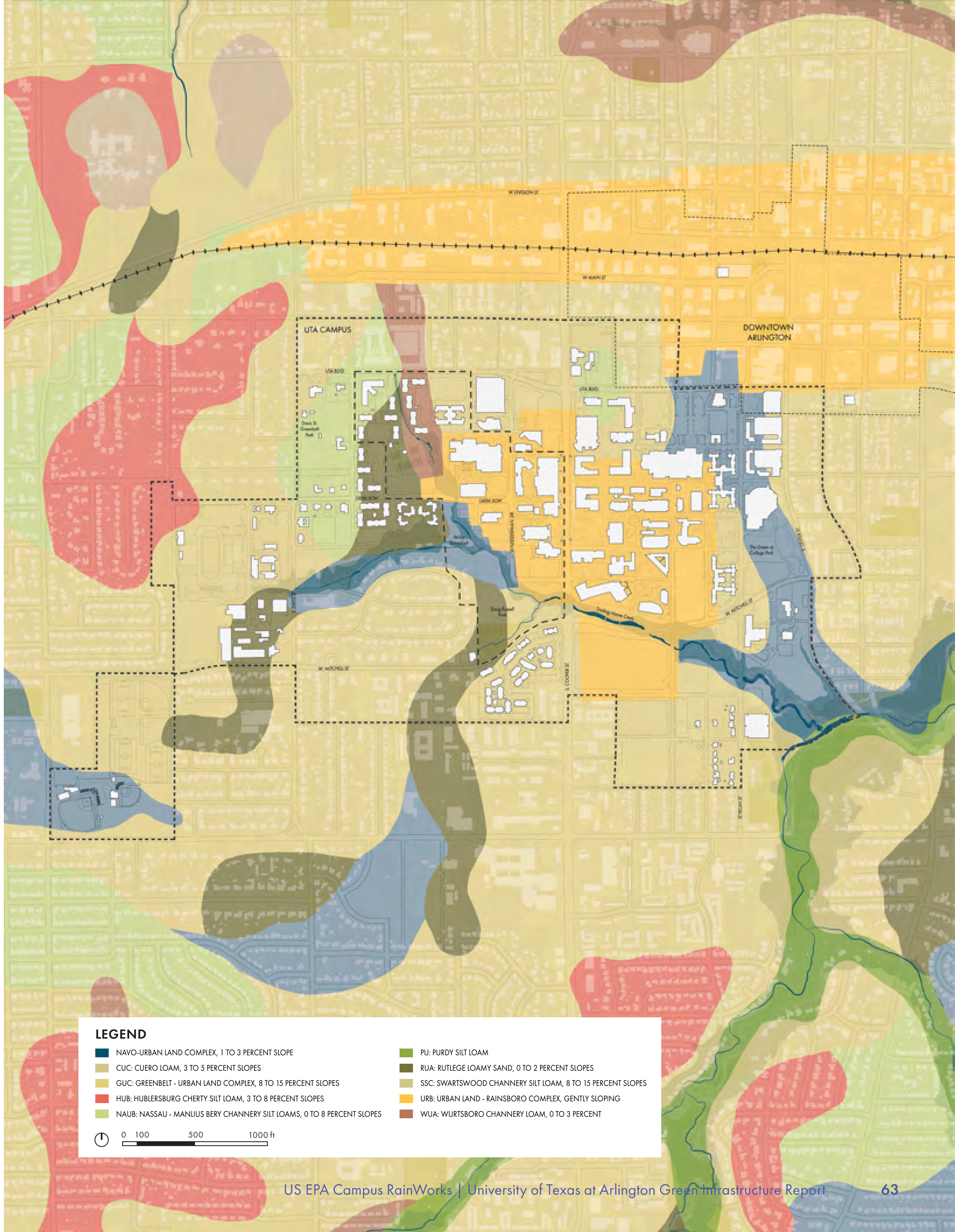
GREEN INFRASTRUCTURE TECHNICAL CRITERIA

GREEN INFRASTRUCTURE MEASURE NAME	TECHNICAL CRITERIA		
	Max Drainage Area	**Pressure Head Needed**	**Maximum Slope in Measure**
	Acres	Feet	%
Green Roofs	100% of BMP size	0.5 - 1	10
Rainwater Harvesting	N/A	N/A	2
Oil/Grit Separator	1	4	6
Downspout Disconnect	0,06	N/A	6
Site Reforestation/Revegetation	0.25 Min	N/A	N/A
Infiltration Trench	5	6-8	15
Permeable Pavers/Surfaces	300% of BMP size	N/A	0.5
Bioretention	5	5	6
Flow-Through Planters/Landscape Infiltration	0,06	2	6
Dry Bioswales	5	1	4
Wet Bioswales	5	1	4
Dry Well	0,06	2	6
Organic Filter	10	5-8	2-3
Surface Sand Filters	10	2-3	6
Dry Detention Pond	10 Min.	6-8	15
Extended Dry Detention Pond	10 Min.	6-8	15
Wet Pond	25	6-8	15
Pocket Pond	10	6-8	0
Underground Filter	5	2-3	8
Flood Management Area	200	N/A	1
Stormwater Wetland	25	3-5	8
Pocket Stormwater Wetland	5	3-5	8
Stream Restoration	N/A	N/A	N/A

Note

Information taken from the North Central Texas Council of Government's Transportation Integrated Stormwater Manual (2014) is highlighted in green. In the absence of explicit information stated in the Integrated Stormwater Manual, technical information was supplemented from Volume 2 of the Georgia Stormwater Management Manual (2016), highlighted in orange.

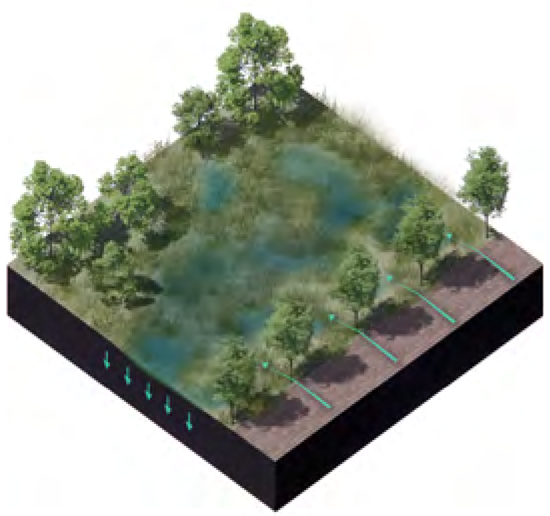
opposite:
UTA area soil map
(Source: USGS).



GREEN INFRASTRUCTURE MEASURES OR BEST MANAGEMENT PRACTICES (BMPS)

Unless noted, all definitions below are derived from the *Georgia Stormwater Management Manual, Volume 2 Technical Handbook* (2016) (link)

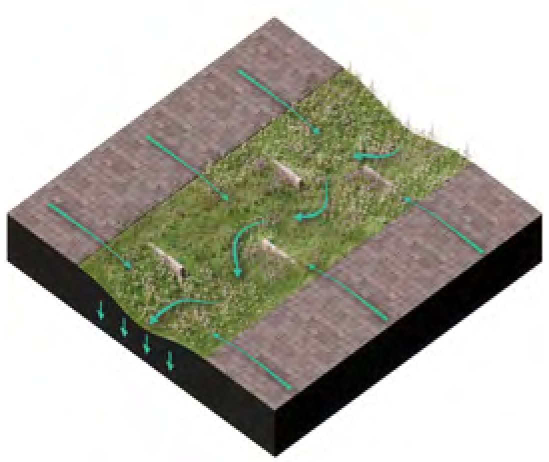
Upper watershed strategies
Middle watershed strategies
Lower watershed strategies



Stormwater Wetland

Stormwater Wetland

Stormwater wetlands are constructed wetland systems used for stormwater management. Stormwater wetlands consist of a combination of shallow marsh areas, open water, and semi-wet areas above the permanent water surface. As stormwater runoff flows through a wetland,it is treated, primarily through gravitational settling and biological uptake.

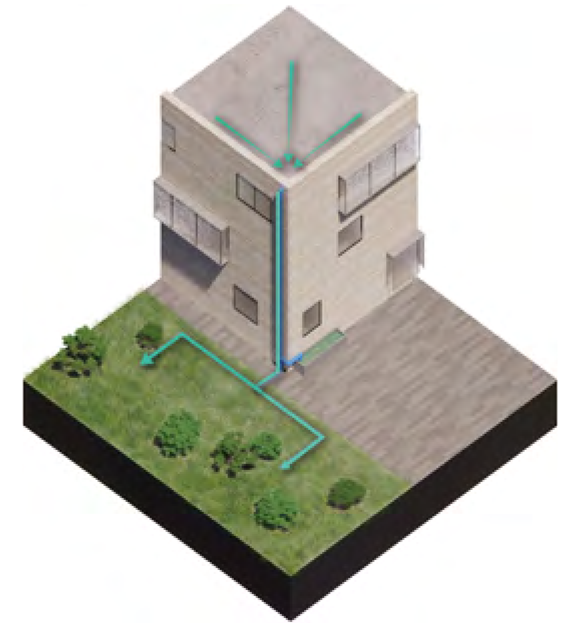


Dry Bioswales

Dry Bioswale

Dry swales are vegetated open channels that are designed and constructed to capture and treat stormwater runoff within dry cells formed by check dams or other structures. A dry swale is designed to prevent standing water, with or without an underdrain.

Upper watershed strategies
Middle watershed strategies
Lower watershed strategies



Downspout Disconnect

Downspout Disconnect

A downspout disconnect spreads rooftop runoff from individual downspouts across lawns, vegetated areas, and other pervious areas, where the runoff is slowed, filtered, and can infiltrate into the native soils

Surface Sand Filters

Surface Sand Filters

Sand filters are multi-chamber structures designed to treat stormwater runoff through filtration, using a sandbed as its primary filter media. Filtered runoff may be returned to the conveyance system through an underdrain system, or allowed to partially exfiltrate into the soil.

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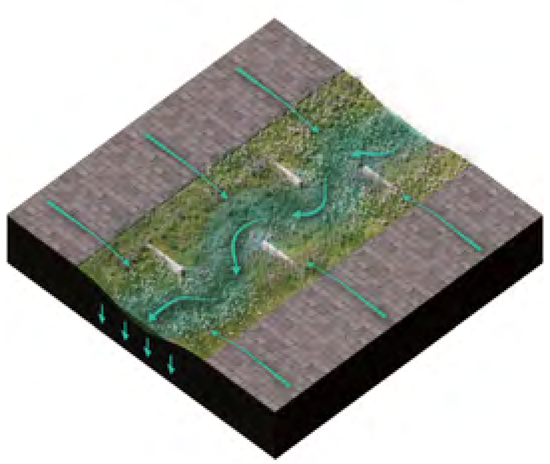
Lower watershed strategies

Stream Restoration

Stream Restoration

Stream restoration is often performed to reduce the effects of stressors on the environment and return stream structure and function to pre-disturbance conditions. Often, restoration projects aim to improve water quality and in-stream habitat, manage riparian zones, stabilize stream banks, and allow fish to pass barriers.

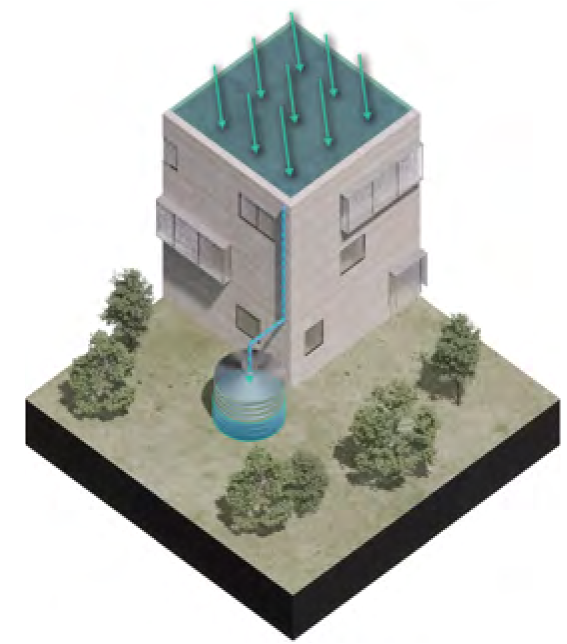


Wet Bioswale

Wet Bioswale

Wet bioswales are vegetated open channels that are designed and constructed to capture and treat stormwater runoff within wet cells formed by check dams or other structures. A wet swale is designed to hold water.

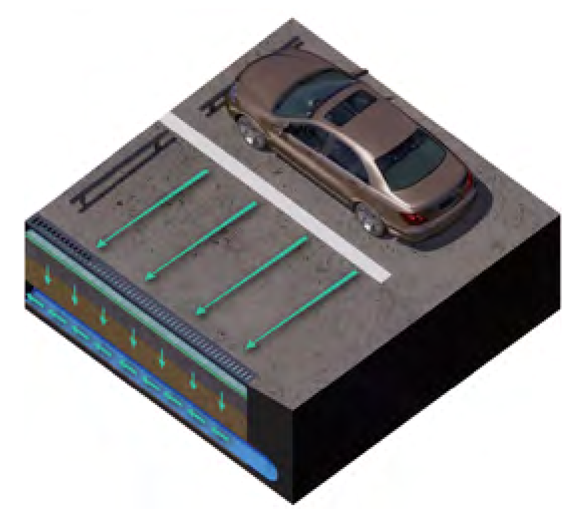
Upper watershed strategies
Middle watershed strategies
Lower watershed strategies



Rainwater Harvesting

Rainwater Harvesting

Rainwater harvesting is a common stormwater management practice used to catch rainfall and store it for later use. Typically, gutters and downspout systems are used to collect the water from roof tops and direct it to a storage tank. Rainwater Harvesting systems can be either above or below the ground. Once captured in the storage tank, the water may be used for non-potable indoor (requires treatment) and outdoor uses.



Underground Filter

Underground Filter

Underground sand filters are concrete structures designed to store and filter rainwater through sand to remove pollutants collected from rooftops, sidewalks, and roads. Water first filters through an oil/grit trap to remove heavy debris, and then flows through layers of sand and gravel before being released through a pipe into local streams or storm drain system.

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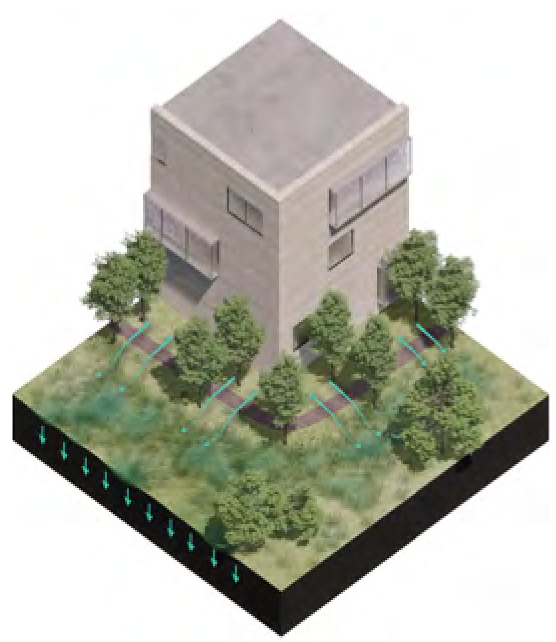
Lower watershed strategies

Pocket Pond

Pocket Pond

A pocket pond is characterized by a small drainage area; the water level is sustained by groundwater during dry weather.

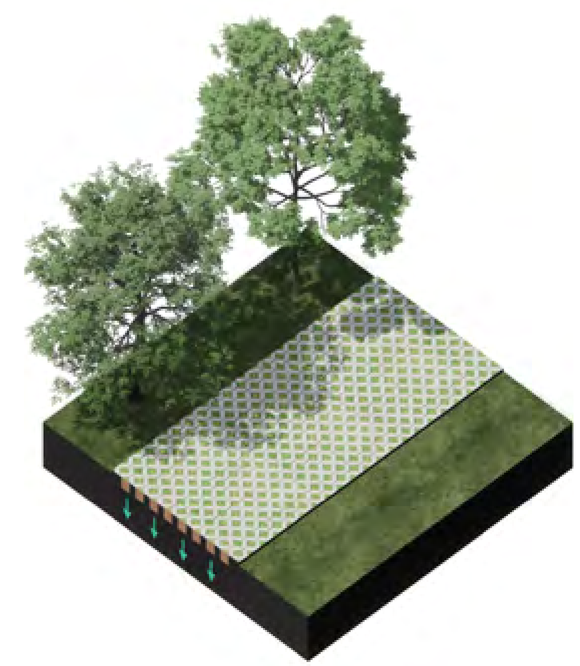


Pocket Stormwater Wetland

Pocket Stormwater Wetland

A pocket wetland is used to capture and treat a specific volume of stormwater runoff. This structure is a shallow wetland with a permanent pool and wetland species added to the bottom to enhance the pollutant removal capability. For this BMP, a high groundwater table is used to maintain the shallow pool and wetland vegetation.

Upper watershed strategies
Middle watershed strategies
Lower watershed strategies



Permeable Pavers/ Surfaces

Permeable Pavers / Surfaces

A permeable paver system is a pavement surface composed of structural units with void areas that are filled with pervious materials such as gravel, sand, or grass turf. The system is installed over a gravel base course that provides structural support and stores stormwater runoff that infiltrates through the system into underlying permeable soils.

Organic Filters

Organic Filters

Organic filters are surface media filters that use organic materials, such as leaf compost or a peat/sand mixture,as the filter media. Runoff is filtered through the media prior to discharging through an underdrain system. The Organic media may be able to provide enhanced removal of some contaminants, such as heavy metals.

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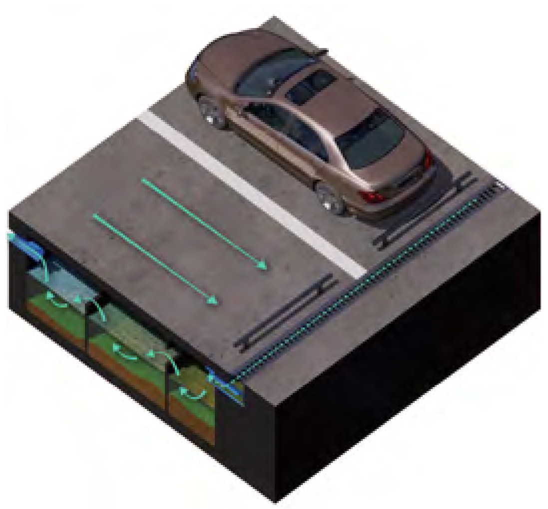


Oil / Grit Separator

Oil / Grit Separator

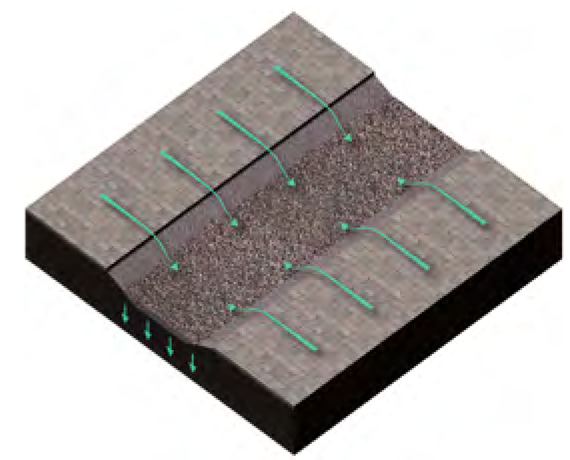
Oil / grit separators are hydrodynamic controls that use the movement of stormwater runoff through a specially-designed structure to remove target pollutants. They are typically used on smaller, impervious, commercial sites and urban hotspots.

Bioretention

Bioretention

Bioretention areas are shallow stormwater basins or landscaped areas that utilize engineered soils and vegetation to capture and treat stormwater runoff. Bioretention areas may be designed with an underdrain that returns runoff to the conveyance system or designed without an underdrain to exfiltrate runoff into the soil.

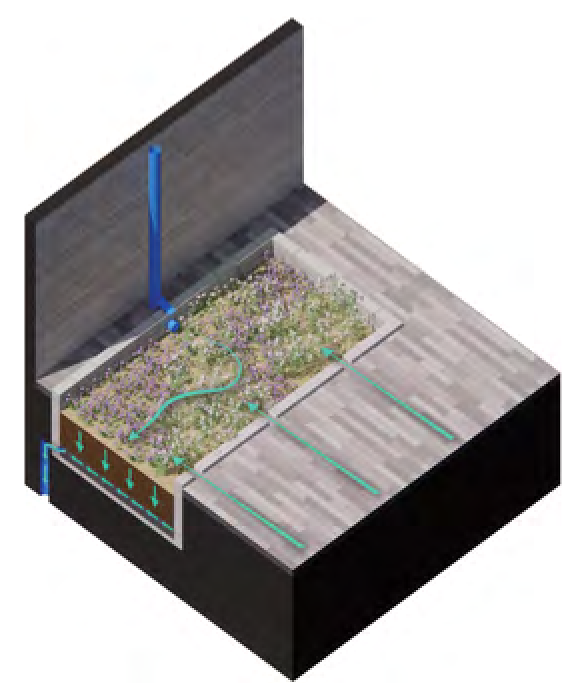
Upper watershed strategies
Middle watershed strategies
Lower watershed strategies



Infiltration Trench

Infiltration Trench

An infiltration trench is a shallow excavation, typically filled with stone or an engineered soil mix, which is designed to temporarily hold stormwater runoff until it infiltrates into the surrounding soils. Infiltration practices are able to reduce stormwater quantity, recharge the groundwater, and reduce pollutant loads.



Flow Through Planter

Flow-Through Planter

Flow-through planters are structures placed above ground with impervious bottoms that are filled with soil and vegetation which allow stormwater to infiltrate through the soil before being discharged. The bottom of a planter contains a porous pipe that drains the stormwater after it has filtered through the soil and vegetation. Planters are typically installed next to buildings or common open areas to treat stormwater from rooftops.

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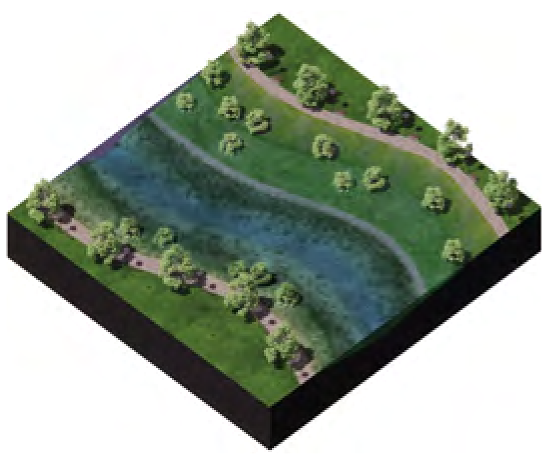
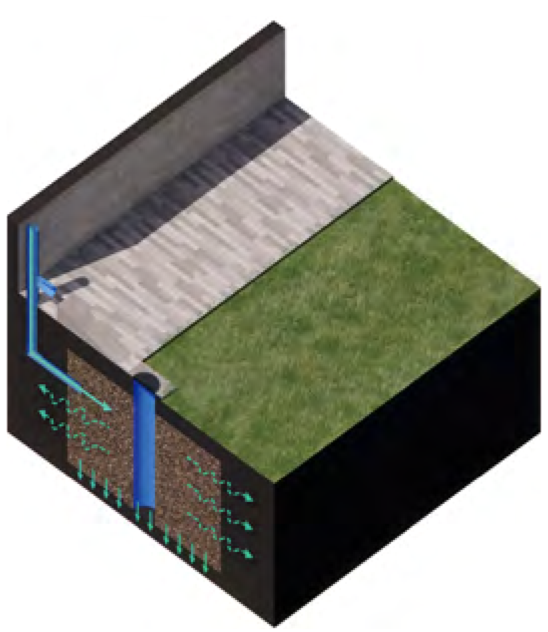


Flood Management Area

Flood Management Area

Flood management areas retain and buffer the effects of heavy rainfall and protect economic activities and communities from flood damage. Natural management areas like flood plains have an important role to play in reducing flood risks and are also the natural habitat of many endangered species. However, they can also be man made areas that can are used for detention such as lowered playing fields.

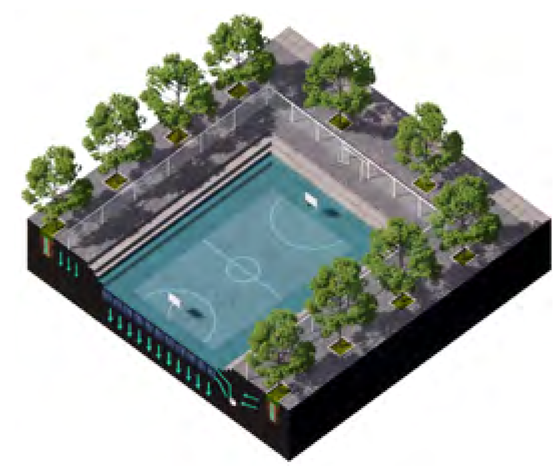


Dry Well

Dry Well

Dry wells are shallow excavations, typically filled with stone, that are designed to intercept and temporarily store post-construction stormwater runoff under the ground surface until it infiltrates into the underlying and surrounding soils. If properly designed, they can provide significant reductions in post-construction stormwater runoff rates, volumes, and pollutant loads on development sites.

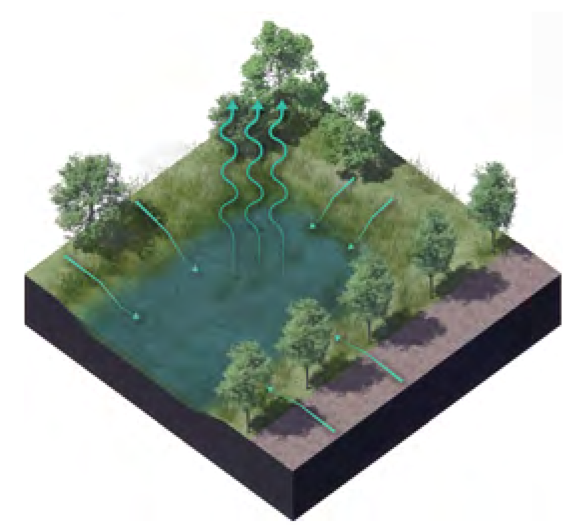
Upper watershed strategies
Middle watershed strategies
Lower watershed strategies



Water Squares

Water Squares

When sub-surface crates are full, sunken playgrounds fill up temporarily with additional stormwater run-off. These water squares reduce damage, increase water quality due to combined stormwater reduction and increase recreational activities.



Stormwater Pond/ Wet Pond

Stormwater Pond/ Wet Pond

Stormwater ponds are constructed stormwater retention basins that have a permanent pool (or micropool) of water. Some runoff reduction is achieved within a stormwater pond or detention system through evaporation and transpiration. Stormwater ponds provide water quality treatment through sediment precipitation in the permanent pool.

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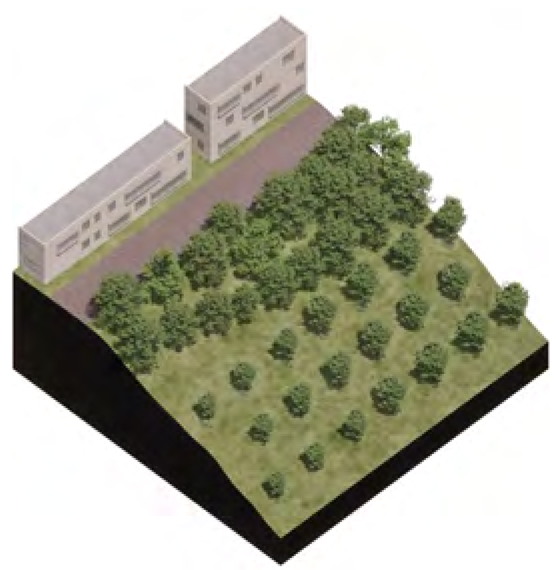


Site Revegetation

Site Reforestation/ Revegetation

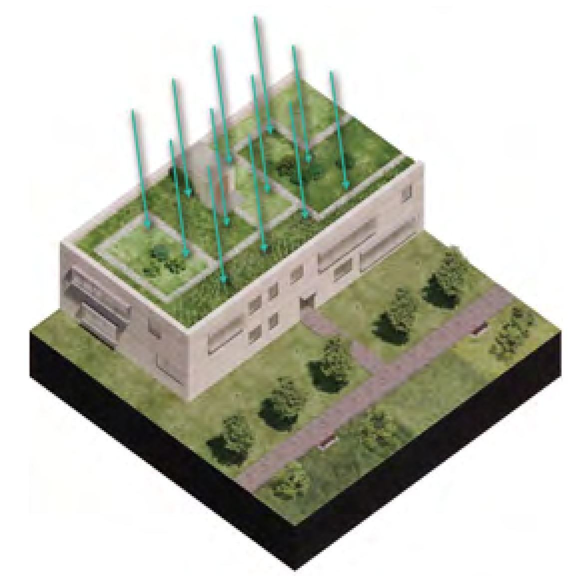
Reforestation or revegetation is a process of planting trees, shrubs, and other native vegetation in disturbed pervious areas to restore the area to pre-development or better conditions. The process can be used to establish mature native plant communities, such as forests, in pervious areas that have been disturbed by clearing, grading and other land disturbing activities. These plant communities intercept rainfall and slow and filter the stormwater runoff to improve infiltration in the ground. Areas that have been reforested or revegetated should be maintained in an undisturbed, natural state over time. These areas must be designated as conservation areas and protected in perpetuity through a legally enforceable conservation instrument (e.g., conservation easement, deed restriction).

Extended Dry Detention Ponds

Extended Dry Detention Ponds

Extended dry detention basins are modified conventional dry detention ponds, designed to hold stormwater for at least 24 hours to allow solids to settle and to reduce local and downstream flooding. Extended dry detention basins may be designed with either a fixed or adjustable outflow device. Pretreatment is a fundamental design component of an extended dry detention basin to reduce the potential for clogging. Other components such as a micropool or shallow marsh may be added to enhance pollutant removal.

Upper watershed strategies
Middle watershed strategies
Lower watershed strategies



Green Roof

Green Roof

Green roofs represent an alternative to traditional impervious roof surfaces and typically consist of underlying waterproofing, drainage systems, and an engineered planting media. Stormwater runoff is captured and temporarily stored in the engineered planting media, where it is subjected to evaporation and transpiration before being conveyed back into the storm drain system. There are two different types of green roof systems. Intensive green roofs have a thick layer of soil, can support a diverse plant community, and may include trees. Extensive green roofs have a much thinner layer of soil that is comprised primarily of drought tolerant vegetation.

Dry Detention Pond

Dry Detention Pond

A dry detention pond is an impoundment or excavated basin for the short-term detention of stormwater runoff from a completed development that allows a controlled release from the structure at downstream, pre-development flow rates. Conventional dry detention basins typically control peak runoff for 2-year and 10-year 24-hour storms. They are not specifically designed to provide extended dewatering times, wet pools, or groundwater recharge. Sometimes flows can be controlled using an outlet pipe but this approach typically cannot control multiple design storms.

RAINWORKS CHARRETTE AGENDA

Friday, October 7, 2022, 8:15 am – 3:30 pm

08:15 Gather & welcome

09:00 Charrette agenda & goals

09:10 Campus context & initiatives

- Campus overview; recent & projected growth (John Hall)
- RainWorks entries and student work (Taner Ozdil)
- Campus sustainability initiatives (Hanan Boukhaima)
- Municipal & regional planning initiatives (Gincy Thoppil)
- Watersheds & natural systems; climate change (Rachel Still)

10:10 Campus tour

11:10 Challenges, opportunities & principles breakout

1. Break-out group 1: Healthy water, healthy creek
2. Break out group 2: Addressing climate resiliency on campus
3. Break out group 3: Connecting communities
4. Break out group 4: Trails for people and nature

11:50 Report back, lunch

12:45 Objectives, design strategies & schematic breakout

1. Break-out group 1: Healthy water, healthy creek
2. Break out group 2: Addressing climate resiliency on campus
3. Break out group 3: Connecting communities
4. Break out group 4: Trails for people and nature

02:15 Presentations

03:00 Takeaways & implications

03:20 Closing remarks & adjourn

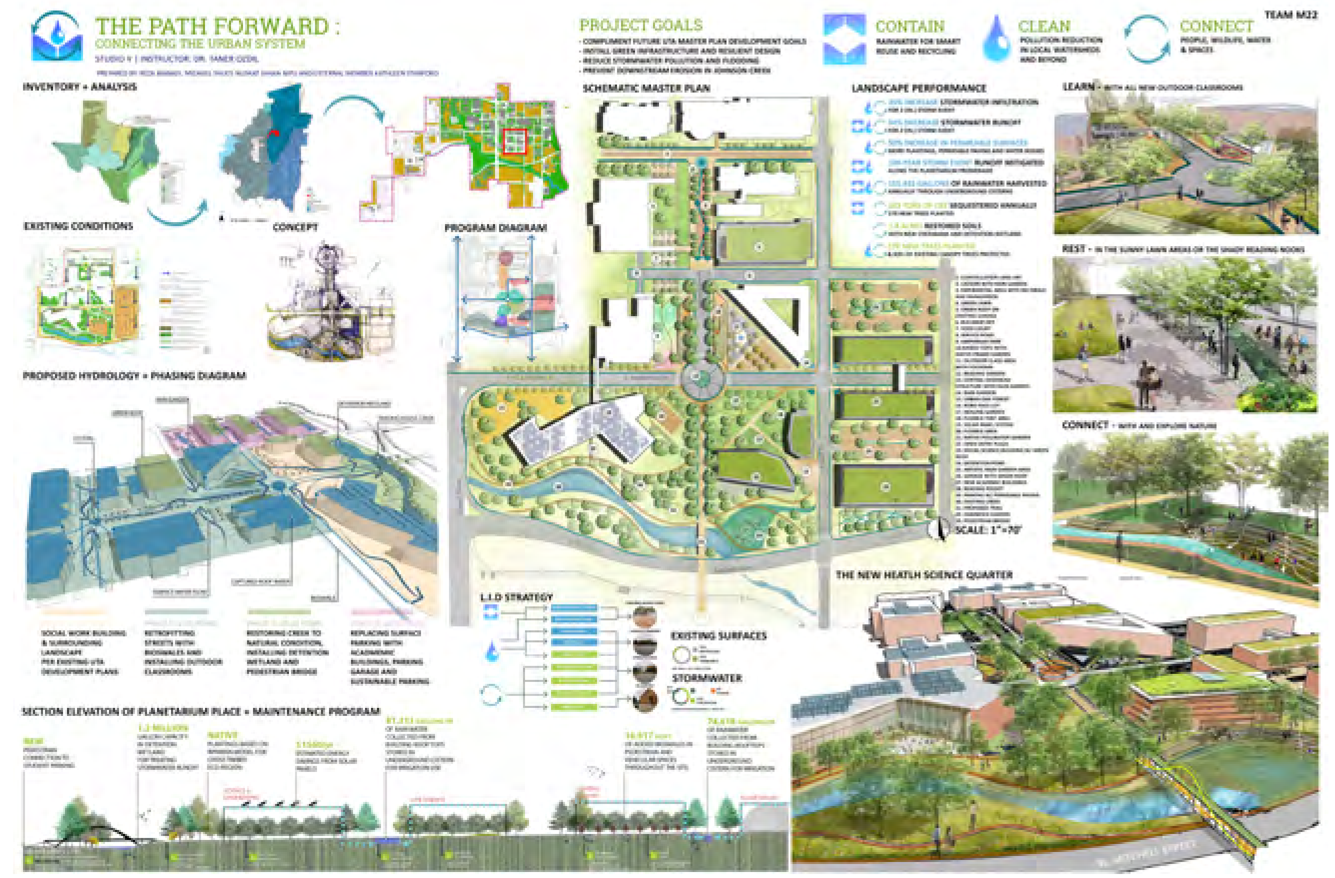
CHARRETTE REGISTRANTS & PARTICIPANTS

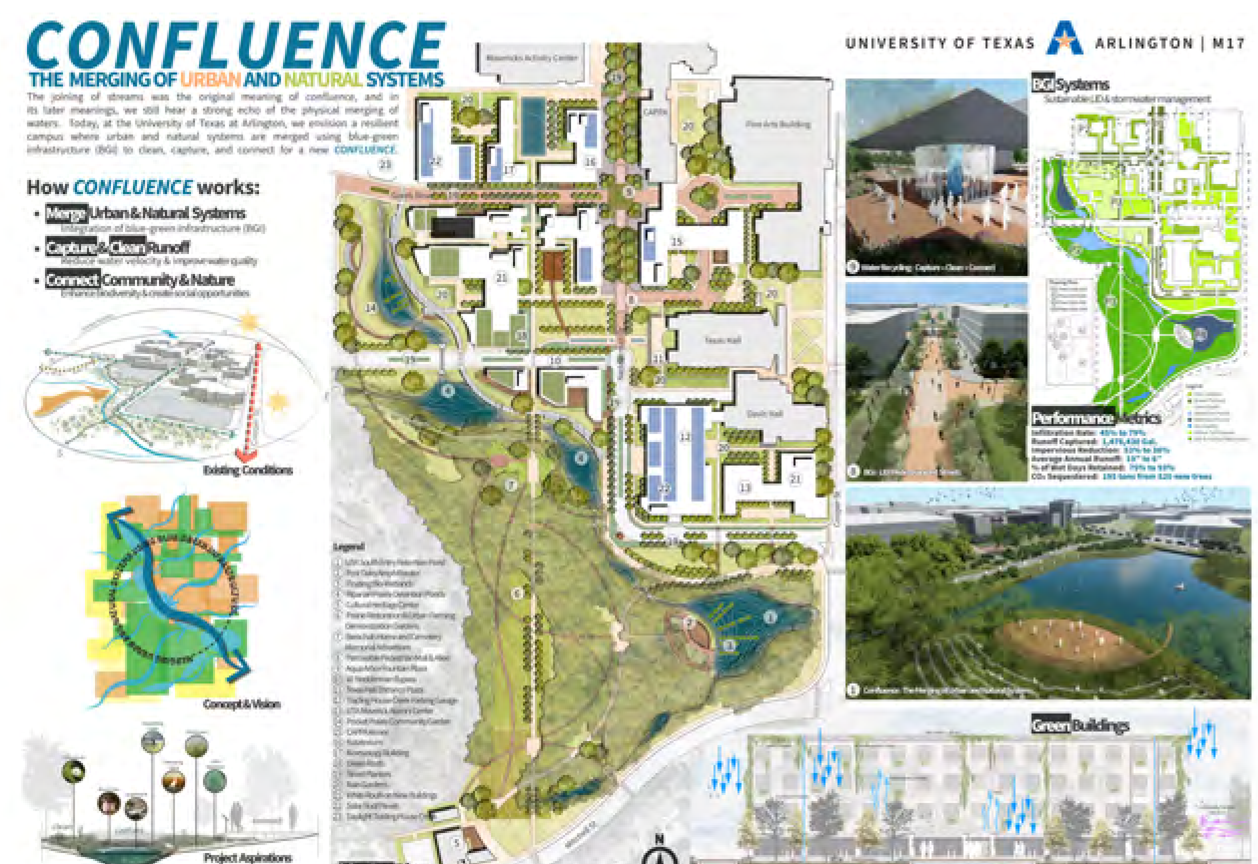
Charrette participants included UTA and CAPPA leadership as well as students, staff, faculty, alumni, community members, and professionals.

Jennifer Cowley	UTA, President
John D. Hall	UTA, VP Administration & Economic Development
Maria Martinez-Cosio	UTA, Interim Dean, CAPPA
Elizabeth Heise	UTA, Assistant Vice Provost
Austin Allen	UTA, Interim Associate Dean
Rebecca Boles	UTA, Assistant Dean
Diane Jones Allen	UTA, Director - Landscape Architecture
Amanda Hinton	UTA - Student
Angelica Villalobos	UTA - Student
Anjelyque Easley-DeLuca	UTA - Alumni
Ann Mariya Joseph Thuruthy	UTA - Student
Avery Deering-Frank	UTA - Student
Beth Sipzner	Arlington Urban Design Center
Braden Thomas	UTA - Office of Facilities Management
Bud Melton	Halff Associates, Inc.
Cameron Holmes	KFM Engineering
Chris Riale	Sherwood Design Engineers
Clark Wilson	US EPA
Cooper Begis	UTA - Student
Dasom Mun	UTA - Student
Devin Guinn	AquaGreen Global, LLC
Donald Lange	UTA - Office of Facilities Management
Doug Breuer	One Architecture & Urbanism
Geoff Hall	Westwood professional services
Gincy Thoppil	City of Arlington
Habib Ahmari	UTA
Hanan Boukhaima	UTA - Student
Jake Schwarz	Dunaway Associates
Jeff Johnson	UTA - Office of Facilities Management
Jennifer Stanton Ortiz	Di Sciullo-Terry, Stanton & Associates, Inc
Jessie Hitchcock	UTA - Student
Joowon Im	UTA
Josiah Miller	UTA - Student
Joyce Coffee	Climate Resilience Consulting
Joyce Stanton	DiSciullo-Terry, Stanton & Associates, Inc
Kenneth Jefferson	UTA
Kevin Wester	UTA - Office of Facilities Management, Grounds
Lot Locher	One Architecture & Urbanism
Lyndsay Mitchell	City of Arlington - Office of Strategic Initiatives
Mark Heinicke	City of Arlington Parks & Recreation Department
Mark Meyer	TBG Partners
Melissa Walker	City of Arlington
Michael Shuey	Studio Balcones
Michael Webb	MBL Inc
Arlington Chivers	UTA - Libraries
Nicholas Nelson	TNP
Nick Fang	UTA
Oren Mandelbaum	UTA - Student
Patricia Sinel	City of Arlington
Rachel Still	Sherwood Design Engineers
Robert Cronin	MMA Inc
Susan Dequeant	UTA - Center for Service Learning
Suzanna Perea	EPA Region 6
Taner Ozdil	UTA - CAPPA & CfMD
Violet Lam	UTA - Student

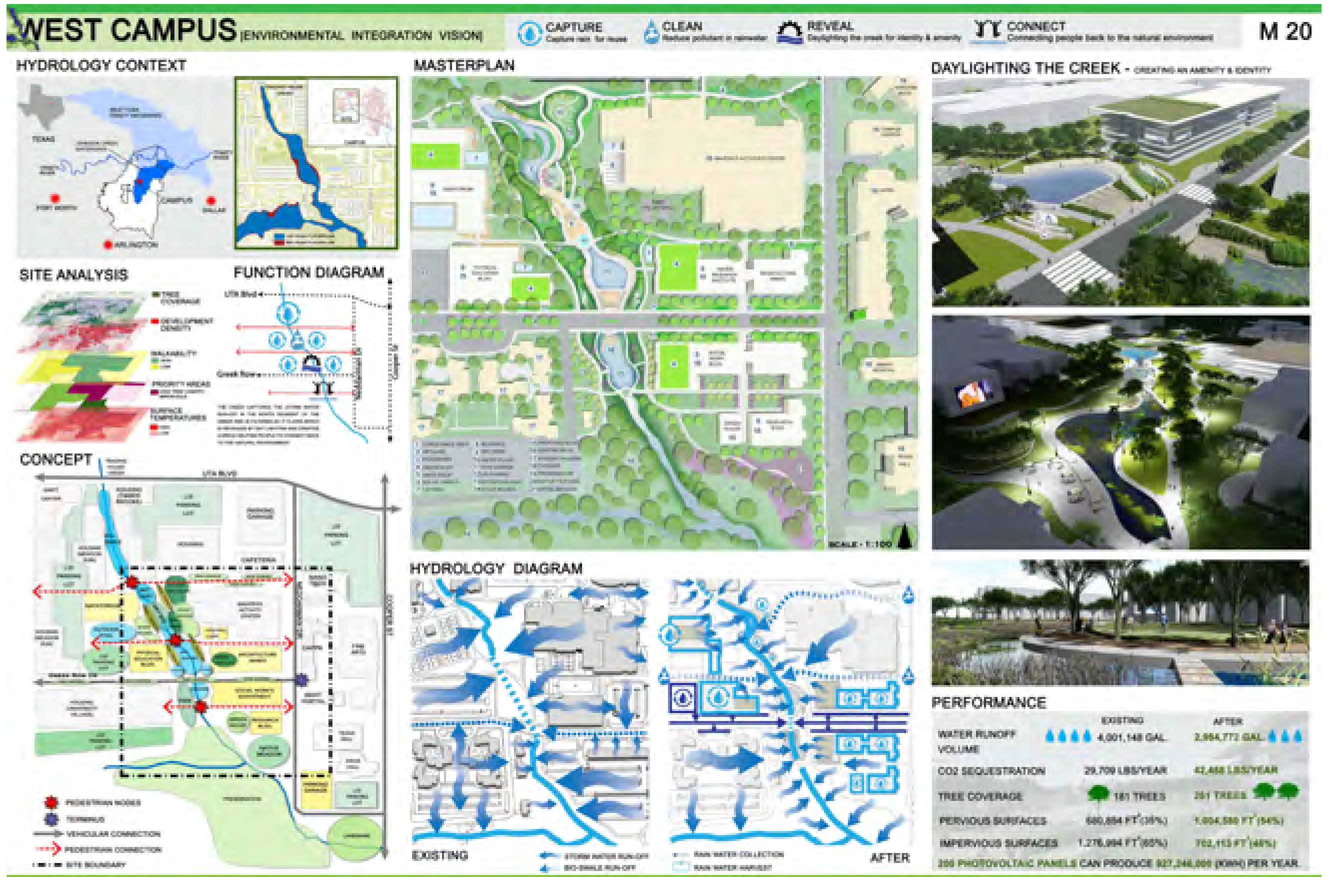
SAMPLE CAMPUS RAINWORKS SUBMISSIONS MASTER PLANNING CATEGORY 2019-2021

"COLLEGE PARK CONNECTION" Elena Naccari, Matthew Thornton, Peter Wagner
"ONE" Anjelyque Easley, Bonnie Blocker, Nikki Simonini
"THE PATH FORWARD" Michael Shuey, Nusrat Jahan Nipu, Reza Mabadi, Kathleen Stanford
"CONFLUENCE" Melissa Lemuz, Angeles Margarida, Monte McMahen, Luiz Rojo, Michael Webb

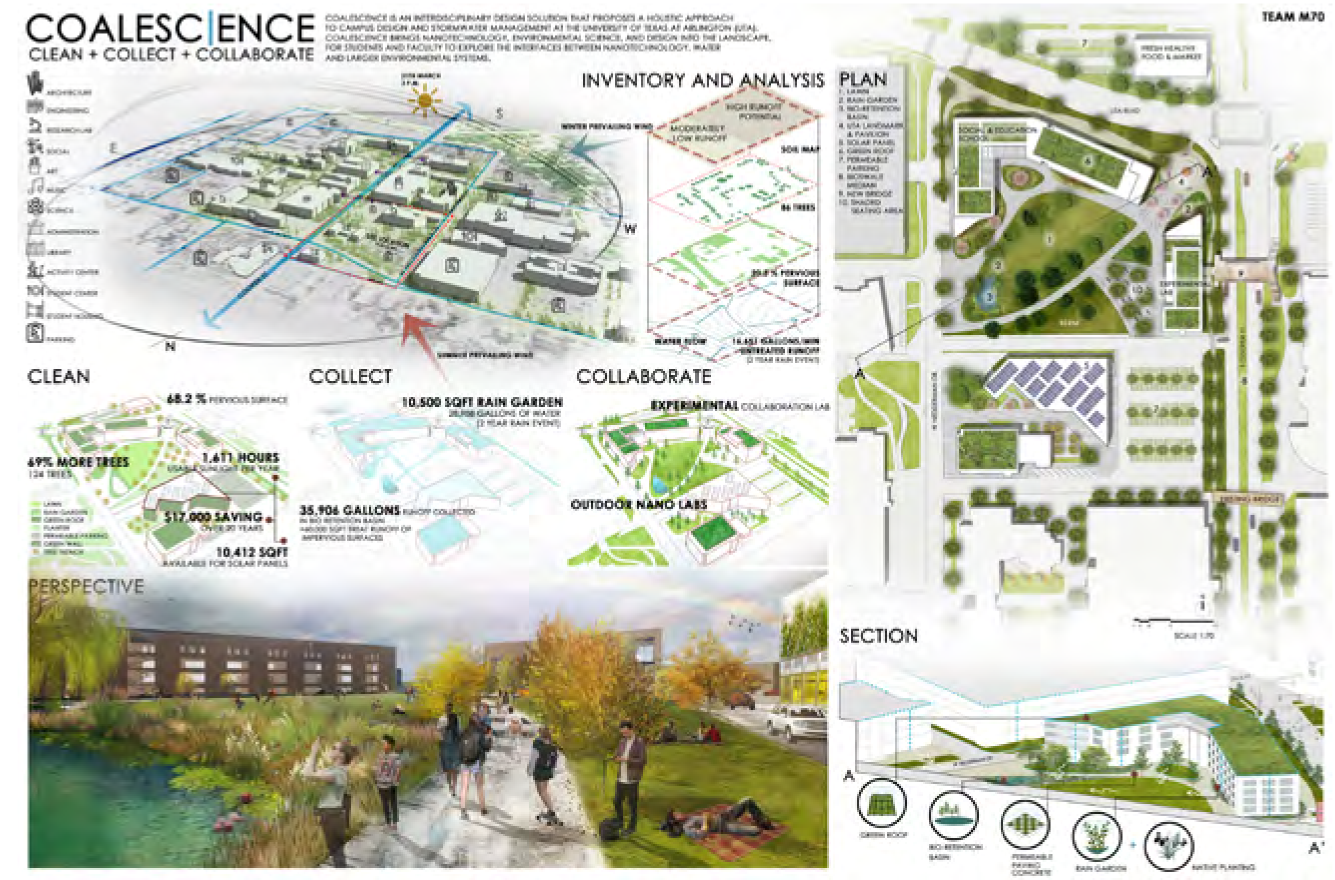




SAMPLE CAMPUS RAINWORKS SUBMISSIONS
MASTER PLANNING CATEGORY 2017-2019



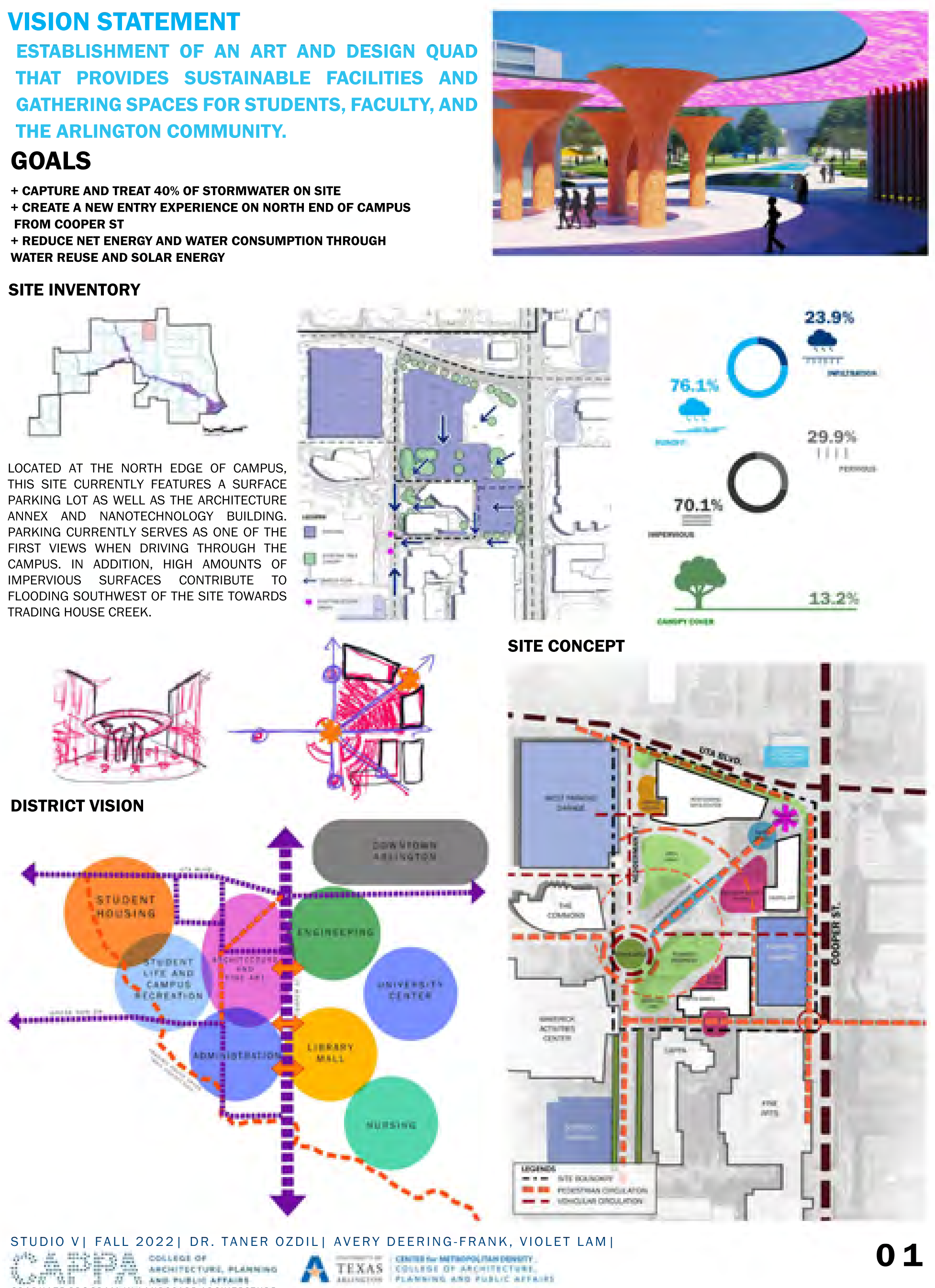
"WEST CAMPUS" Crystal Kazakos, Annabeth Webb, Juan Fuentes, Niveditha Gangadhar
"ECO-LAB CENTER" Mohamed Amer, Ali Khoshkar, Steven Nunez
"COALESCENCE" Behnoud Aghapour, Ann Mai, Mahsa Yari, Mohamad Nabatian
"EMBEDDED" Ravija Munshi, Adriana Tobias, Brandon Utterback, Camille Wildburger

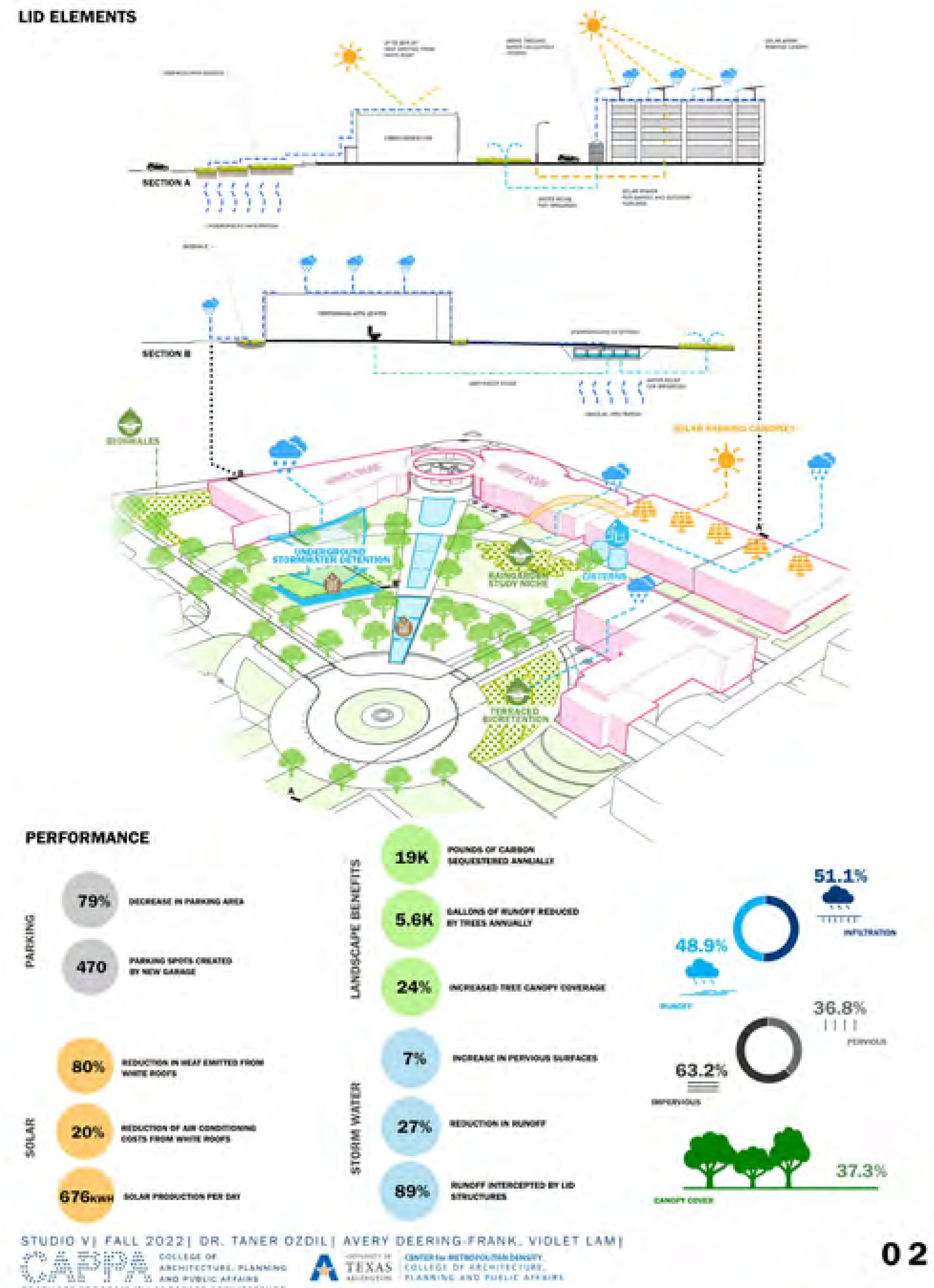


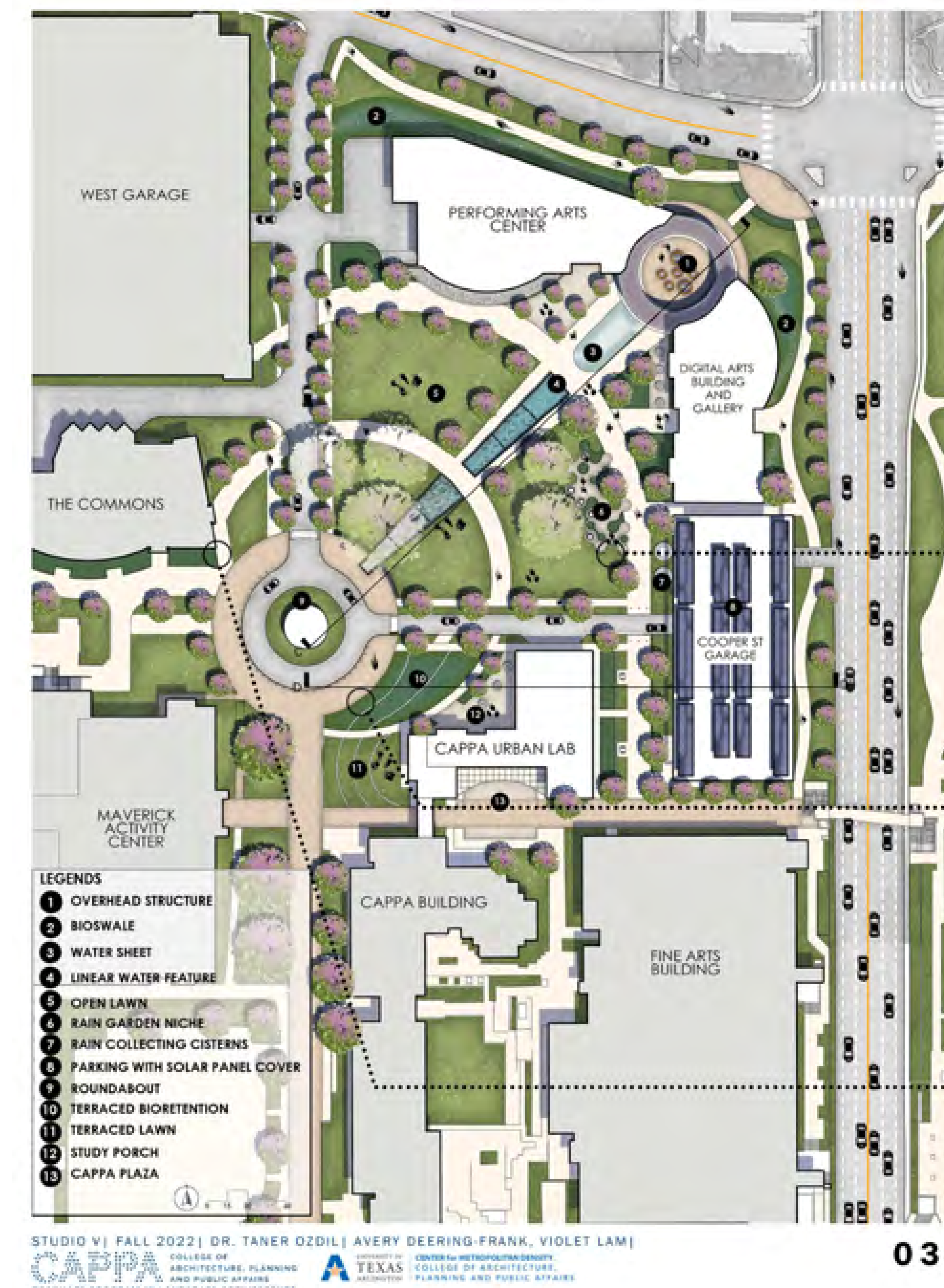
2022 UTA CAMPUS VISION STUDENT WORK AND EXHIBIT
ART AND DESIGN QUAD

Building on the Campus RainWorks Challenge prompt, the Exhibit showcased UTA campus visions for four separate sites along Trading House Creek.

"ART AND DESIGN QUAD" Student Team; Avery M. Deering-Frank, Violet Tu Man Lam,



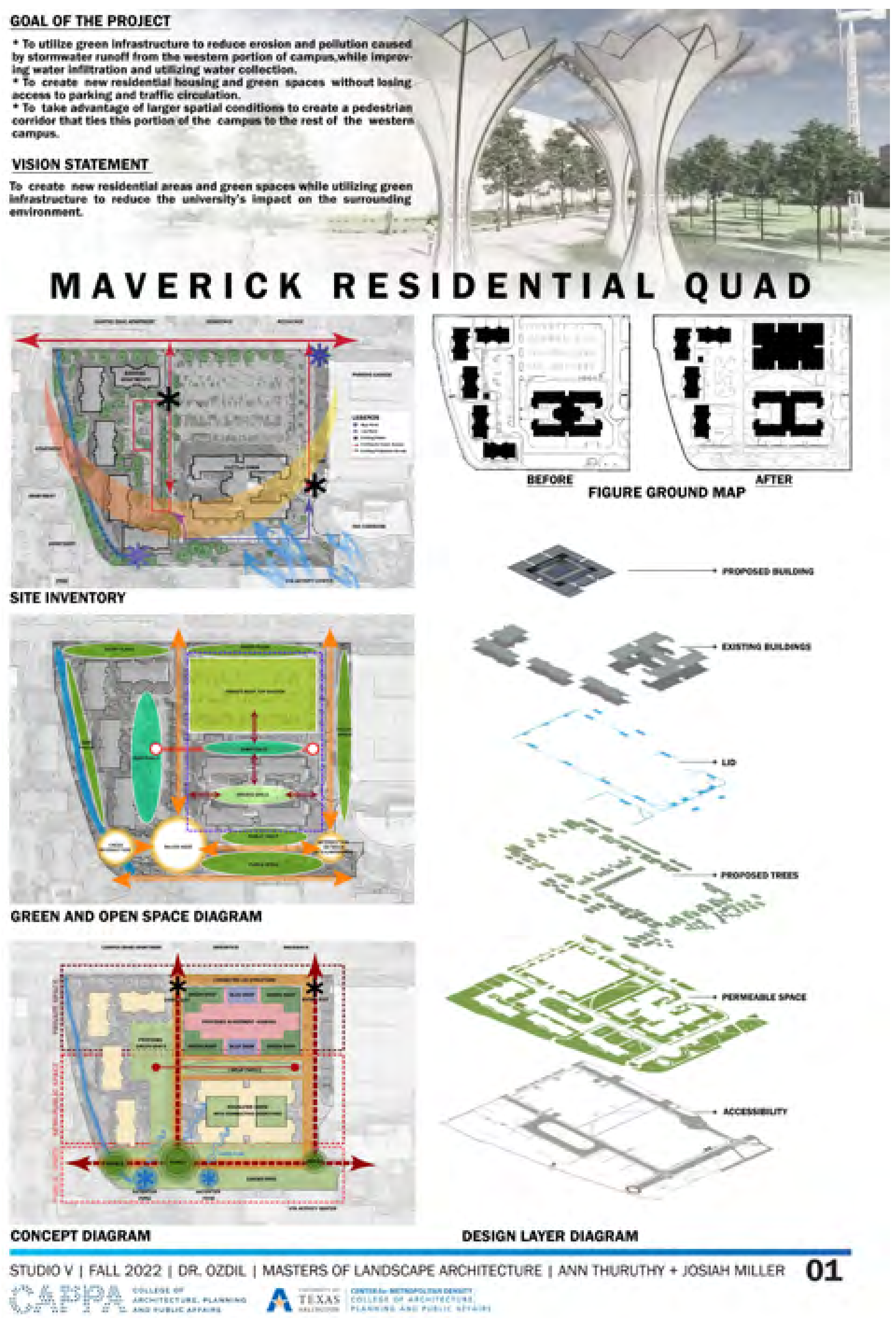


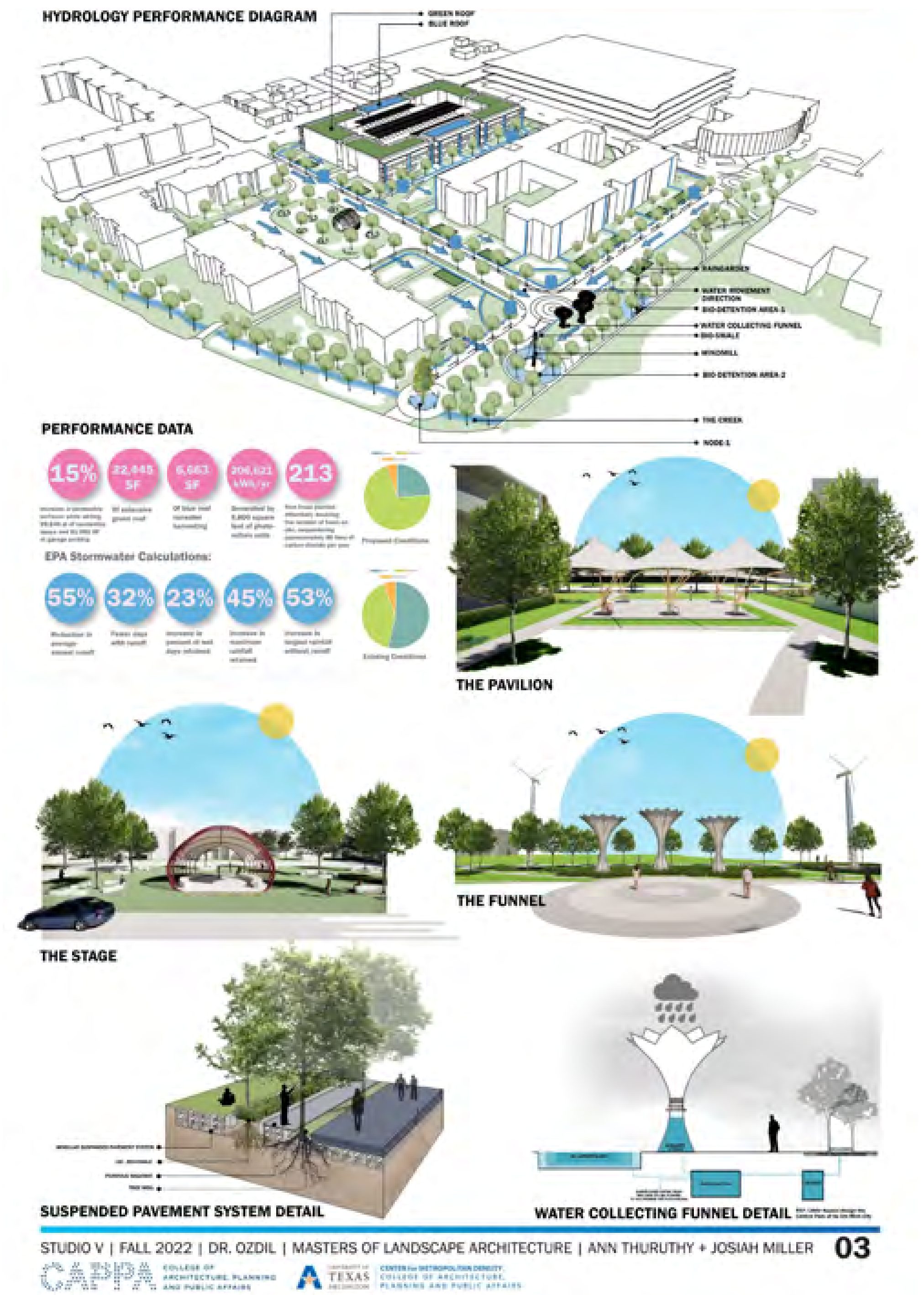


2022 UTA CAMPUS VISION STUDENT WORK AND EXHIBIT
MAVERICK RESIDENTIAL QUAD

Building on the Campus RainWorks Challenge prompt, the Exhibit showcased UTA campus visions for four separate sites along Trading House Creek.

"MAVERICK RESIDENTIAL QUAD" Josiah Miller, Ann Mariya Joseph Thuruthy

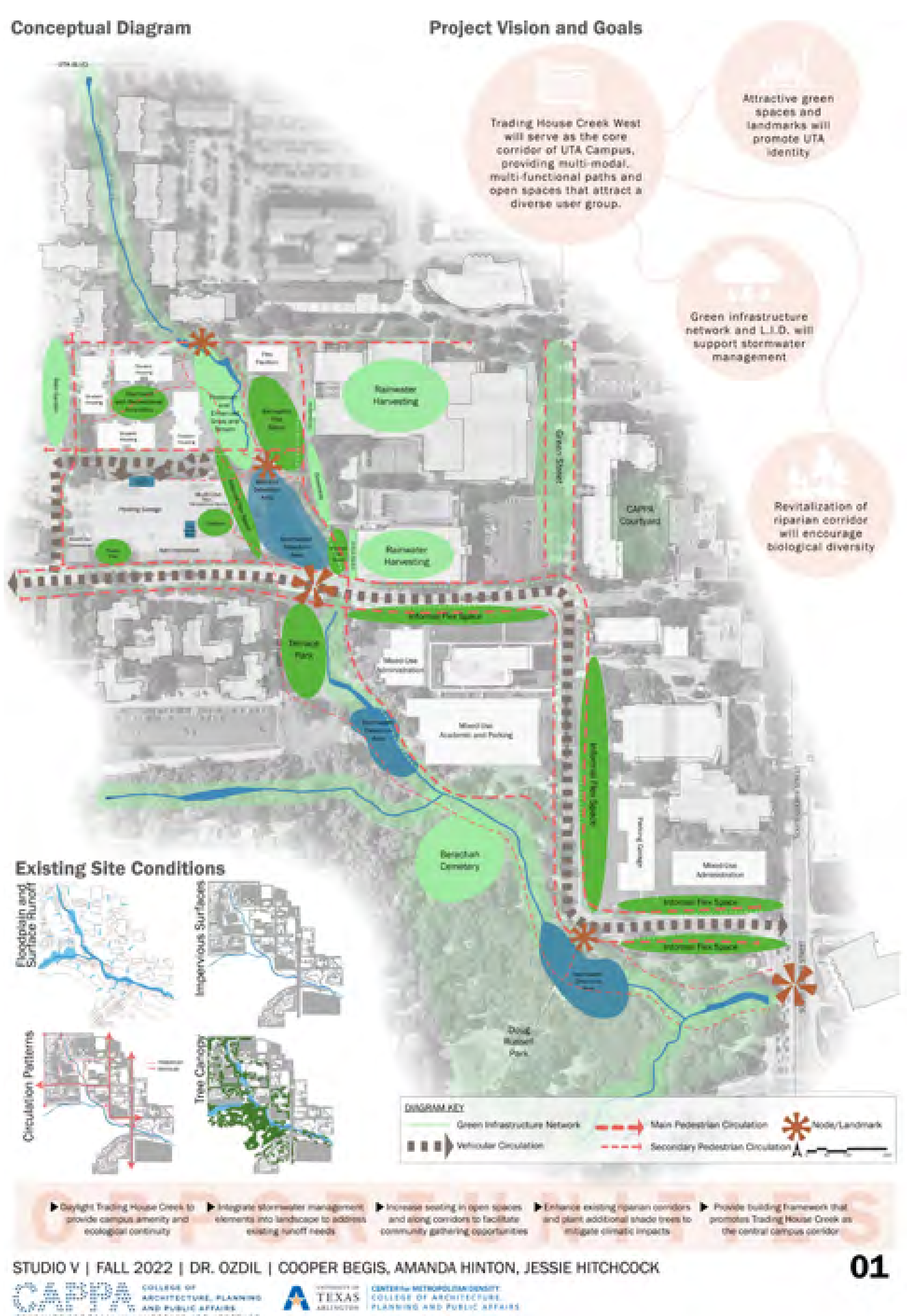


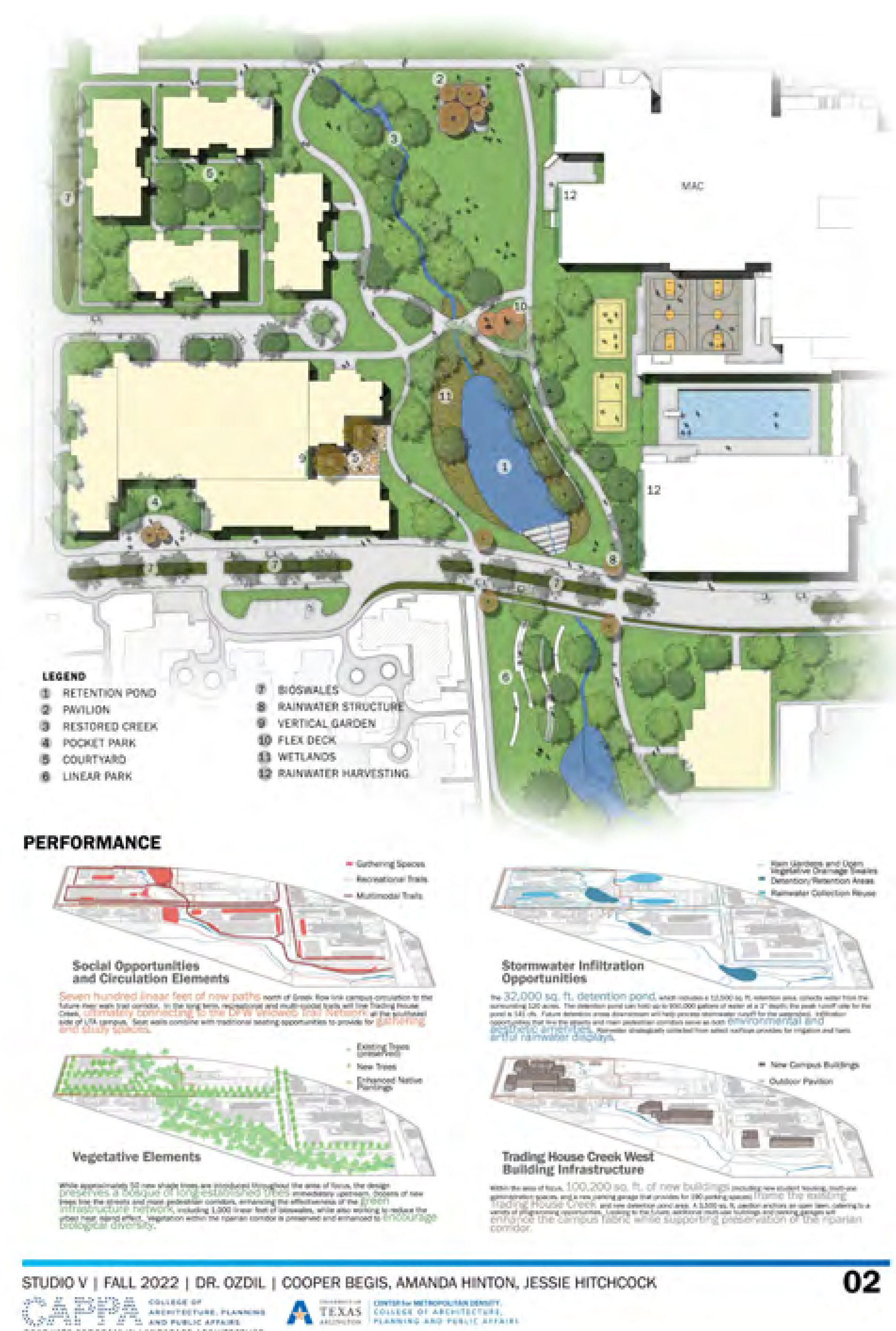


2022 UTA CAMPUS VISION STUDENT WORK AND EXHIBIT
TRADING HOUSE CREEK WEST

Building on the Campus RainWorks Challenge prompt, the Exhibit showcased UTA campus visions for four separate sites along Trading House Creek.

"TRADING HOUSE CREEK WEST" Amanda Rae Buss, Jessie Hitchcock, Cooper Luke Begis

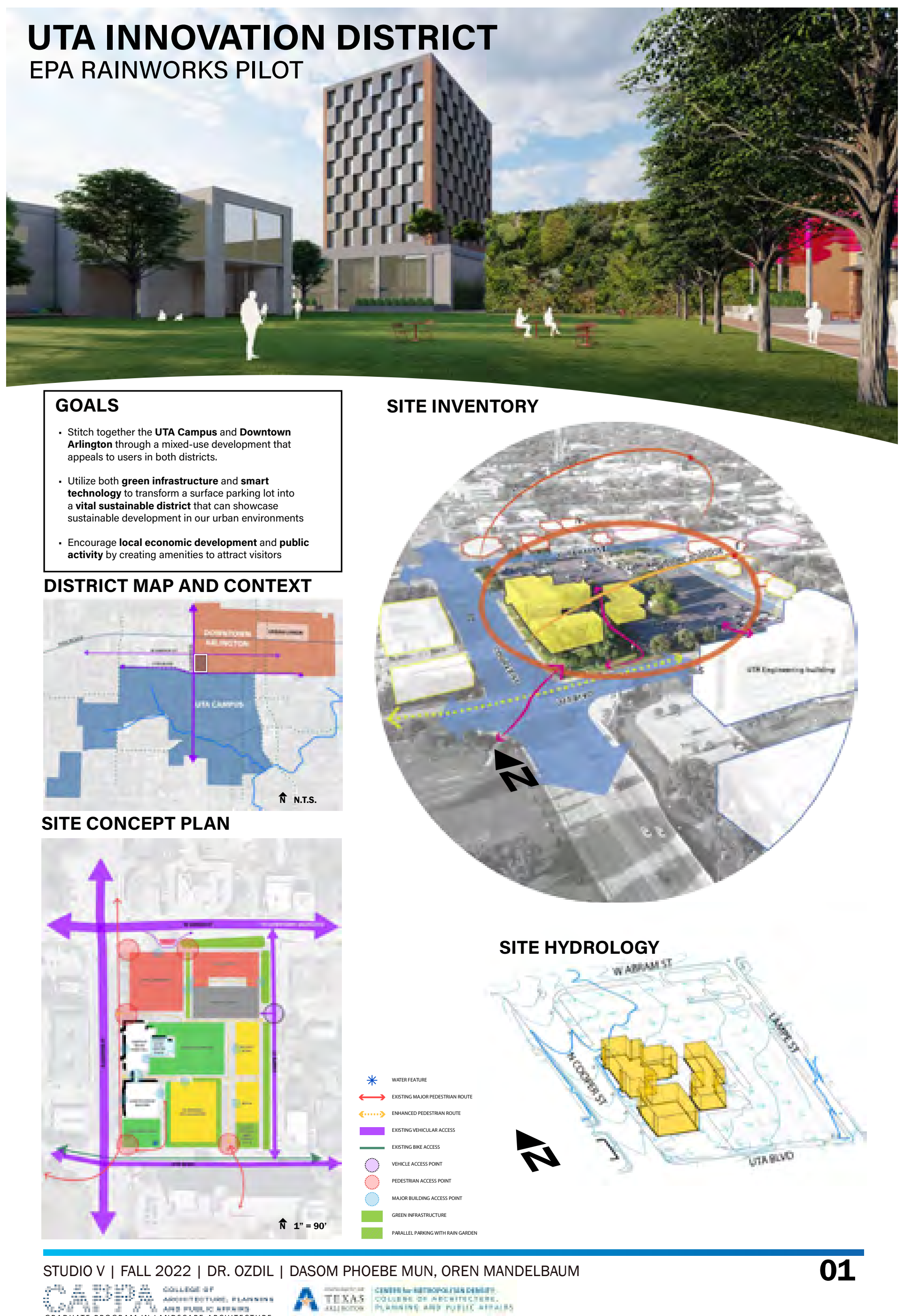


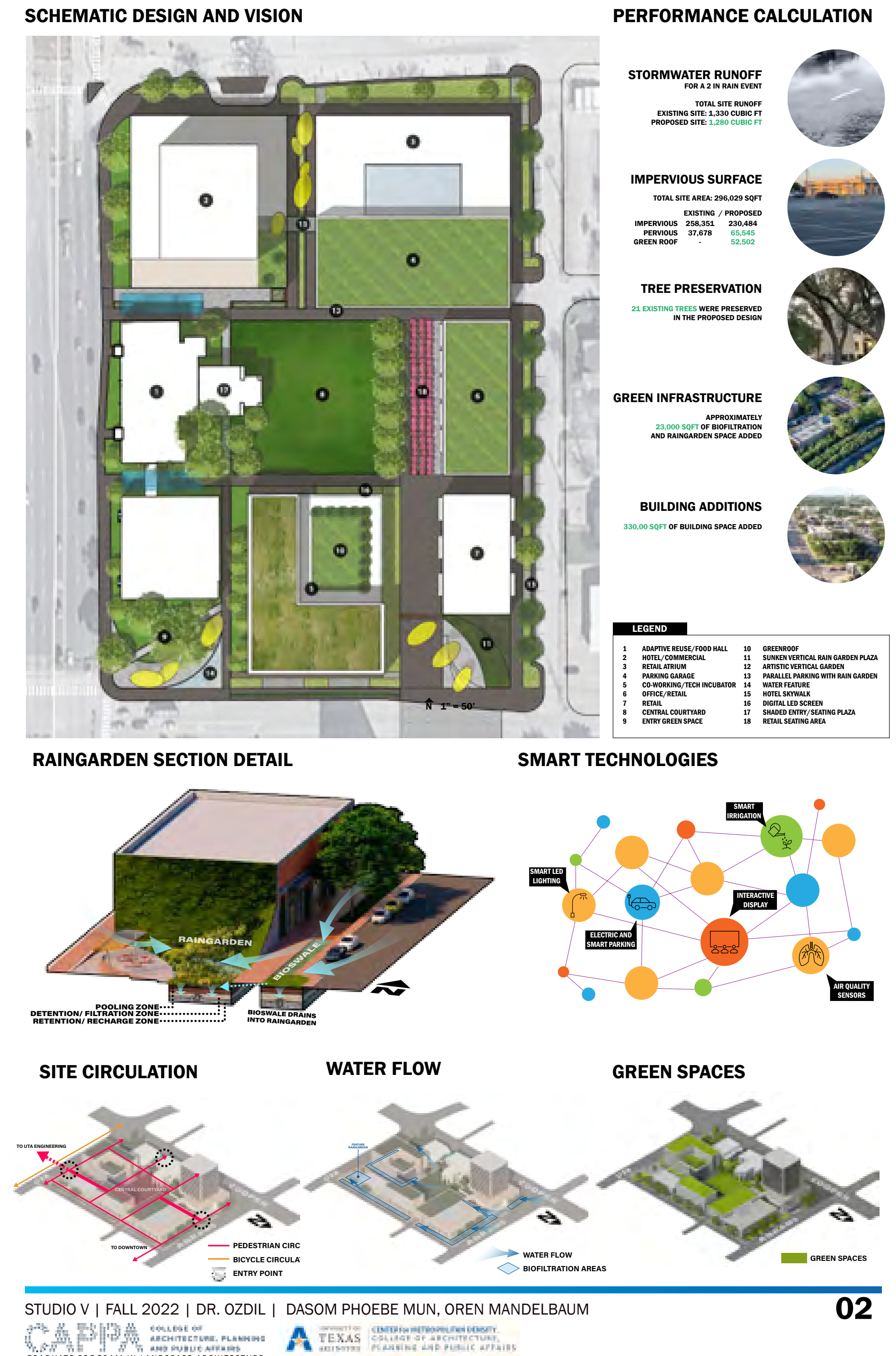


2022 UTA CAMPUS VISION STUDENT WORK AND EXHIBIT
UTA INNOVATION DISTRICT

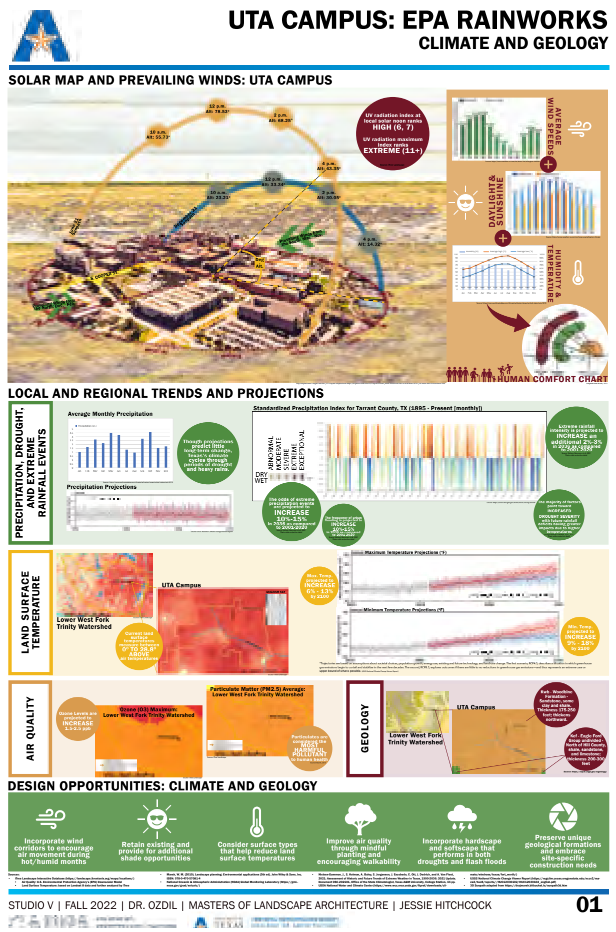
Building on the Campus RainWorks Challenge prompt, the Exhibit showcased UTA campus visions for four separate sites along Trading House Creek.

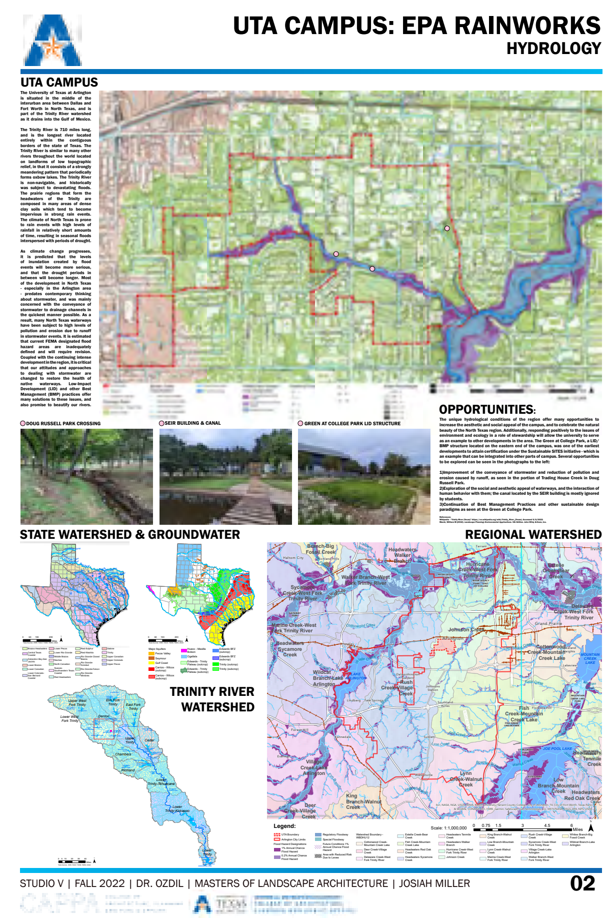
"UTA INNOVATION DISTRICT" Oren Daniel Mandelbaum, Dasom Mun

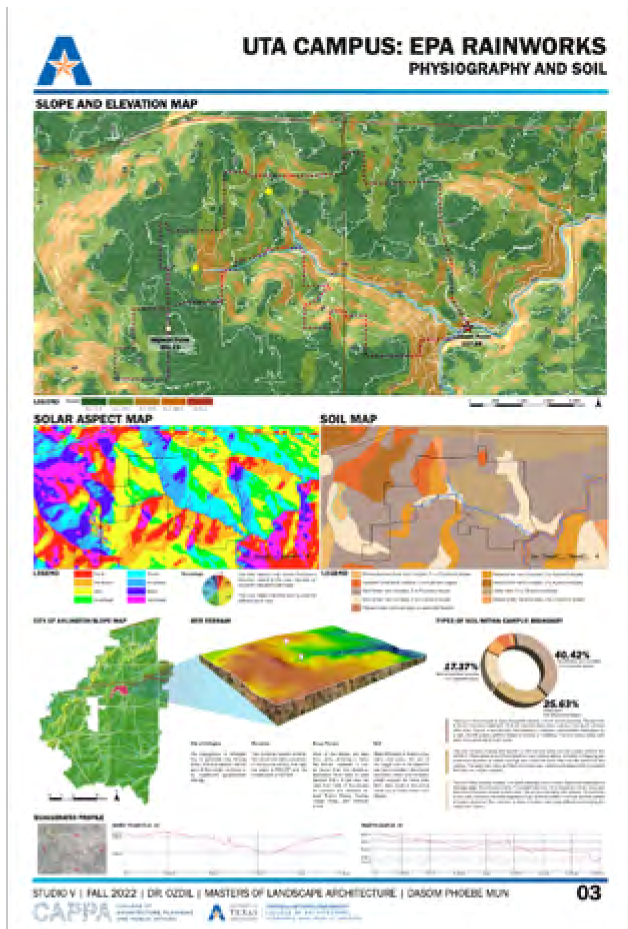


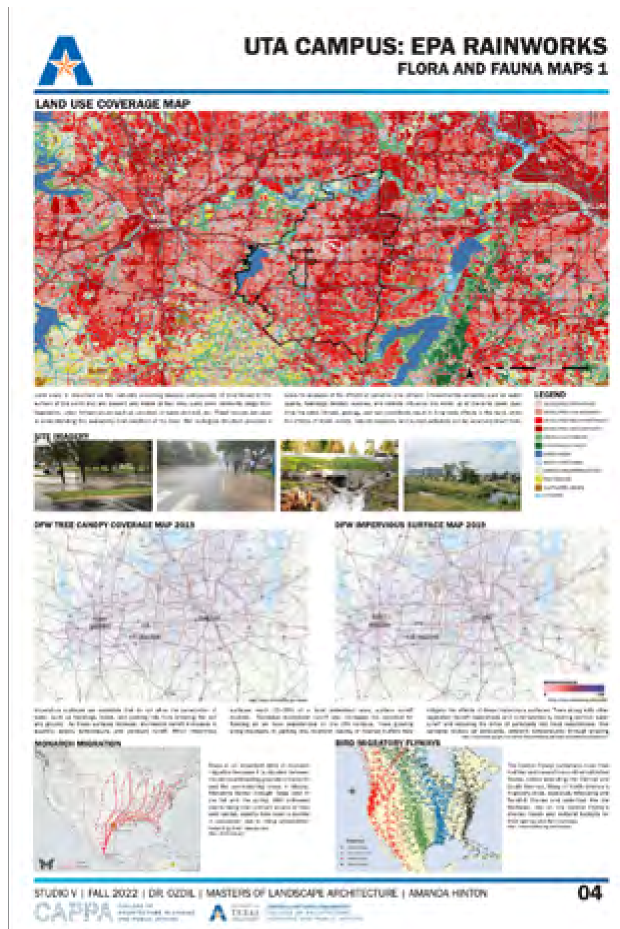


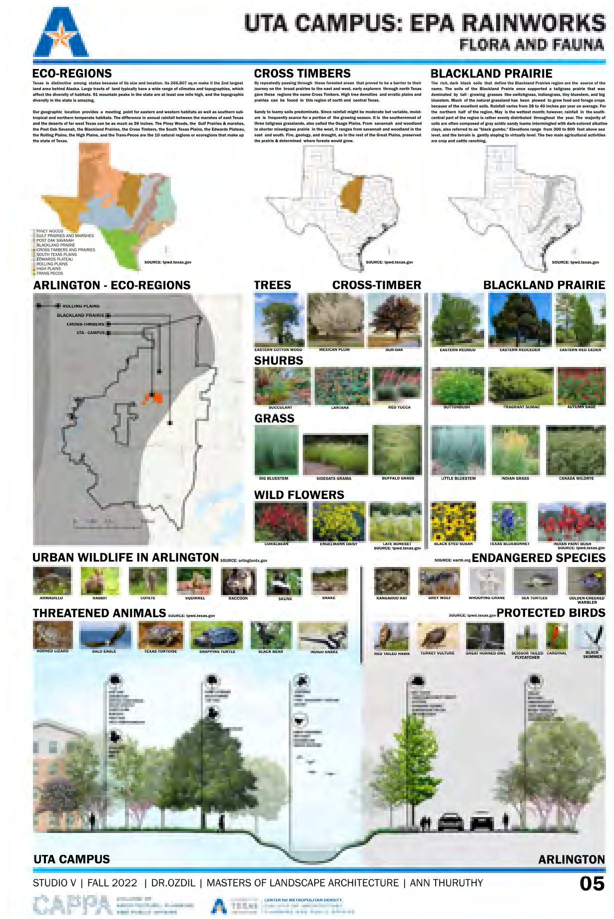
RECENT STUDENT WORK

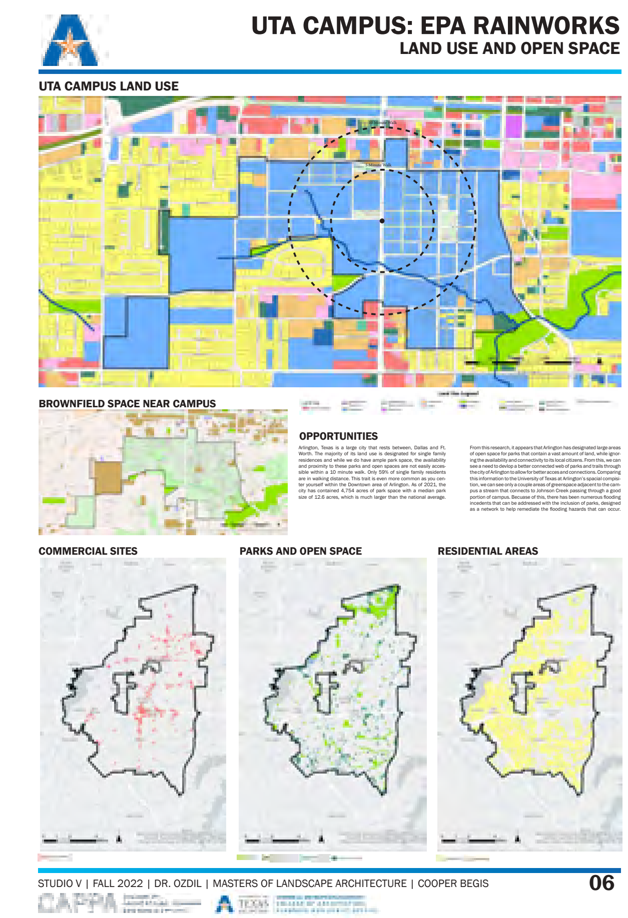


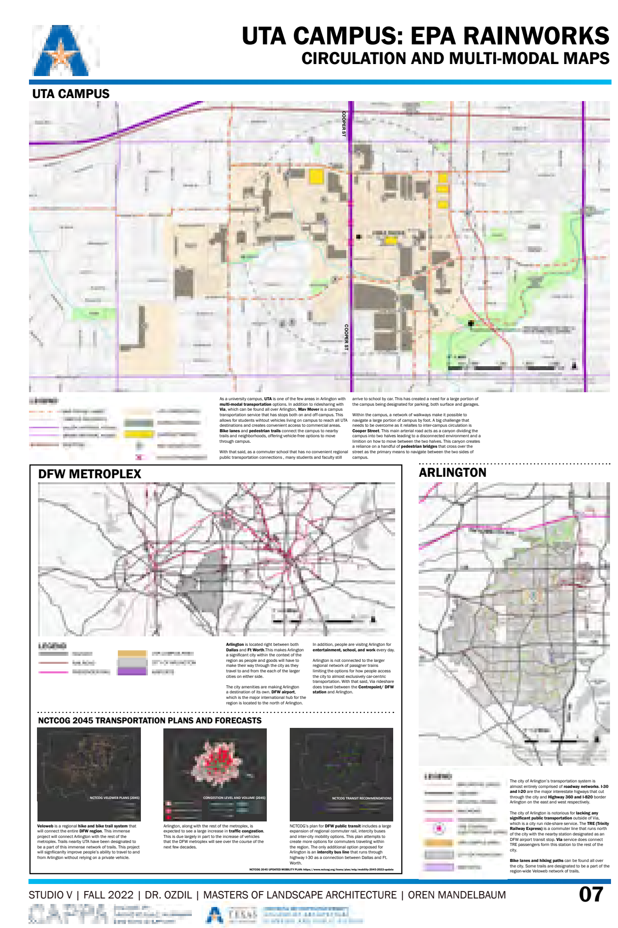


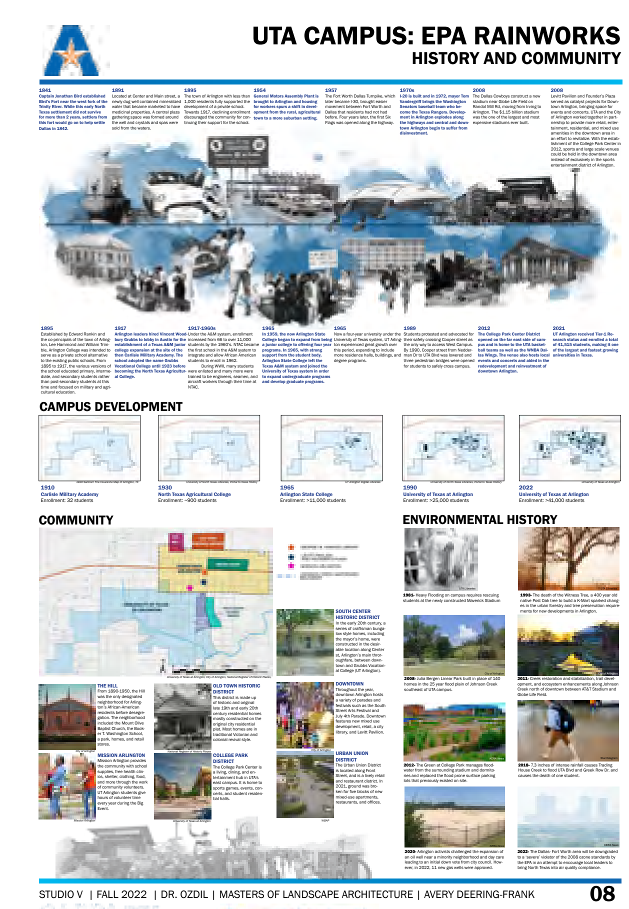












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