ECO-FLOW: A WATER-SENSITIVE PLACEMAKING RESPONSE TO CLIMATE CHANGE

2015 Environmental Protection Agency
Campus RainWorks Challenge
University of Texas at Arlington
December 18, 2015

Design Team M42:
Baishaki Biswas, B. Architecture, Candidate for Masters in Landscape Architecture
Sherry Fabricant, B.A. Psychology, B.B.A. Management, Candidate for Masters in Landscape Architecture
Jacob Schwarz, B.S. Exercise & Sports Science, Candidate for Masters in Landscape Architecture
Ahoura Zandiatashbar, B. Architecture Engineering, M. Architecture, M. Urban Design, Ph.D. Student in Urban Planning

Faculty Advisor:
Taner R. Ozdil, Ph.D., ASLA, Department of Planning & Landscape Architecture

PROJECT ABSTRACT

ECO-FLOW is a water-sensitive placemaking response to climate change for the newly envisioned student living, dining, recreation and parking facilities at the University of Texas at Arlington. The innovative, resilient, and collaborative effort is in response to the 2015 Environmental Protection Agency's Campus RainWorks Challenge. The goal was to engage students and university stakeholders in an interdisciplinary, hands-on learning experience promoting green infrastructure practices as it relates to climate change impacts. The study site will likely experience both extreme dry and wet historical events. In response to climate change projections and changing attitudes in urban life, the ECO-FLOW design solution centers on the natural flow of water and the liveliness of human movement while improving ecological integrity of the site and added value to the campus. The EPA's Stormwater Management Model Calculator was used to measure before and after stormwater run-off from the study site (Figure 6). A variety of Low Impact Design strategies (Table 1) were implemented resulting in a reduction of impervious surfaces from 83% to 63%, a 22% decrease in heat contribution, and 50% increase in tree canopy. Infiltration rates increase 60% during a 2" storm event and downstream flooding is mitigated. Implementation strategies take the form of four main phases addressing first water management, student movement/needs and solar radiation, the creek corridor ecological and hydrological adaptation, and finally green infrastructure expansion to the remaining campus. When implemented, ECO-FLOW promotes a sustainable, resilient, water/solar radiation-wise campus environment that serves as a role model for North Texas.

Figure 1. Design Site and Campus Context

INTRODUCTION

As our team embarks on this year's campus RainWorks challenge, France will chair and host the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change. According to the organizing committee, the objective is to achieve, for the first time in over 20 years of negotiations, a binding and universal agreement on climate, from all the nations of the world. Urban flooding and stormwater quality control have gained increased attention as climate change becomes more obvious with rising temperatures and increased precipitation along with future predictions of record-setting storms and changes in weather patterns. Regionally, intense groundwater extraction and depletion over time has placed Tarrant County on the state's list of Priority Groundwater Management Areas by the Texas Commission on Environmental Quality. Stresses due to climate change, impervious land cover and limited resources spark growing demands for change in the way we look at our built environments. ECO-FLOW: A WATER-SENSITIVE PLACEMAKING RESPONSE TO CLIMATE CHANGE aims to support and inspire The University of Texas at Arlington's (UTA) Environmental Action Plan in its efforts to create a sustainable, water-wise campus environment that serves as a role model for North Texas. When implemented, plan benefits will increase awareness, infiltration rates, reduce impervious run-off, improve water and air quality, produce green energy and healthier habitats but also serve as a model for retrofit and future development in the spirit of natural water hydrology and placemaking for human activity. The project leverages UTA imageability bringing green infrastructure westbound and contributes to student quality of life infusing needed social, leisure and educational functions.

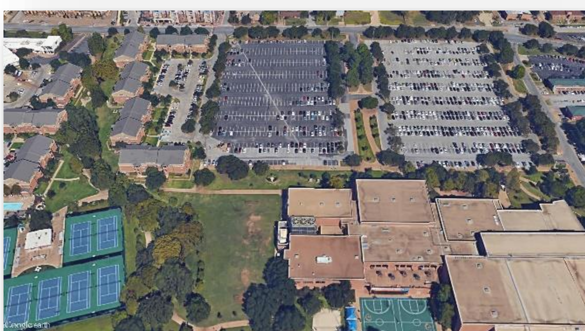


Figure 1B. Existing Lot 33

Figure 1C. Trading House Creek (shown here with pollutant filters from diesel spill)

SITE SELECTION, INVENTORY AND ANALYSIS

The design team met with UTA's facilities management team and reviewed the campus master plan in order to determine what future development was likely. The team chose to focus on development slated for the northwestern part of campus as it sits alongside the head of a major drainage inlet. This urbanized watershed drains into the northern portion of campus receiving its base flow from urban areas north of campus. This inlet feeds the site area with pollutant infused run-off that dumps into Trading House Creek which flows through UTA campus (Figures 1 A-C). Urban and campus stormwater run-off affects the UTA campus water quality, water quantity, habitat and biological resources, student health, quality of life, campus branding, and the aesthetic appearance of the campus waterway.

CAMPUS CONTEXT

UTA is centrally located within the Dallas-Fort Worth Metropolitan (DFW) area (Figure 2A) oriented within the Johnson Creek watershed that drains from the regional Lower West Fork Trinity River watershed (Figure 2B). UTA currently enrolls approximately 35,000 students with 4000 of those living on campus and another 6000 adjacent to or in close proximity.

Figure 2A.

The UTA master plan proposes our design site should house students in newly developed residences, erect structured parking, and include a dining hall. Currently the campus houses The Green at College Park (a sustainable sites initiative project), a structured parking photovoltaic system and a research focused green roof.

WATERSHED & CLIMATE

While climate change will likely increase both summer and winter average temperatures, the impact in Texas (and the DFW area, in particular) will be most evident in the number of days of extreme heat each year and record flood events. In Come Heat or High Water USA Infrastructure.org (2015) writes "By the end of this century, the average number of extremely hot days across the region each year—with temperatures above 95°F—will likely increase by as much as 14 times from nine days per year in recent decades to as many as 123 days per year."

Trinity River Watershed, Lower West Fork * **Texas Average Summer Temperatures**

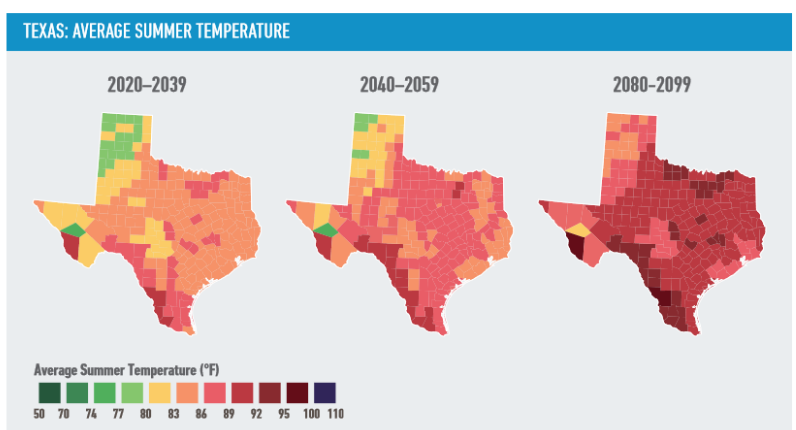


Figure 2B. Adapted from: TexasAgriLife.org **Source: American Climate Prospectus**

DFW future climate prediction trials suggests extreme temperatures up to 125 °F by the end of 21st century, exceeding historic heat waves by 12°F. By 2050, soil moisture is reduced by 10-15% in all seasons compared to historic values due to increase in temperatures. The likelihood of drought will also amplify the urban heat island effect, particularly during summer

TEXAS DATA QUICK REFERENCE	2020 2039		2040 2059	
	LIKELY	1-in-20 Chance	LIKELY	1-in-20 Chance
Days over 95°F	63 to 80	88	74 to 106	112
Mortality (total no. of deaths)	136- 2,578	3,561	1,147-4,549	6,405
Labor Productivity Change	-1.1%	-1.60%	-1.7% to -0.4%	-2.60%
Energy Expenditures Change	-0.5% to 7.4%	11.40%	1.5% to 12.4%	17.80%
Change in Crop Yields	-4.9% to 3.2%	-8.50%	-9.9% to 9.4%	-14.70%

	2030		2050	
Additional Coastal Storm Damage	$167M to $222M	$245M	$483M to $648M	$739M

Figure 3: Recreated - COME HEAT AND HIGH WATER: Climate Risk in the SE U.S. and Texas

months, that can result in up to 10°F temperature difference between downtown Dallas and adjacent rural locations. An increase in mean rainfall by up to 10% and severe thunderstorms by up to 40% in the spring season will likely lead to a higher risk of flooding affecting the infrastructure. Extreme flooding events are expected (Winguth et al, Climate Change/Extreme Weather Vulnerability of Dallas/Tarrant County Infrastructure). Annual water restrictions are already common in our area.

According to VISON NORTH TEXAS Regional Summit, operating under current development conditions, by 2030 impervious surfaces will double and by 2050 existing water supplies and production will not meet demands. In the face of climate change, we find ourselves in an era where we can no longer ignore how we approach development as it relates to water supply and our impact on the environment. Emerging development patterns must implement green infrastructure approaches in order to make a difference.

SITE HYDROLGY, SOILS, & TREE COVER

In addition to the major water flow entering the site at the above mentioned drain inlet, site surfaces (walkways, parking lots, roof tops) equal 83% impervious cover totaling 14 acres of the 17 acre site. Site run-off flows directly into the creek system with little infiltration as soils are heavily compacted.

The Natural Resources Conservation Services Soil Survey reveals the majority of the site consists of Wilson Urban Land Complex, 0-2% slope and Urban Land with somewhat poorly drained soils and clayey sediment. The areas on either side of the creek consists of Gasil Urban Land Complex with 1-8% slopes and are at risk for erosion.

Existing site canopy consists of roughly 10% (1.76 acres) of the site while the majority are Live Oaks (37%), Red Oaks (9%), and Bald Cypress (6%) with the remaining 52% being miscellaneous smaller varieties. Total existing on-site tree count equals two hundred and sixty (260).

ANALYSIS: STORMWATER MODELING

The EPA's Stormwater Management Model (SWMM) Calculator was used to measure stormwater run-off from the study site. The SWMM measured 73% (baseline) stormwater run-off under existing conditions (30"/yr.). Using the near term climate change scenario (through 2049) the run-off for hot/dry simulation (26"/yr.) also resulted in 73% whereas it increased to 75% stormwater run-off under wet/warm climate change situation (32"/yr.). Results in the following sections are measured using the hot/dry simulation (Figure 6).

OPPORTUNITIES

Unfortunately, at the writing of this report, the design team learned that a 300-gallon diesel fuel spill has made its way to the UTA campus entering our design site at the aforementioned drain inlet. Its effect is being downplayed as an environmental hazard with no real threat to the community as long as no one enters the creek until it's cleaned up. We propose a filter detention basin at the location of this inlet as a first line of water quality enhancement to the UTA campus. This Low Impact Design (LID) practice would have minimized the ecological impact of the creek. Clearly, design opportunities exist using LID philosophy in order to capture precipitation, clean and/or reduce run-off, and recharge the water table (see strategies used in Table 1). Utilizing site fingerprinting methods the design team implements non-structural LID practices such as building on the best location for activities while incurring minimal site disruption and restoring the site (daylighting the creek) where applicable. Conservation techniques used include minimizing total disturbed area (protect existing trees) and by protecting natural flow pathways and riparian buffers along the creek. The design team will minimize impacts by using cluster development and reducing and disconnecting impervious surfaces. Opportunities for structural LID practices (Green Infrastructure) for design implementation are bioretention cells (rain gardens), cisterns, green roofs and walls, permeable concrete, grassed swales (bioswales) and on-site infiltration. Other notable strategies at the concept level include A/C water recovery, photovoltaic energy systems, and biohavens.

GREEN CAMPUS APPROACH

The overall design concept transforms the campus through implementation of non-structural LID practices and green infrastructure in relation to the natural water flow of Trading House Creek. The creek flows through the northwest and southern portions of campus. It also implements other alternative green energy solutions seeking a comprehensive approach. In accordance with VISION NORTH TEXAS and the UTA ENVIRONMENTAL PLAN, along with the urgent need to act in response to current changes in climate, the design team has come up with a series of solutions in relation to the natural water flowing through campus **(Design Board 1 & 2, Table 1)** as well as focusing on human activities taking place in these spaces.

ECO-FLOW: A WATER SENSITIVE-PLACEMAKING RESPONSE TO CLIMATE CHANGE MASTER PLAN

The master plan responds to the liveliness and movement of both the natural flow of water and the natural tendency of humans. The concept recognizes the needs of both water and human activity therefore the concept is expressed in 3 layers: water flow (hydrology), people flow (activity), and placemaking (programmable spaces). Programmable spaces within the site (as well as the campus concept) provide educational opportunities demonstrating this concept and how green infrastructure responds to it. Recreational opportunities are provided within the programmable spaces and via a creek trailhead (connecting to the urban forest).

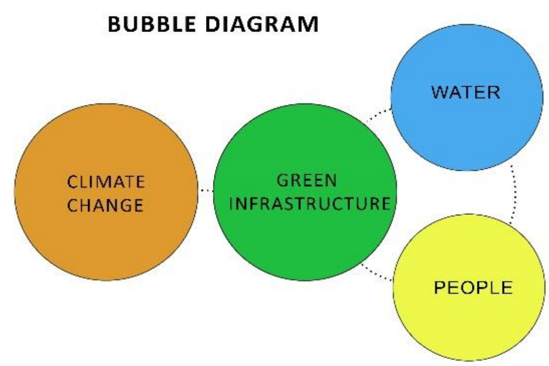


Figure 5.

COLLECT/CLEAN/PROTECT/ PROVIDE
Green Infrastructure approaches

LID STRATEGIES	RESILIENCY CONSIDERATIONS
BIOSWALES & RAIN GARDENS	
Rain water from residences and impervious areas disconnect existing stormwater systems by using grass lawn swales and rain gardens before flowing towards the creek area (Table 2)	Reduces problems associated with on-site erosion and high levels of flow energy. Protects ecosystem integrity.
GREEN ROOFS AND GREEN WALLS	
Green roofs improve water quality by filtering, absorbing and/or detaining rainfall. Green walls are self-sufficient vertical gardens attached to buildings. Both of these are found in the dining hall addition.	Reduces 'heat island effect, indoor energy demand, stormwater volume and CO_2 impacts. Treats nitrogen pollution and negates acid ran effect.
CISTERN	
Roof water management systems providing on-lot storage. A 300K gallon Steel Reinforce Polyethylene (SRPE) underground system installed.	Manages stormwater run-off, conserves water, and reduces potable water use and costs.

DAYLIGHT CREEK	
Redirect underground drainage system by restoring continuous above ground flow of Trading House Creek.	Increases infiltration rates and reduces peak flow energy.
PERVIOUS MATERIALS	
Permeable Materials used in redesign of all walkways.	Increases infiltration, decreases run-off volume and peak flow energy, Improves water quality.
POCKET RETENTION POND W/BIOHAVEN	
Retention basins capture and retain run-off during storm events and act as a permanent wet pond. A pocket basin is established south of site adjacent to the new outdoor stage. (30,000 sq.). Biohaven island technology is used to filter all remaining water retained in pond.	Mitigates downstream flooding, decreases stream bank erosion, Increases infiltration rates, water quality and habitat diversity.
RESTORE HABITAT & SOIL AMENDMENT	
Succession planting along creek areas in order to restore riparian areas and improvements to soil structure at all bioretention sites.	Improves water quality, infiltration rates, and biodiversity. Reduces stormwater run-off.
OTHER CONCEPT STRATEGIES	**RESILENCY CONSIDERATIONS**
PHOTOVOLTAIC SYSTEM	
Solar power systems. Structured parking holds a 385kW system. Currently UTA has 1 structured parking garage hosting 1638 separate panels (235W ea.) producing 480V AC Power. Solar roof tiles are also installed on apartment buildings on the creek trail. Reflective white roof installed.	Produces green energy, avoids releasing CO_2 into atmosphere for mitigating climate impact. Based on existing system, 2 added systems should generate approx. 1.1 million kWh of electrical energy and avoid tons of CO_2/yr.
A/C WATER RECOVERY	
Condensate Recovery Systems are specifically designed equipment to recover condensate from A/C installations in order to reduce waste water. Recovery ranges from 3-10 gallons/day per 1000 sq. ft. building space.	Reduces wastewater and domestic water use. Cold condensate provides additional free cooling from a cooling tower circulating water and water is already distilled.

TABLE 1. GREEN INFRASTURCTURE APPROACHES

RAIN GARDEN PLANTS BOTANICAL	Common Name	Height	Width	Light	Moisture
Perennials					
Anisacanthus quadrifidus var. Wrightii	Flame Acanthus	4'	4'	S	Xeric
Asclepias tuberosa	Butterfly Weed	3'	6"	S	Xeric
Hibiscus coccineus	Red Star Hibiscus	4-6'	3'	S	Xeric
Stachys byzantine	Lamb's Ear	6"	12"	S	Xeric
Stokesia laevis	Stokes' Aster	2'	2'	S	Xeric
Asclepias incarnata	Swamp Milkweed	5'	3'	S	Bog
Cyperus alternfolius	Umbrella Sedge	4'	4'	SH	Bog
Dryopteris normalis	Wood Fern	3'	1'	SH	Bog
Equisetum hymenale	Horestail Reed	4'	6'	S/PSH	Bog
Ipomopsis rubra	Standing Cypress	2-6'	6-12"	S	Bog
Liatris spicata	Gayfeather	2'	18"	S	Bog
Lobelia cardinalis	Cardinal Flower	2-4'	2'	S/PSH	Bog
Physotegia intermedia	Spring Obedient Plant	3-6'	1'	S/PSH	Bog
Corespsis verticillata 'Moonbeam'	Moonbeam Coreopsis	1'	1'	S/PSH	Mesic
Crinum americanum	Crinum Lily	2'	2'	S	Mesic
Eupatorium coelestinum	Blue Mistflower	8"	16"	S	Mesic
Hemerocallis spp.	Daylilies	3'	2'	S	Mesic
Hymenocallis liriosme	Spider Lily	2'	1'	S	Mesic
M. aboreus var. drummondii	Turk's Cap	2-3'	1'	S/PSH	Mesic
Monarda didyma	Bee Balm	2'	2'	S	Mesic
Rudbeckia hirta	Black-eyed Susan	1-2'	1'	S	Mesic
Ruellia brittoniana 'Katie's'	Ruellia Katie	6"	12"	S	Mesic
Solidago spp.	Goldenrod	2-4'	3-5'	S	Mesic
Tagetes lucida	Mexican Min Marigold	1-2'	1-3'	S	Mesic
Ornamental Grasses					
Bouteloua dactyloides	Buffalograss	6"	varies	S	Xeric
Chasmanthium latifolium	Inland Seaoats	2-4'	varies	SH	Bog
Carex spp.	Sedge	varies	varies	S/SH	Mesic
Tripsacum dactyloides	Eastern Gama Grass	4-8'	Varies	S/SH	Mesic
Shrubs					
Spirea x bumalda 'Anthony waterer'	Anthony Water Spirea	2-3'	3'	S	Xeric
Cephalanthus occidentalis	Buttonbush	10'	10'	S/PSH	Bog
Itea virginica	Sweetspire	3-4'	4-6'	S/PSH	Bog
Callicarpa americana	American Beauty Berry	4-6'	5-8'	S/SH	Mesic
Ilex decidua	Possumhaw Holly	20'	15'	S/SH	Mesic
Trees					
Asimina triloba	Pawpaw	15'	15'	SH/PSH	Mesic
Sophora affinis	Eve's Necklace	30'	20'	S	Mesic
Taxodium distichum	Bald Cypress	70'	30'	S	Mesic

Table 2: Adapted (full list at): http://water.tamu.edu/files/2013/02/stormwater-management-rain-gardens.pdf

IMPLEMENTATION

Water (2016-2018)

The majority of the existing site is currently surface parking. Areas planned for water flow redirection per a series of rain garden treatment train systems and day lighting the creek serves as a mode of educational and visual awareness opportunities. During this phase cisterns are installed as well as the detention and retention ponds along the creek. High impact/cost-effective areas are targeted. Planning in conjunction with UTA Institute for Sustainability and Global Impact initiates an awareness campaign concerning UTA campus response to water practices and climate change. Design practices are built into the UTA Environmental and Master Plans.

People (2018-2020)

Once the demonstration gardens and daylighting are complete, the focus turns to construction of structured parking, residence and dining halls. New construction and building design serve as educational and awareness opportunities targeting the extensive green roof, the photovoltaic systems, A/C water recovery and disconnecting built site hydrology. In the face of climate change, population increase (sprawl), and a general change in attitudes concerning people places, placemaking is emphasized.

Creek (2020-2022)

Water flow is highlighted as it follows Trading House Creek linear greenway though campus. Phase 3 focuses on habitat enrichment and diversity surrounding the creek. Overall stream bank and habitat is targeted by restoring succession and meadow/prairie plantings. The trailhead is improved, incorporating educational signage and program areas as well as focusing on the urban forests. Connection from Trading House Creek trailhead will connect into the City of Arlington's Johnson Creek Greenway. This connection offers further opportunity for recreational endeavors.

Campus Extension (2022-2030)

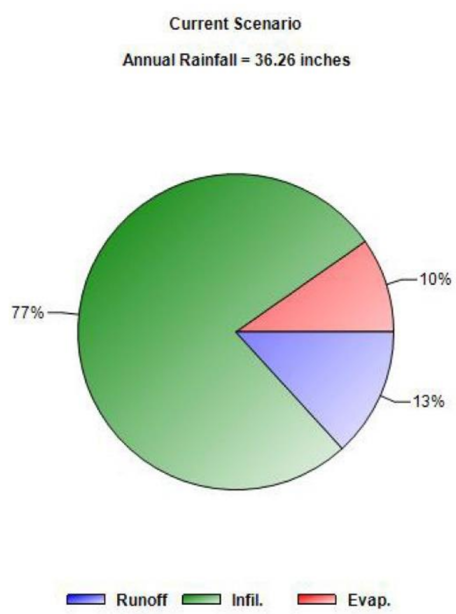
As a result of newly implemented green infrastructure and non-structural LID strategies during phases 1-3, the UTA community has secured an excellent position to showcase its commitment and action towards sustainability and global impact through resilient adaptation practices. During the first phase, the UTA master is revised to include campus-wide changes. The last phase involves a campus-wide LID retrofit process to address the remainder of the campus.

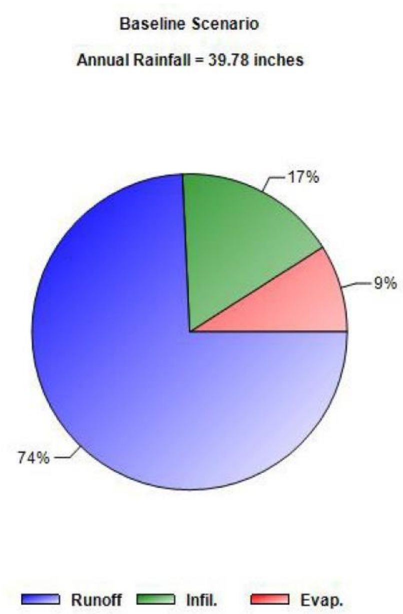
ANALYSIS RESULTS

Results were calculated using the EPA Stormwater Calculator during a 2" storm event. Compared to existing 83% of impervious cover, the new site design implements green infrastructure reducing impervious cover to 64% of the site. Rain gardens, infiltration basins, and permeable paving were assumed to have a capture ratio of 100%. Figure 6 reflects results based on near term climate change (2020-2049) under a Hot/Dry year. In a Warm/Wet year stormwater run-off increase to 15% (opposed to 13% in a Warm/Dry year). Far term (2045-2074) climate change numbers were also run but did not reflect significant changes from the near term results. LID controls implemented calculate a decrease in average annual stormwater run-off of 25-26”/year.

EPA Calculator Statistic (2 Rain Event)	Current Scenario (near term thru 2049)	Baseline Scenario (Existing conditions 2015)
Study Site (17 acres)	**(63% Impervious)**	**(83% Impervious)**
Average Annual Rainfall (in.)	36.26	39.78
Average Annual Runoff (in.)	3.96	29.71
Days per Year with Rainfall	2.3	3.15
Days per Year with Runoff	0	1.7
Percent of Wet Days Retained	100	40.35
Smallest Rainfall w/Runoff (in.)	0	2.45
Largest Rainfall w/o Runoff (in.)	6.38	2.48
Max. Rainfall Retained (in.)	4.69	1.07

EPA Stormwater Calculator Statistics (adapted)





60% increase in infiltration (green area).

61% decrease in rainwater run-off (blue area).

Green Infrastructure: (63% Impervious)

277,508 gallons captured
403,311 gallons decreased run-off

Existing Baseline (83% Impervious):

808,514 gallons run-off

Figure 6. EPA Stormwater Calculator Statistics (Calculated cross-reference (to confirm figures), variance = <10%)

EXPECTED OUTCOMES

- Reduce impervious area, 20%
- Reduce directly connected (to traditional drainage) impervious area, 100%
- Increased infiltration, 60%, Decrease in run-off, 61%
- New design reduces stormwater run-off depth from existing site 25"/yr.
- Reduce run-off depth from existing site simulating for climate in hot/dry year, 21"/yr.
- Reduce run-off depth from existing site simulating climate in a warm/wet year, 24"/yr.
- Reduce potable water use for irrigation attributed to captured rainwater, 596,642 gal./yr.
- Annual groundwater recharge 623,000 gal./yr.
- Area of protected streambank soils, 100%
- Area of restored soils 3 acres, 2%
- Canopy trees protected (of 260) 93%
- Native/adapted trees added – Increase of 2% site cover in tree vegetation, 250 trees
- Increase in roof area shaded by vegetation of roof Dining hall, Activity Center: 80%, 50%
- Green wall added, 300 sq. ft.
- Decrease in hardscape area 3 acres
- Green energy generated from photovoltaic system at structured parking, 1.162m. kWh
- Greenhouse gasses avoided via photovoltaic systems, 5000 tons CO2/yr.
- Change to native and adapted planting beds and rain gardens as well as succession plantings in concept design protects and improved ecosystem services
- Change in pollinator diversity will be supported
- Rain garden native/adapted plants added (Table2). Total new trees added, 250
- Stream bank restored with succession plantings for improved erosion control
- New trees should sequester minimum 14,050 pounds CO_2/yr.
- Biohaven island filter in pocket pond will remove all remaining water pollutants from site run-off prior to joining Johnson Creek Watershed

CONCLUSTION: VALUE ADDED

Expected benefits of green infrastructure described above add substantial environmental value to UTA campus. The project design focuses on value added to the UTA community by offering social, educational, and recreational opportunities as well an aesthetically pleasing environment. Creek ecology is enriched and habitat diversity increases. The creek acts as a unifying element linking west to east campus as well as connecting to the surrounding neighborhoods. Most importantly, it balances recent east campus development and responds to the demand for campus branding. ECO-FLOW: A WATER-SENSITIVE PLACEMAKING RESPONSE TO CLIMATE CHANGE leverages campus branding on the west side of campus and balances campus life between both district edges. When implemented, ECO-FLOW promotes a sustainable, resilient, water/solar radiation-wise campus environment that serves as a role model for North Texas.

REFERENCES

10 Things To Know About The U.N. Climate Talks In Paris. Greenfieldboyce, N. (n.d.). Retrieved December 1, 2015, from http://www.npr.org/2015/11/30/457364450/10-things-to-know- about-the-u-n-climate-talks-in-paris

Adams, M. and Watson, D. (2010) *Design for Flooding: Architecture, Landscape, and Urban Design for Resilience to Climate Change 1st Edition*: Wiley

Benefits of your tree. (n.d.). Retrieved December 14, 2015, from http://www.treebenefits.com/calculator/ReturnValues.cfm?climatezone=South

Big Data Predicts Centuries Of Harm If Climate Warming Goes Unchecked. Retrieved December 1, 2015, from http://www.npr.org/2015/11/30/457794505/big-data-predicts-centuries- of-harm-if-climate-warming-goes-unchecked

Carbon Dioxide Capture and Sequestration | Climate Change | US EPA. (n.d.). Retrieved December 17, 2015, from http://www3.epa.gov/climatechange/ccs/

Case Study Briefs | Landscape Performance Series. (n.d.). Retrieved December 17, 2015, from http://landscapeperformance.org/case-study-briefs

Condensate_Recovery_System_-Technical_Guide.pdf. (n.d.). Retrieved December 2, 2015, from http://www.seai.ie/Your_Business/Technology/Buildings/Condensate_Recovery_System_-Technical_Guide.pdf

COP21 | United nations conference on climate change. (n.d.). Retrieved December 1, 2015, from http://www.cop21.gouv.fr/en

COA-SWMP-2015-Final-Draft.pdf. (n.d.). Retrieved November 22, 2015, from http://www.arlington-tx.gov/stormwater/wp-content/uploads/sites/35/2015/04/COA- SWMP-2015-Final-Draft.pdf

Fuel spill makes way to campus | News | theshorthorn.com. (n.d.). Retrieved December 1, 2015, from http://www.theshorthorn.com/news/fuel-spill-makes-way-to-

Green Infrastructure | US EPA. (n.d.). Retrieved October 29, 2015, from http://www2.epa.gov/greeninfrastructure

IPCC - Intergovernmental Panel on Climate Change. (n.d.). Retrieved December 2, 2015, from https://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg3_report_mitigation_of_climate_change.htm

Low Impact Development Center. (n.d.). Retrieved December 2, 2015, from http://www.lowimpactdevelopment.org/greeningepa.htm

Low Impact Development (LID) Urban Design Tools. (n.d.). Retrieved December 2, 2015, from http://www.lid-stormwater.net/

National Stormwater Calculator | Water Research | US EPA. (n.d.). Retrieved December 17, 2015, from http://www.epa.gov/water-research/national-stormwater-calculator

North Central Texas Council of Governments (n.d.). Retrieved November 27, 2015, from http://www.nctcog.org/

Project for Public Spaces. (n.d.). Retrieved November 09, 2015, from http://www.pps.org/

Schools tapping A/C condensate to conserve water - Houston Chronicle. (n.d.). Retrieved December 2, 2015, from http://www.chron.com/news/houston-texas/article/Schools-tapping-A-C-condensate-to-conserve-water-2178614.php

Sustainability-report-2012.pdf. (n.d.). Retrieved October 29, 2015, from http://www.uta.edu/sustainability/_downloads/sustainability-report-2012.pdf

The Green at College Park at the University of Texas at Arlington | SITES. (n.d.). Retrieved November 23, 2015, from http://sitesweb.gbci.org/green-college-park-university-texas-

The Social Life of Small Urban Spaces : William H. Whyte : Free Download & Streaming : Internet Archive. (n.d.). Retrieved November 17, 2015, from https://archive.org/details/SmallUrbanSpaces

TSPE DFW Mid-Cities - The Challenge of Urban Flooding with Steve Eubanks, PE, CF. (n.d.). Retrieved November 22, 2015, from http://events.r20.constantcontact.com/register/event;jsessionid=F08C346029FC31D79 2A32B08811B4142.worker_registrant?llr=oe5d9qrab&oeidk=a07ebawu9x6c0ebf96d

US EPA, O. (n.d.). Industrial Wastewater Studies - Miscellaneous [Reports and Assessments]. Retrieved October 29, 2015, from http://www2.epa.gov/eg/industrial-wastewater-studies-miscellaneous

Using-Air-Handler-CondensatePGuccione-Final.pdf. (n.d.). Retrieved December 2, 2015, from http://www.districtenergy.org/assets/pdfs/2012-Campus-Arlington/Presentations/Tues-A/4A2PRUITTWILKISONGUCCIONENEWUsing-Air-Handler-CondensatePGuccione-Final.pdfVision North Texas. (n.d.). Retrieved November 24, 2015, from http://www.visionnorthtexas.org/

Web Soil Survey. (n.d.). Retrieved November 24, 2015, from http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

What does it mean to be climate resilient? | Climate Home - climate change news. (n.d.). Retrieved November 2, 2015, from http://www.climatechangenews.com/2014/11/10/what-does-it-mean-to-be-climate-resilient/#sthash.QeXGb0nm.dpuf]

Winguth, A.M.E., and B. Kelp, 2013. The Urban Heat Island of the North-Central Texas Region and Its Relation to the 2011 Severe Texas Drought. *J. of Applied Meterology and Climatology*, **52**, 8-2433.

wpengine. (n.d.). AgriLife Research: Groundwater challenges emerging around Dallas-Fort Worth metroplex. Retrieved November 22, 2015, from http://baen.tamu.edu/2013/04/agrilife-research-groundwater-challenges-emerging-around-dallas-fort-worth-metroplex/

ACKNOWLEDGMENTS

We would like to thank for following people for graciously providing feedback, information, and valueable time during our team project!

Robb Chock, P.E., UTA Facilities Engineer

Yekang Ko, Assistant Professor Urban Planning

Eric Leidlein, Executive Director for UTA Axillary Services

Meghna Tare, Executive Director, UTA Institute for Sustainability and Global Impact (ISGI)

Bill Poole, Assistant Vice President for UTA Facilities Management and Campus Operations

Arne Winguth, Associate Professor, Earth & Environmental Sciences (Climate Change)