



comprehensive and systematic framework for the research, ease the research process for multiple case studies, and to not lose sight to document diverse set of findings. These sub-categories are used primarily to identify and organize the performance benefits of landscape architecture projects in this collaborative investigation.

The UT Arlington research combines quantitative and qualitative methods to document three landscape architectural projects, and to assess their performance benefits (Deming et. al., 2011; Ozdil, 2008; Murphy, 2005; Moughtin, 1999). Methodological underpinnings of this case study research are primarily derived from a systematic review of performance criteria and variables from: (1) the Landscape Architecture Foundation's landscape performance series *Case Study Briefs* (LAF, 2013), (2) the case study methods that are developed for designers and planners in related literature (Francis, 1999; Gehl, 1988; Preiser et. al., 1988; Marcus et. al. 1998), and (3) the Primary data collection methods through; surveys (Dilman, 1978), site observations, behavior mapping, and assessment techniques (Marcus et. al. 1998; Whyte, 1980 & 1990), (4) and finally project related secondary data collected from project firms, project stakeholders, public resources and databases. The data gathered from all the research instruments are further analyzed, synthesized and summarized as the performance benefits for the three case studies under investigation. The findings are organized within the LAF framework, as it is outlined earlier in this document for online publication. The research is designed to highlight the values and the significance of these three landscape architecture projects by utilizing objective measures and by documenting and evaluating their performances to inform future urban landscapes.

#### **Data Collections Methods:**

The research involves collection of primary and secondary data through on-site or online surveys, site observations and systematic review of available secondary data. As a first step, the research team acquired necessary permissions from Institutional Review Board at UT Arlington prior to primary data collection involving human subjects.

**Survey:** A survey instrument is developed to collect social performance data for all three sites. The survey is developed to measure user perception on topics such as; quality of life, sense of identity, health and educational benefits, safety and security, presence of arts, and availability of informal and organized events, and etc. The survey is informed by relevant literature as well as by other survey instruments prepared for parks and other landscapes projects (such as Dallas' Park & Recreation Survey, New York's Central Park Survey to name a few). The survey primarily asks the visitors for their perceptions and experiences of the site. The survey instrument and the variables questioned within were kept almost identical in all three cases in order to develop a more homogenous measure to study varying sites, and to provide LAF with a replicable and generalizable instrument.

The survey is composed of three parts. The first part of the questionnaire attempts to document user profiles as well as user perception and choices on activities available on the site by using multiple choice questions. The second part of the survey asks users to rate performance related statements with Likert scale questions. The final portion of the survey was kept for additional comments/concerns of visitors who want to share additional information with the research team.

The survey was voluntary and the identity of the respondents was assured to be kept confidential to ease privacy concerns. The survey is kept short (15 minutes to take complete) and prepared for both online and on-site platforms in order to increase its utilization by potential respondents. Due to time and resources limitations, researchers utilized online and on-site survey interchangeably in some case studies. Surveys for all three sites were conducted over

the summer months. The surveys were conducted on both weekdays and weekends in random intervals for better representation of the varying visitors using each site. While on-site surveys had more concentrated time frame (day or week) online surveys were open to users for a longer period of time.

**Site Observations:** Passive observations, photography, video recording, site inventory and analysis techniques (such as use of street furniture counts/measurements, etc.), as well as behavior mapping and tracing methods are also utilized in some instances to better understand the case study features and the performance of the case study sites. The research team primarily benefited from site visits and observations to understand the user behavior about the way the spaces are being used. Observational methods utilized in this research did not involve any intrusive interaction with the subjects and necessary precautions are taken not to impede or govern the subjects' activities. Although photography or video recording is used, the identity of the space users is blurred unless they allow researchers to use their images. The research team in all three case studies informed the stakeholders prior to site visits, and acquired necessary permissions. While on-site for data collection, the research team used signs at various locations and informed consent forms to secure permissions from the subjects.

**Archival and Secondary Data:** This research heavily benefited from archival and secondary data attained from project firms, project stakeholders, public resources, and private databases. As part of LAF's mission this research was a product of a partnership among the academic research team, project firm, and LAF. Where and when data were available from the secondary sources such as from the landscape architecture firm, client(s), project partners, scholarly literature, and publicly the project team systematically collected and organized the data, diligently reviewed its content, assessed its rigor and integrity. The research team later used the relevant data to document the project, and assessed the landscape performance for all three sites.

#### **Data Analysis and Research Design:**

The UT Arlington team designed its research strategy under three focused thematic areas; environmental, economic, and social (including cultural and aesthetic) for all three case studies. In the beginning of the investigation, the research team benefited from this strategy to conduct a systematic research that produces replicable performance criterias and methods for all three sites. After the measurable criterias are identified and the possibilities were exhausted, the UT Arlington team further refined its approach by customizing performance criteria and procedures to each case study site to better document and report the varying qualities of each site independently. While achieving a comparable set of performance benefits for all sites was the goal and this strategy produces the greater framework for the research, customizing detailed performance criteria later in the process helped the research team to overcome the concerns about data availability, varying project typologies, project goals and outcomes.

The findings of the investigations in all cases focused on first, site related performance benefits, then its immediate adjecencies, and finally on the project block group/neighborhood/district or zip code. For example, performance benefits that are most direct and telling about the project site are more emphasized in comparison to indirect performance benefits and findings about the project adjacencies, or neighborhoods. This strategy is also used in the reporting of the findings to clarify the document and to ease the review.

In conclusion, the data collected through these strategies were systematically reviewed and appropriate methods for analysis for specific performance criterias are highlighted in the detailed methodology below. The following section presents research design specifics for The

University of Texas at Dallas Campus Identity & Landscape Framework Plan, a basic summary of the performance criteria under investigation, and the data sources and the procedure involved in measuring that particular performance criteria.

### Overview of UT Arlington's Research Strategy for The University of Texas at Dallas Campus Identity & Landscape Framework Plan:



**Figure.1** UT Dallas Campus Identity & Landscape Framework Plan, Before and After

(Source: PWP Landscape Architecture, 2013)

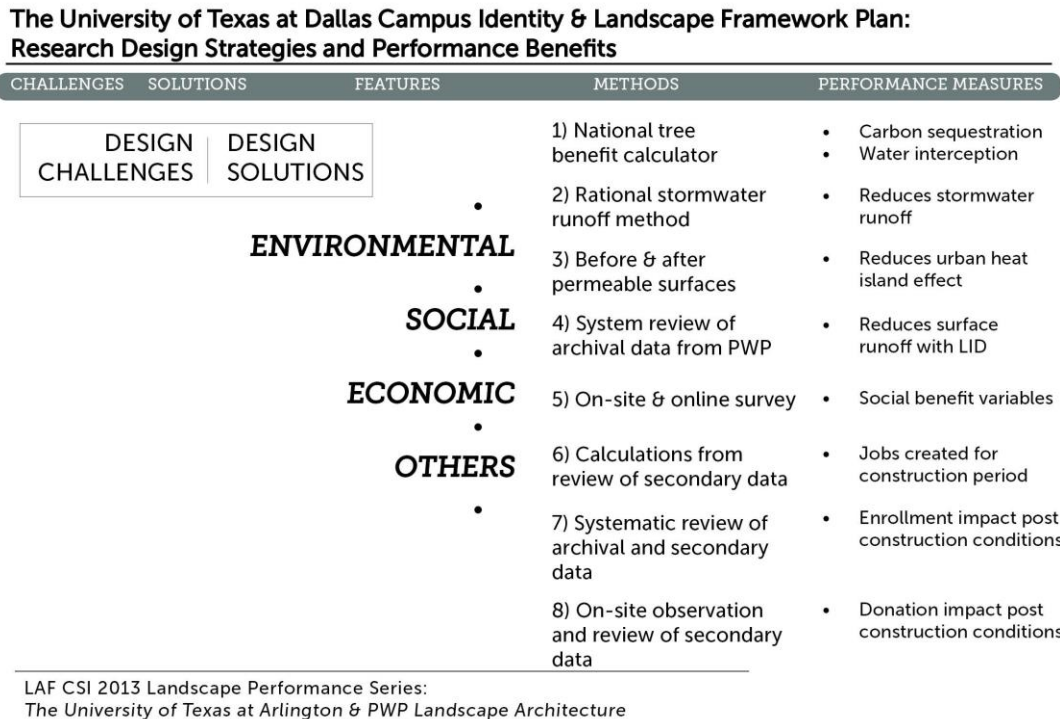
The University of Texas at Dallas Campus Identity & Landscape Framework Plan transitions the campus from being a suburban, car-centric environment to a pedestrian friendly space. This enhancement was aided through substantial native plantings and through an increase of the canopy tree count on-site. Funding from the University of Texas system, the state government and private sources enabled the original \$6 million plan to move forward and later be augmented through a \$30 million private donation.

Through life-span the campus evolved into a stark collection of buildings, surrounded by asphalt parking lots and inhospitable public plazas. The natural landscape and creek corridors that historically graced the property are compromised and mostly destroyed. The insular circulation system of the campus resulted in the absence of pedestrians or casual gatherings in campus' outdoor spaces.

The central portion of the campus is now a series of memorable, engaging public spaces, pocket parks, walkways, and water features. One of the more dramatic ecological changes involved the transformation of the new entrance and drive to the University. The landscape has helped transform the image of the campus and become a source of pride to students, faculty, and staff as well as to the surrounding community. The campus today is considered the new public face of the University and even the increase in enrollment in some capacity is attributed to The University of Texas at Dallas Campus Identity & Landscape Framework Plan. The

implementation of phase 1 of the masterplan will contribute to the University's ultimate goal of achieving a Tier-1 status.

The research team followed the comprehensive investigation strategies outlined in the earlier portion of this document for The University of Texas at Dallas Campus Identity & Landscape Framework Plan case study. The research strategy involved understanding design challenges and solutions identified by the project firm and exploring their social, economic and environmental implications (see figure.1 below).



**Figure.2**

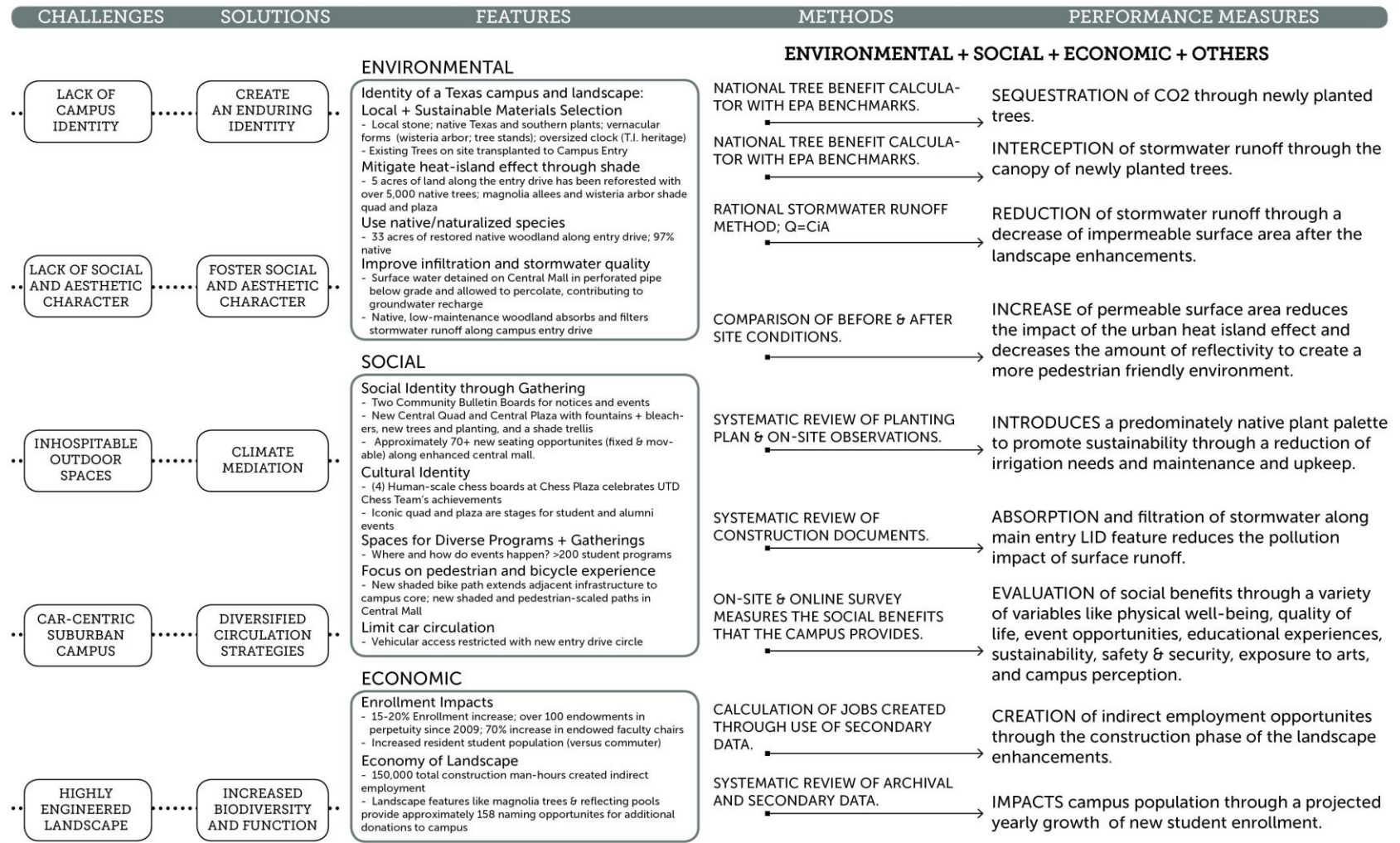
Given the project's emphasis on transforming campus's image and the sensitivity towards environmental conditions, the research team emphasized performance criteria's that are more telling about the evolving campus's natural systems and ecology, as well as the changing perception of the campus users; faculty, staff, students, prospective students, and visitors. After various iterations between the project firm and the university research team, a detailed procedures and performance measures were developed which can be tied to project's initial challenges, goals and objectives (see figure.2 for detailed research design).

The UT Dallas campus's proximity to UT Arlington allowed the research team to test on-site surveys and site observations as one of the primary data collection methods. Due to limited availability of attendees to summer school at UT Dallas campus this strategy is later modified by circulating on-line survey via campus mail and official websites. Although the permission process was time consuming, involving two Institutional Review Boards oversights and permissions procedures over a two-month period, the outcome was rewarding in collecting social performance data from the campus users as highlighted with a brief report later in this document.

The research team made attempts to document the economic performance indicators for this project but the causality between the improvement and the economic changes was indirect and not as informative as researcher desired. Given the suburban context of the campus and the relative distance of the improvements to the surrounding community, indirect performance measures are also not heavily highlighted in this case study.

The next section outlines the specific performance measures documented for The University of Texas at Dallas Campus Identity & Landscape Framework Plan by illustrating the data sources and the procedures followed as well as the limitations that are encountered measuring the particular performance criteria.

The University of Texas at Dallas Campus Identity & Landscape Framework Plan: Research Design Strategies and Performance Benefits



LAF CSI 2013 Landscape Performance Series: The University of Texas at Arlington & PWP Landscape Architecture

PLACE | PEOPLE | PROTECTION | PLANNING | PLANTS

Figure.3

**\*Performance Indicator: The following bullet points are listed below in their full form. They are formatted to comply with the online portal restrictions. The list below contains more detail.**

### **Environmental**

**Sequesters 154 tons of CO2 annually through newly planted trees, equivalent to the CO2 emitted from driving approximately 373,494 miles in a single passenger vehicle. The tree canopies also intercept approximately 1,077,946 gallons of stormwater runoff annually.**

<b>Scientific name</b>	<b>DBH (inches)</b>	<b>CO2 sequestered by one tree (lbs)</b>	<b>Quantity of trees</b>	<b>Total CO2 sequestered (lbs)</b>
Magnolia Grandiflora	6	46	116	5336
Quercus macrocarpa	5	116	33	3828
Taxodium ascendens	5	52	16	832
Acer saccharum	3.25	81	141	11421
Quercus Buckleyi	6	157	10	1570
Ulmus crassifolia (5 gal)	2	23	57	1311
Ulmus crassifolia (10 gal)	3	52	381	19812
Ulmus crassifolia (15 gal)	4	81	789	63909
Ulmus crassifolia (20 gal)	5	116	19	2204
Ulmus crassifolia (30 gal)	6	157	44	6908
Quercus macrocarpa (15 gal)	4	81	170	13770
Quercus muhlenbergii (15 gal)	4	88	171	15048
Quercus shumardii (15 gal)	4	81	171	13851
Quercus shumardii (20 gal)	5	116	1	116
Quercus shumardii (30 gal)	6	157	35	5495
Quercus laceyi (30 gal)	6	157	10	1570
Quercus Buckleyi (30gal)	6	157	8	1256
Acer saccharum	1.75	16	14	224
Acer saccharum	2	23	14	322
Acer saccharum	2.25	32	51	1632
Acer saccharum	2.5	38	49	1862
Acer saccharum	2.75	45	2	90
Acer saccharum	3	52	3	156
Carya illinoensis (3 gal)	2	81	99	8019
Carya illinoensis (7 gal)	2	81	782	63342
Pinus eldarica (15 gal)	4	35	426	14910
Ilex vomitoria (5 gal)	2	20	261	5220
Ilex vomitoria (15 gal)	4	20	269	5380



Ilex decidua (5 gal)	2	20	117	2340
Ilex decidua (10 gal)	3	20	40	800
Ilex decidua (15 gal)	4	20	76	1520
Rhus lanceolata (5 gal)	2	38	132	5016
Rhus lanceolata (7 gal)	2	38	60	2280
Rhus lanceolata (10 gal)	3	38	73	2774
Ungnadia speciosa (5 gal)	2	21	149	3129
Ungnadia speciosa (10 gal)	3	38	131	4978
Cercis canadensis var texensis	4	56	50	2800
Cercis canadensis var mexicana (5 gal)	2	56	50	2800
Diospyros texana (10 gal)	3	56	10	560
Prunus mexicana (5 gal)	2	10	103	1030
Prunus mexicana (10 gal)	3	16	105	1680
Cornus drumondii (5 gal)	2	21	97	2037
Cornus drumondii (10 gal)	3	38	101	3838
Quercus macrocarpa	5	116	7	812
<b>Total</b>			<b>5443</b>	<b>307788</b>

**Table.1: Tree list for phase 1.**

**Methods:** As illustrated in the table above the carbon sequestered is calculated with National Tree Benefit Calculator (<http://www.treebenefits.com/calculator/>).

For example: A single *magnolia grandiflora* tree of 6" DBH sequesters 46 lbs of CO<sub>2</sub>. There are total 116 *magnolia grandiflora* trees in the planting plan of the University of Texas at Dallas Campus Identity and Landscape Framework Plan. Thus, the total amount of CO<sub>2</sub> sequestered by 116 *magnolia grandiflora* trees would be:

$$46 \text{ lbs} * 116 = 5336 \text{ lbs}$$

One metric ton comprises of 2204 lbs. Thus, the total CO<sub>2</sub> sequestered with the help of all the trees would be:

$$307788 / 2204 \sim 139.61 \text{ metric tones}$$

<b>Annual Vehicle Distance Travelled in Miles and Related Data - 2011 (1) By Highway Category and Vehicle Type March 2013</b>						
YEA R	ITEM Motor-Vehicle Travel:(million s of vehicle- miles)	LIGHT DUTY VEHICLES SHORT WB (2)	MOTOR- CYCLES	SUBTOTALS		ALL MOTOR VEHICLES
				ALL LIGHT DUTY VEHICLES (2)	SINGLE-UNIT 2-AXLE 6-TIRE OR MORE & COMBINATION TRUCKS	
2011		192,513,27 8	8,330,21 0	233,841,42 2	10,270,693	253,108,38 9

2010	Number of motor vehicle registered	190,202,782	8,009,503	230,444,440	10,770,054	250,070,048
2011	Average miles traveled per vehicle	10,614	2,221	11,318	26,016	11,640
2010		10,650	2,311	11,493	26,604	11,866
2011	Average fuel consumption per vehicle (gallons)	460	51	530	4,126	666
2010		456	53	534	4,180	681
2011	Average miles traveled per gallon of fuel consumed	23.1	43.5	21.4	6.3	17.5
2010		23.3	43.4	21.5	6.4	17.4

**Table. 2** Source: <http://www.fhwa.dot.gov/policyinformation/statistics/2011/vm1.cfm>

The numbers for the miles travelled in a year (11,318) and average (21.4mpg) of the passenger vehicle is set as bench mark (for comparison of the CO2 emitted) from Federal Highway Administration (FHWA) 2013 data as can be seen in the table above.

With the help of Carbon Calculator (<http://www.americanforests.org/discover-forests/carbon-calculator/>), a gas fuelled passenger vehicle travelling 11,318 miles in a year at 21.4 mpg average emits 9394 lbs of CO2 which is equivalent to 4.24 metric tons.

$$9394/2204 \sim 4.24 \text{ metric tonnes}$$

The total CO2 sequestered by trees is equivalent to approximately CO2 emitted from 33 passenger vehicles in a year.

$$139.61/4.24 \sim 33 \text{ passenger vehicles}$$

$$11,318 \text{ miles} * 33 = \mathbf{373,494 \text{ miles}}$$

Finally, the 139.61 metric tonnes of CO2 sequestered by the trees is equivalent to 373,494 miles travelled in a year in a single passenger vehicle.

**Limitations:** Since the project is recently completed in October 2012, the plants are still not fully matured. The DBH for the plants is considered as 4" as per the information sourced from The Office of James Burnett. The data highlighted in the table for the passenger vehicle to set as a benchmark is the US national average of the year 2011. (Data is retrieved in 2013 from FHWA website).

***Calculations of water intercepted by the tree canopy***

Scientific name	DBH (inches)	Stormwater intercepted by one tree (gallons)	Quantity of trees	Total stormwater runoff intercepted (gallons)
Magnolia Grandiflora	6	511	116	59276
Quercus macrocarpa	5	381	33	12573
Taxodium ascendens	5	217	16	3472
Acer saccharum	3.25	232	141	32712
Quercus Buckleyi	6	604	10	6040

Ulmus crassifolia (5 gal)	2	82	57	4674
Ulmus crassifolia (10 gal)	3	157	381	59817
Ulmus crassifolia (15 gal)	4	232	789	183048
Ulmus crassifolia (20 gal)	5	381	19	7239
Ulmus crassifolia (30 gal)	6	604	44	26576
Quercus macrocarpa (15 gal)	4	232	170	39440
Quercus muhlenbergii (15 gal)	4	402	171	68742
Quercus shumardii (15 gal)	4	232	171	39672
Quercus shumardii (20 gal)	5	381	1	381
Quercus shumardii (30 gal)	6	604	35	21140
Quercus laceyi (30 gal)	6	604	10	6040
Quercus Buckleyi (30gal)	6	604	8	4832
Acer saccharum - 1.75"	1.75	63	14	882
Acer saccharum - 2"	2	82	14	1148
Acer saccharum - 2.25"	2.25	101	51	5151
Acer saccharum - 2.5"	2.5	120	49	5880
Acer saccharum - 2.75"	2.75	138	2	276
Acer saccharum - 3"	3	157	3	471
Carya illinoensis (3 gal)	2	232	99	22968
Carya illinoensis (7 gal)	2	232	782	181424
Pinus eldarica (15 gal)	4	134	426	57084
Ilex vomitoria (5 gal)	2	80	261	20880
Ilex vomitoria (15 gal)	4	80	269	21520
Ilex decidua (5 gal)	2	40	117	4680
Ilex decidua (10 gal)	3	60	40	2400
Ilex decidua (15 gal)	4	80	76	6080
Rhus lanceolata (5 gal)	2	179	132	23628
Rhus lanceolata (7 gal)	2	179	60	10740
Rhus lanceolata (10 gal)	3	179	73	13067
Ungnadia speciosa (5 gal)	2	130	149	19370
Ungnadia speciosa (10 gal)	3	179	131	23449
Cercis canadensis var texensis (4")	4	228	50	11400
Cercis canadensis var mexicana (5 gal)	2	228	50	11400
Diospyros texana (10 gal)	3	272	10	2720
Prunus mexicana (5 gal)	2	86	103	8858

Prunus mexicana (10 gal)	3	128	105	13440
Cornus drumondii (5 gal)	2	130	97	12610
Cornus drumondii (10 gal)	3	179	101	18079
Quercus macrocarpa	5	381	7	2667
<b>Total</b>			<b>5443</b>	<b>1077946</b>

**Table.3: Tree list for phase 1.**

**Methods:** As illustrated in the table above the stormwater intercepted is calculated with National Tree Benefit Calculator (<http://www.treebenefits.com/calculator/>).

For example: A single *magnolia grandiflora* tree of 6" DBH intercepts 511 gallons of stormwater. There are total 116 *magnolia grandiflora* trees in the planting plan of the University of Texas at Dallas Campus Identity and Landscape Framework Plan. Thus, the total amount of stormwater intercepted by 116 *magnolia grandiflora* trees would be:

$$511 \text{ gallons} \times 116 = 59276 \text{ gallons}$$

The EPA's Water Trivia Facts states that an American resident uses 100,000 gallons of water in a year ([http://water.epa.gov/learn/kids/drinkingwater/water\\_trivia\\_facts.cfm](http://water.epa.gov/learn/kids/drinkingwater/water_trivia_facts.cfm)).

$$1,077,946 \text{ gallons} / 100,000 \text{ gallons} \sim \mathbf{10.7 \text{ American residents}}$$

Finally, approximately 11 American residents uses 1,077,946 gallons of water in a year, equivalent to the stormwater intercepted by the trees in the University of Texas at Dallas Campus Identity and Landscape Framework Plan.

**Limitations:** Since the planting plan which was referred had the sizes of the trees indicated in gallon size (as seen in the table above). The DBH for the plants was approximated from the gallon size of the trees to be able to calculate the carbon sequestered with the help of the Nation tree benefit calculator tool.

**Reduces the peak stormwater flow rate for a 2-in rain event by 18.7% from 35.1 cfs to 28.6 cfs by reducing impervious surfaces by 49% or 4.3 acres.**

Stormwater runoff - post-development					
Description	Area (sq. ft)	i (inches)	Area (acres)	C (Co-efficient number)	Q=CiA (cu.ft/sec)
Concrete streets	114998	2	2.6400	0.9500	5.0160
Lawn & planting	1221858	2	28.0500	0.3500	19.6350
Paving	79062	2	1.8150	0.9000	3.2670
Brick paving	21562	2	0.4950	0.6500	0.6435
<b>Total</b>	<b>1437480</b>		<b>33.0000</b>		<b>28.5615</b>

Stormwater runoff - pre-development					
Description	Area (sq. ft)	i (inches)	Area (acres)	C (Co-efficient number)	Q=CiA (cu.ft/sec)

Concrete streets	165310	2	3.7950	0.9500	7.2105
Uncultivated land	970299	2	22.2750	0.4000	17.8200
Lawn & planting	86249	2	1.9800	0.3000	1.1880
Paving	215622	2	4.9500	0.9000	8.9100
<b>Total</b>	<b>1437480</b>		<b>33.0000</b>		<b>35.1285</b>

**Table.4: Stormwater runoff; pre and post development comparison**

**Methods:** As illustrated in the tables above the stormwater runoff is calculated with Rational Method ( $Q=CiA$ ). The Co-efficient numbers for different materials is referenced from the LARE reference manual.

For example: A 114,998 sq. ft of concrete surface will create a 5.0160 cubic ft per second of runoff in a single rain event of 2". (Please note that the area used in the following calculation is converted into acres. An acre of area is equivalent to 43,560 sq. ft of area):

$$CiA = Q$$

$$0.95 \times 2 \text{ inches} \times 2.64 \text{ acres} = 5.0160 \text{ cu. ft/sec}$$

As seen from the tables above the total stormwater runoff post-development is 28.56 cu.ft/sec and the total stormwater runoff pre-development is 35.13 cu.ft/sec.

$$35.13 \text{ cu.ft/sec} - 28.56 \text{ cu.ft/sec} = 6.57 \text{ cu.ft/sec}$$

Thus, reducing the stormwater run-off post development by **6.57 cu.ft/sec.**

Considering the pre-development stormwater run-off as 100 %, the post-development runoff is 81.30%, as a result, reducing the stormwater runoff by **18.70%**

Finally, overall there is 6.57 cu.ft/sec reductions in the stormwater runoff which is 18.70% reduction for the whole site of phase 1 of UT Dallas Campus.

**Manages all run-off along the 1.1-mile main entry drive for up to a 100-year storm event using native woodland bioretention areas.**

The project reduces pollutants from stormwater runoff with the native woodland bio-retention area along the campus entry drive. The new design has the capacity to filter and treat up to 100% of the stormwater as well as the non-point source pollutants within its watershed. Performance is based on a onetime 1.5" rain event (typical for the Dallas area). The calculations illustrate that the post-development condition can retain up to 100,550cu.ft. of stormwater runoff (assuming 35% porosity of the soil). This is equivalent to the stormwater runoff created by a 9.975" rain event (once in a 100 year for Dallas area). Such improved capacity can remediate pollutants such as Suspended Solids, Phosphorus, Soluble Phosphorus, Nitrogen, Nitrogen in the forms of Nitrate and Nitrite, Copper, Zinc and Bacteriological indicators like E. coli, coliform and others (Bacteria).

**Methods:** To determine the percentages of the pollutants the bio-retention area absorbs, based on stormwater runoff, the following seven steps was undertaken:

1. Determine the cross section of the bio-retention area.
2. Estimate the volume of the stormwater runoff the bio-retention area retains.
3. Obtain the area of the watershed (draining only in the bio-retention area).

4. Back calculate the design storm (the bio-retention currently is capable of retaining) using the Curve Number Method.
5. Estimate concentration of pollutants in the inflow (which is done by estimating the concentration in the outflow).
6. Estimate the load of pollutants over the year based on the literature.
7. Use removal efficiency of the bio-retention area (based on the national pollutant removal performance database, version 3, September 2007 by center for watershed protection) to calculate reduction of pollutants.

	<b>TSS</b>	<b>TP</b>	<b>Sol P</b>	<b>TN</b>	<b>NO<sub>x</sub></b>	<b>Cu</b>	<b>Zn</b>	<b>Bacteria</b>
<b>Median</b>	<b>59</b>	<b>5</b>	<b>-9</b>	<b>46</b>	<b>43</b>	<b>81</b>	<b>79</b>	<b>N/A</b>
<b>Min</b>	<b>-100</b>	<b>-100</b>	<b>-100</b>	<b>-2</b>	<b>0</b>	<b>9</b>	<b>31</b>	<b>N/A</b>
<b>Max</b>	<b>98</b>	<b>65</b>	<b>69</b>	<b>61</b>	<b>76</b>	<b>99</b>	<b>98</b>	<b>N/A</b>
<b>Q1</b>	<b>15</b>	<b>-76</b>	<b>-9</b>	<b>40</b>	<b>16</b>	<b>37</b>	<b>37</b>	<b>N/A</b>
<b>Q3</b>	<b>74</b>	<b>30</b>	<b>49</b>	<b>55</b>	<b>67</b>	<b>97</b>	<b>95</b>	<b>N/A</b>
<b>Number</b>	<b>4</b>	<b>10</b>	<b>5</b>	<b>8</b>	<b>9</b>	<b>5</b>	<b>5</b>	<b>0</b>

**Table.5: Bio-retention Removal Efficiency Statistics**

<b>Area calculations</b>					
<b>Description</b>	<b>Bio-retention area</b>	<b>Area (pervious surfaces)</b>	<b>Area (impervious surfaces)</b>	<b>Total area</b>	
	<b>sq. ft.</b>	<b>sq. ft.</b>	<b>sq. ft.</b>	<b>sq. ft.</b>	<b>acres</b>
B1	13484	25820	12141	51445	1.18
B2	4583	9333	3820	17736	0.41
B3	3695	3432	1970	9097	0.21
B4	4090	7481	8100	19671	0.45
B5	6510	4434	2828	13772	0.32
B6	13087	3316	13690	30093	0.69
B7	16343	0	12187	28530	0.65
B8	16640	0	20976	37616	0.86
B9	17660	410	6760	24830	0.57
<b>Total</b>	<b>96092</b>	<b>54226</b>	<b>82472</b>	<b>232790</b>	<b>5.34</b>

**Table.6: Bio-retention area calculations.**

As illustrated in the table the area calculations were done for the various watersheds draining into the bio-retention area. The watersheds considered for calculations were referred from the documents provided by the firm. As seen in the table above, three kinds of areas (bio-retention area, pervious surfaces area and impervious surfaces area) were calculated.

The cross-section detail from the construction document of the bio-retention area was obtained from the firm and reviewed. After reviewing those documents, the depth of the bio-retention was found at an average of 4 ft.

**Stormwater calculations for bio-retention area**

Description	length (ft.)	width (ft.)	depth (ft.)	volume (cu.ft)	volume bio-retention retains with 35% porosity in soil
native woodland bio-retention area along the campus entry drive	1690	42.5	4	287,300	100,555

**Table.7: Total bio-retention area.**

As illustrated in the table above, the volume of the stormwater runoff which the bio-retention area is able to retain is 287,300cu.ft. Assuming that the soil type used in the bio-retention area has a porosity of 35%, the volume of 100,555cu.ft. of stormwater runoff will be retained in the bio-retention area.

Thereafter, based on the area calculations done previously, areas of the pervious surfaces and the impervious surfaces were added separately to calculate areas for each. The individual areas are used with the Curve Number Method calculation for the stormwater run-off to calculate the volume of the run-off created in a 1.5” rain event, which is a typical occurrence for Dallas area. These calculations can be seen in the table below.

Capacity of the bio-retention area (required considering 1.5 inch storm event)							
Description	Area (sq. ft)	P	CN	S	Q (in inch)	Q (in feet)	Runoff (cu.ft.)
pervious surfaces	54226	1.5	84	1.9048	0.4141	0.0345	1871.4104
impervious surfaces	82472	1.5	95	0.5263	1.0126	0.0844	6959.3802
<b>Total</b>							<b>8830.7906</b>

**Table.8: Capacity of bio-retention area for a 1.5 inch rain event.**

The back calculations were done again with the Curve Number Method to calculate what kind of a storm event will make the bio-retention area overflow its capacity. It was found that a single 9.975” storm event will cause the bio-retention area to overflow. This storm event equates to a 100 year event for the Dallas area. The calculations can be seen in the table below.

Capacity of the bio-retention area (estimated to retain the stormwater run-off - assuming the porosity of 35%)							
Description	Area (sq. ft)	P	CN	S	Q (inches)	Q (feet)	Runoff (cu.ft.)
pervious surfaces	54226	9.973	84	1.9048	8.0035	0.6670	36166.6354
impervious surfaces	82472	9.973	95	0.5263	9.3688	0.7807	64388.3710
<b>Total</b>							<b>100547.2327</b>

**Table.9: Capacity of bio-retention area with 35% soil porosity.**

Finally, based on the calculations and the tables above (assuming that there are no perforated pipes in the bio-retention area as well), we can conclude that it has the capacity to absorb most of the pollutants from the stormwater runoff it receives in 1.5” rain event. Since stormwater runoff is not leaving the project area and there is no outflow from the bio-retention area, the fifth, sixth and the seventh steps becomes void and not necessary for this bio-retention area.

**Limitations:** The areas for the watersheds were calculated by importing the PDF construction documents provided by the firms; hence there is a potential for human error in the area calculations. Also, the calculations may vary significantly and produce different results; especially if the porosity of the soil changes and if the bio-retention area has an outflow or any kind of perforated pipes.

## **Social**

### **Performance Indicators.1-3:**

- *Improves the quality of life for 70% of campus users surveyed, including students, faculty and staff.*
- *Influenced decision to apply/enroll at UT Dallas for 44% of students surveyed. The campus landscape improvements also likely contributed to a 13% increase in enrollment from 2010 to 2012.*
- *Improves the quality of life for 70% of campus users surveyed, primarily by reducing stress and providing improved places to be outdoors and meet friends.*

According to the University of Texas at Dallas Campus Identity Landscape Framework Plan Survey conducted by the UT Arlington research team, respondents agree with the statement that the current campus landscape (N: 334):

- ***Improves perception of the campus through renewed landscape for 87%*** of the survey respondents primarily by enhancing campus greenery, improving outdoor experiences, renewing campus identity, and improving work environment.
- ***Promotes a safe & secure environment for 80%*** of the survey respondents primarily through the lighting design, visibility, security personnel, presence of others, and emergency kiosks.
- ***Is perceived favorably by 75%*** of the respondents (69% strongly agree).
- ***Improves the quality of life for 70%*** of the survey respondents primarily through improved perception of the area, reducing mental stress, a place to be outdoors, and a place to meet friends (20% neutral).
- ***Creates a sense of identity for 68%*** of the survey respondents.
- ***Promotes healthy living for 67%*** of the survey respondents primarily through passive activities (leisurely stroll), relaxing, and vigorous walk (31% neutral).
- ***Promotes scheduled/organized events for 67%*** of the survey respondents (21% neutral). The current campus landscape primarily promotes student fairs, festivals, music concerts, and exhibits as ***scheduled/organized events***, and food consumption, a place to take a break, and as meeting space as informal events.
- ***Accessible for all (American Disability Act-ADA) for 64%*** of the survey respondents (10% do not consider this question applicable).
- ***Encourages them to live within walking distance for 52%*** of the survey respondents (while 23% neutral about this statement).
- ***Increases outdoor activity for 52%*** of the survey respondents (23% neutral).
- ***Promotes educational activities for 50%*** of the survey respondents (35% neutral).
- ***Promotes art and artistic activities for 49%*** of the survey respondents (32% neutral).
- ***Promotes a better understanding of sustainability for 44%*** of the survey respondents through urban greenery, walkability, native planting, and stormwater management (35% neutral).



- **Influences decision to apply/enroll at UT Dallas for 44% of the students respondents (34% was neutral, 22% disagrees with the statement).**

**Survey notes:** 334 University of Texas at Dallas Campus Identity Landscape Framework Plan Survey (UT Dallas) users are surveyed between mid-July and early August, 2013 by UT Arlington research team. 303 of the responses come from on-site survey while 31 responses come from on-site survey. 44% of the respondents noted themselves as “Employee”, 28% of the park users surveyed noted themselves as ‘**student commuter**’, while 20% noted themselves as ‘**student resident**’. Survey findings also illustrated that 66% of the users visits the campus **daily** while 18% visits the campus **more than three times per week**. Additionally, 85% of the respondents arrives UT Dallas by using a **personal vehicle** while only 8% arrives **on foot** and 4% arrives by a form of **public transportation**.

**Method:** See the overview in the beginning

**Limitation:** Survey recruitment letter is circulated among various e-mail lists, design and planning professionals and social media groups throughout North Texas. However, the majority of the responses collected after the recruitment letter is circulated to UT Dallas campus e-mail list and UT Dallas official social media sites. This approach assured campus users to fill the survey. However, the survey is conducted over the summer months and nearly half of the respondents were employees, while the other half was students. Employee student ratio is about 1 to 10 at UT Dallas campus therefore the overall summary results above may not fully represents average campus user. However, this also gives an advantage of collecting data from people who have before and after knowledge of the campus.

*\*Not all of the survey results/findings are reported in their entirety do to LAF’s online formatting restrictions, therefore the list only includes a sample of the survey findings. For further information, contact the Research Fellow for this case study: Dr. Taner R. Ozdil, ASLA, [tozdil@uta.edu](mailto:tozdil@uta.edu).*

- *Additional notes on a point within Performance Indicator 2: The campus landscape improvements also likely contributed to a 13% increase in enrollment from 2010 to 2012. The student population is projected to grow 4% annually with a projected total of 25,294 in 2018.*

**Methods:** Systematic review of the literature of The University of Texas at Dallas Annual Report (2012).

**Limitation:** The landscape enhancements may have an indirect influence on enrollment, but there are other variables involved that contribute to this growth. Although reliable sources are adopted for this research the information provided above comes from secondary sources and may have inherent data omissions and errors that cannot be detected or confirmed by UT Arlington research team.

## **Economic**

**Created an estimated 72 jobs with approximately 150,000 construction man-hours documented for the time period between October 2008 to October 2010.**

**Methods:** Hour total is derived from the systematic literature review of the UT Dallas Construction Facts and Statistics (2010).

150,000 hours / 40 hour/week = 3750 (40 hour work weeks) / 104 weeks (duration of construction = 36 jobs or indirect employment positions.

**Limitation:** The hours total is an estimate and the calculation works of the basis that the contractors and subcontractors adhered to a strict 40 hour work week.

**Stimulated university fundraising, with \$31.2 million in project-related funds raised to-date. This includes donations to support design and construction and naming rights opportunities for trees, reflecting pools and other completed elements.**

**Methods:** The ‘naming rights’ count is primary data attributed to on-site observation. The dollar figure is derived from a systematic review of literature sources. The reviewed secondary source is The President’s Viewpoint publication (2010).

**Limitation:** There is no set monetary value for the ‘naming rights’ opportunities, so the impact of donations cannot fully be projected. For the monetary value, \$30 million of the \$31.2 million is donated from one source. Without this donation, the vision of the project would be different from what is present today. Although reliable sources are adopted for this research the information provided above comes from secondary sources and may have inherent data omissions and errors that cannot be detected or confirmed by UT Arlington research team.

**Sustainable Features Calculations**

*Adds 13% of permeable surface to the site. Reduces the impermeability to 13.5% (post-development) compared to impermeability of 26.5% (pre-development)for the whole site which alleviates the stormwater runoff by 18.70% reduction in stormwater runoff. The increase in permeability also impacts urban heat island effect through mitigation of surface temperature and reflectivity.*

Permeable and impermeable surfaces - post-development		
Description	Area (sq. ft)	Percentage (%)
Impermeable surfaces	194060	13.50
Permeable surfaces	1243420	86.50
<b>Total</b>	<b>1437480</b>	<b>100</b>

Permeable and impermeable surfaces - pre-development		
Description	Area (sq. ft)	Percentage (%)
Impermeable surfaces	380932	26.50
Permeable surfaces	1056548	73.50
<b>Total</b>	<b>1437480</b>	<b>100</b>

**Table.10: Permeable and impermeable surface comparison.**

**Methods:** As illustrated in the tables above the percentages of the impermeable and permeable surfaces is calculated. Post-development, there are 13.5% impermeable surfaces and 86.5%

permeable surfaces. Predevelopment, there are 26.5% impermeable surfaces and 73.5% permeable surfaces.

The reduction in impermeable surfaces is:

$$380,932 \text{ sf} - 194,060 \text{ sf} = 186,872 \text{ sf}$$
$$186,872 \text{ sf} / 380,932 \text{ sf} = 49.1\%$$

**Limitations:** Since the firm provided us with the documents listing the materials used, the permeable surfaces and impermeable surfaces are considered after reviewing those documents. Lawn and planting, brick paving and uncultivated land surfaces are considered as the permeable surfaces while concrete streets and paving are considered as the impermeable surfaces.

### **Cost Comparison Calculations**

*The central trellis, the major sculptural element of the design, cost of installation for the fiber reinforced polymer (FRP) may be up to 20% higher than typical industry standards, but this structural material makes up for the price difference through its lower dead load, limited corrodibility and a lifespan that is approximately twice as long a conventional metal building material. The central arbor utilizes approximately 45,400 linear feet of FRP (an approximate weight of 41,500 lbs). In comparison, this length of stainless steel pipe weighs over 200,500 lbs. This amounts to a 79% weight difference which is favorable to transportation, installation, life-span, maintenance and upkeep.*

**Methods:** First, the linear feet of 2" diameter (6" on-center- spacing) is calculated from a systematic review of the structural construction documents provided by the landscape architect. Second, the weight for FRP (per foot) and stainless steel (for comparison) uses the equation:

$$(\pi/4)(OD^2-ID^2)*\rho*(12 \text{ in.}/1 \text{ ft.}) = \text{pipe weight per foot (Schmit, 1998)}$$

OD=Outside pipe diameter

ID=Inside pipe diameter

$\rho$ =FRP=0.06 lb/cubic inch

$\rho$ =Stainless steel=0.29 lb/cubic inch

Finally, the prices are based on a comparison matrix (The Engineering Toolbox, 2013).

Approximate life span of FRP is sourced from a literature review of *Steel Free Bridge with Fiber Reinforced Polymer, 2012*.

**Limitation:** Due to market conditions and the process of competitive bids for construction projects, it is difficult to obtain a cost/unit for FRP. The weight and price comparison is an approximation based from the amount of FRP used in the canopy of the central arbor.

### **Lessons Learned**

**A catalysis project like phase 1 of the UT Dallas Campus Identity & Landscape Framework Plan can instigate changes not only within the campus but also in the community at large. For example, now that phase 1 is in place the planned 'Cotton Belt' line from DART with a 'transit plaza' and mixed-use center directly north of the campus**

**will be activated with multi-modal connections. The 2025 vision has the place-holder property valued at approximately \$165 million (2010).**

**Methods:** The material is derived from a systematic literature review of the North Central Texas Council of Government's (2011) Innovative Finance Initiative for the Cotton Belt Corridor. This is the planned light rail extension in the region by DART. While most of the stops are planned as traditional, open-air 'depots', the UT Dallas stop will be centered around a state-of-the-art 'transit plaza', convention center, and mixed-use center located adjacent to the north side of the campus.

**Limitation:** The impact of this 'transit plaza' cannot be solely placed on the new landscape framework plan for UT Dallas. It is reasonable to project that UT Dallas campus improvements have played a major role in (1) planned mixed-use and convention center and (2) the unique transit plaza that will support this space.

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