Civic Space Park
Phoenix, AZ

Figure 1. Rendered site plan of Civic Space Park. Image courtesy AECOM.

Methodology for Landscape Performance Benefits
Landscape Architecture Foundation
2014 Case Study Investigation

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I. Introduction

Located in the heart of Phoenix near the Arizona State University's (ASU) downtown campus, Civic Space is a 2.5-acre public park providing the city center with a vibrant amenity and relief from extreme temperatures that can adversely degrade human comfort and well-being especially during hot summer months. Using a combination of shade trees and undulating shade structures, the park is designed to provide shade for 70% of the site at full maturity. The park also features a landmark art installation by artist Janet Echelman, lawn areas, permeable paving, solar power, a covered stage, splash pad, and interactive LED light columns. Civic Space was funded as the open space component of a downtown revitalization effort that connects ASU's Downtown Campus to amenities such as the historic A.E. England Building that was restored as part of the Civic Space project. The building now houses event space, classrooms, and retail opportunities that provide additional revenue for the City and activate the park.

Project Goals and Research Approach

The design goals of the park were to provide shade, reduce summer temperatures, increase soil permeability, and provide a space for public life downtown. Unlike the other 2 projects completed by the research team, this project was not a Sustainable Sites Initiative (SITES) certified project. Therefore, project data from the construction and design process was limited. This led the research team to focus on performance benefits that could be verified with data collected during the Case Study Investigation. After conducting preliminary site visits and interviews, it became clear that the social aspects and efforts at temperature mitigation should be the focus of our research. Evaluating social benefits such as park use was going to be a difficult task considering that research was to be collected during the normally hot Phoenix summer when park use by general visitors and ASU students sharply decreases. Because park use in Phoenix is so strongly influenced by temperature the research team felt that evaluating temperature profiles in the park would also provide useful insights into the human comfort levels provided by the park.

An underlying theme of the research was evaluating the role of an urban oasis in ameliorating temperature for human comfort and for heat island mitigation. The data that were collected illuminated the roles that turf grass, trees, structured shade, and paving have in this ecosystem service. Unlike other regional desert park venues, the Civic Space site does not make use of many techniques for water conservation, especially the extensive use of sprinkler irrigated turf grass and deciduous broadleaf shade trees. Our data show some of the environmental trade-offs that can be made by park planners and designers who elect to use extensively mesic elements such as turf grass lawn in an arid region.

Project Context

Civic Space Park is located at 424 N. Central Avenue in Phoenix, AZ 85004. The site is in an urban location surrounded by development on all sides. Prior to development the site was a mixture of parking lots and previous buildings, which classify the site as a greyfield with no significant landscape features existing. The City of Phoenix is located within the Sonoran Desert and is within USDA Zone 9. The average rainfall and potential evapotranspiration for the city is 8 and 90 inches per year, respectively. Daily maximum air temperatures during the summer months can be extreme with an average of 90 days per year over 100^{o}F.

II. Performance Benefits

<u>Environmental Performance Benefits</u>

PB1	**Collects and infiltrates up to 9,600 cu ft of water per storm event in underground chambers located on-site.**

Typical development guidelines in the City of Phoenix require on-site stormwater management. In some circumstances, such as in downtown areas where space is limited, this condition is waived. Although this was the case for Civic Space Park the design team still pursued a strategy to manage stormwater on-site, preventing the addition of water to the municipal stormwater system. Geotechnical surveys revealed that a highly permeable layer, due to the proximity of the Salt River, was located at a relatively shallow depth. This provided the design team with the opportunity to use an underground infiltration system to safely manage stormwater in a manner that also contributes to the recharge of groundwater resources.

Construction documents provided by the design firm indicate the installation of 8 rows each with 16 StormTech SC-740 chambers. The product cut sheet for StormTech SC-40 Chambers indicates a total storage capacity of 74.9cu ft for each chamber installed over a 6in gravel foundation. The total capacity of all chambers was calculated by multiplying the number of chambers by the capacity of each.

128 chambers x 74.9cu ft= 9,587.2cu ft

To relate the impact of the infiltration volume the research team calculated an equivalent for the amount of water used by an average American household. The EPA indicates that an average American family of 4 utilizes 400 gallons of water each day. To see how many families worth of water is recharged by the stormwater chambers, the total chamber capacity was converted into gallons and divided by 400 gallons per day.

9,587.2cu ft x 7.48 gallons/cu ft = 7,1717.24 gallons

To calculate the number of families:

7,1717.24 gallons/400 gallons = 179 families

If the infiltration chambers are filled to capacity the infiltration would offset the average amount of water used by 179 American families each day. However, this calculation only accounts for the amount of water needed to fill the chambers once. Chambers can be filled in different increments and by multiple storm events throughout the year. It is likely that the permeably layer beneath the park is capable of infiltrating a significantly larger amount of water. However, the design team did not make these calculations as they were outside the required scope for their project.

PB2	**Reduces air temperatures in the park by an average of 1.8°F compared to a typical urban landscape. Trees and shade structures lower mid-day surface temperatures by 12.4°F in turf areas and 23.4°F in hardscape areas.**

Temperature and how it is managed, plays a large role in the success of an arid region public space. To evaluate how this was accomplished in Civic Space Park, the research team measured both surface temperatures and air temperatures. Surface temperatures give a sense of how certain materials impact temperature profiles within the park and air temperatures give a sense of how those materials begin to impact temperature off the ground, within the human sphere.

The research team used a scaled site plan to overlay a 50-ft grid on the site. In the field, a walking tape measure was used to identify the grid points and note the temperature, material type, and presence of shade for each point. This method of collection allowed the team to compare how temperatures change due to material type or shade coverage. Surface temperature records were taken at solar noon and late evening (10:00 pm) to evaluate how surface materials impact the overall heat island effect.

The data referenced for these performance benefits indicates the surface temperatures of park surfaces in the open with no shade cover. Turf grass lawn surfaces were the coolest at solar noon and 10:00 pm (Table 2 and 3). At mid-day, turf areas were 37.4°F cooler than hardscape surfaces and even 4.7°F cooler than landscape areas planted with drought-adapted groundcover. Likely this effect is due to evaporative cooling provided by turf transpiration and release of water from the soil. The primary goal of the design team was to build a park that provides an oasis environment and relief from the heat. Data collected indicates that turf provides the most consistently cool surface. By choosing to utilize turf throughout the project they have increased the potential cooling effect created in the park.

Table 2. Average Surface Temperature (°F) at Solar Noon, June 5, 2014.

Surface Type	Open
Hardscape	125.7
Groundcover	93.0
Turf	88.3

Table 3. Average Surface Temperature (°F) at 10pm, June 5, 2014

Surface Type	Open
Hardscape	92.2
Groundcover	83.9
Turf	67.2

Table 4. Average Temperature Difference (°F) Between Solar Noon and 10pm, June 5, 2014.

Surface Type	Open
Hardscape	33.6
Groundcover	9.1
Turf	21.2

The greatest decline in surface temperatures between solar noon and 10:00 pm was recorded on the hardscape surfaces where the differential was 33.6 ^{o}F. Although hardscape surfaces cooled the most at night, their surface temperatures at 10:00 pm were still 30^{o}F higher than the surface temperature of the turf grass lawn (Table 4).

The data referenced for these performance benefits evaluates the surface temperatures of park elements in the shade. Temperature measurements for surfaces in the open are also provided here for comparison. During the day, shade provides a significant reduction in temperature across all surfaces measured and this was particularly evident for the turf grass lawn and hardscape surfaces (Table 5). However, an interesting observation is that shade generally inhibits heat loss and subsequent cooling during the evening (Table 6). The surfaces that are most effective in reducing temperature in the evening were unshaded (Table 7).

Table 5. Average Surface Temperature (^{o}F) at Solar Noon, June 5, 2014.

Surface Type	**Shade**	**Open**
Hardscape (Concrete)	102.3	125.7
Groundcover	90.7	93.0
Turf	75.9	88.3

Table 6. Average Surface Temperature (^{o}F) at 10pm, June 5, 2014.

Surface Type	**Shade**	**Open**
Hardscape (Concrete)	87.0	92.2
Groundcover	83.6	83.9
Turf	72.2	67.2

Table 7. Average Temperature Difference (^{o}F) Between Noon and 10pm, June 5, 2014.

Surface Type	**Shade**	**Open**
Hardscape (Concrete)	15.3	33.6
Groundcover	7.1	9.1
Turf	3.7	21.2

The measurements collected target 2 impacts of temperature: the comfort of spaces for humans during the day and the ability to release heat and thereby mitigate the heat island effect during the night. It is clear that on both fronts turf grass lawn areas provide the coolest spaces during both the day and night. We conclude that lawn areas in Civic Space Park are helping to achieve the goal of providing an area of respite within a densely urbanized area.

Surface temperature data were recorded on June 5, 2014 at solar noon (12:30 to 1:30 pm) and again at night (10:00 to 11:00 pm). Weather during this interval was normally clear and hot. Measurements were taken with a hand-held infrared thermometer, 7^{o} angle of view. Civic Space Park was divided into a 50-ft square grid matrix. A digital measuring wheel was utilized to identify each grid point on site. At each point temperature, material type, and presence of shade was recorded. A total of 72 total grid point intersections were measured.
A series of portable data loggers (Watch Dog series B button loggers, Spectrum Technologies, Inc.) were used to continuously record air temperatures at 30-minute intervals for 3

consecutive days (June 5 to 7, 2014) in the park and at a nearby streetscape to attain an understanding of how visitors were likely to experience temperature in the park. Weather during the 3 days was seasonably hot and clear. The data loggers were installed at heights of approximately 7 to 10ft above the ground in orientations removed from exposure to direct insolation, either protected by tree canopy shade or placed inside white-louvered plastic micro-meteorological shelter. Air temperature data were directly downloaded to computer for analysis using JMP8 statistical software (http://www.jmp.com/software/jmp8/).

The average temperatures in the park and at a nearby streetscape were 91.7^{o}F and 93.5^{o}F, respectively. However, there were intervals during day when these differences were more pronounced (Figure 2). During the early morning hours (7:00 am to 12:00 pm), air temperatures were cooler in the park compared to offsite. During mid-day, afternoon and into the late night hours (1:00 pm to 3:00 am), air temperatures in turf landscaped areas were coolest while air temperature in paved areas of the park and offsite were similarly 2^{o} to 4^{o}F higher. Finally from about 4:00 am to 6:00 am, air temperatures over paved surfaces in the park were highest perhaps caused by the larger tree canopies blocking the release of long wave radiation.

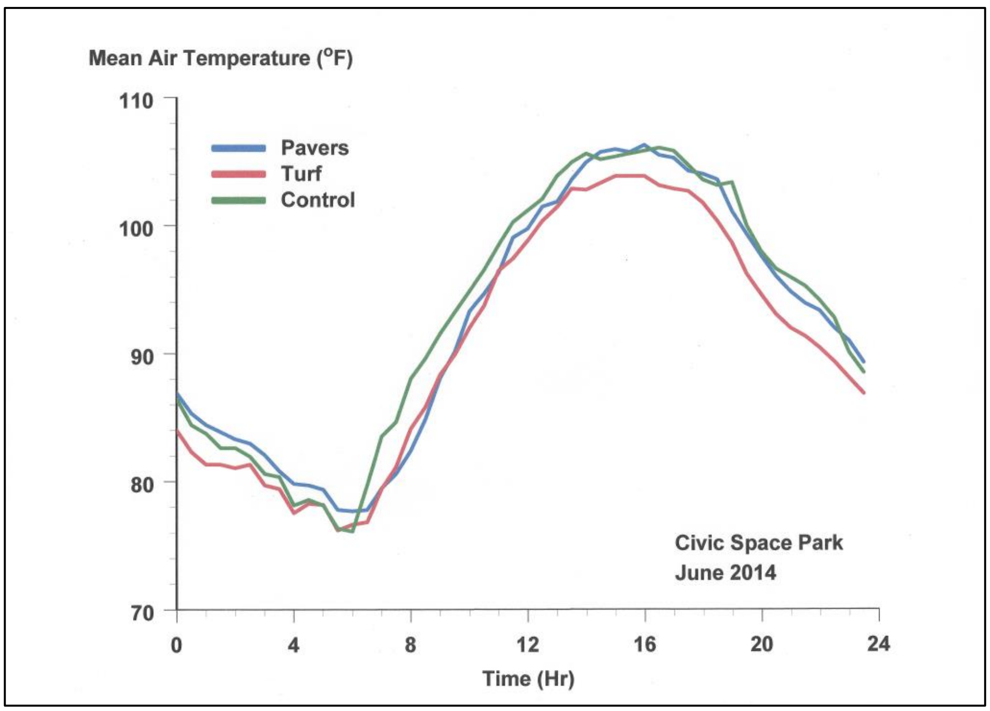

Figure 2. Average pattern of daily air temperatures from June 5 to 7, 2014, over park concrete pavers and turf grass lawn surfaces and a typical urban planting location outside the park (control). Air temperatures were recorded at 7 to 10ft above the ground surface.

Air temperature data were logged by data loggers every 30 min for 3 days from June 5 to 7, 2014. Weather during this interval was normally clear and hot. Loggers were Spectrum Technologies B series WatchDog data logger (http://www.specmeters.com/). Twelve loggers were installed at approximately 7 to 10 ft height under canopy shade of either *Pistacia chinensis* (Chinese pistache) or *Fraxinus velutina* (Arizona ash). Two of these loggers were located in similarly aged Chinese pistache trees in a nearby streetscape, representative of a more typical urban planting condition. One additional data logger was positioned in an open location at a height of 4ft in a white-louvered weather shield. Data from the data loggers was downloaded to computer for analysis.

PB3	**Doubles the productivity (rate of photosynthesis) of trees planted within hardscape areas by utilizing structural soil to expand the effective root zone.**

The park design features trees planted within landscaped areas and within hardscape dominant plazas. Typically growth of trees planted in hardscape areas is severely constrained by limited rooting volumes due to the high levels of soil compaction required for the stability of paving materials. This project used structural soil around the trees planted within hardscape areas. When properly installed, structured soil provides a stable base for paved materials as well as pore space for root growth, which should provide for increased tree health and growth. To establish if this was the case for Civic Space, the research team measured the net leaf gas exchange fluxes (net atmospheric carbon sequestration or photosynthesis) of trees planted within landscape areas and trees planted within hardscape dominant plazas using structural soil to expand the effective root zone. The team also tested two control trees of the same species that were planted off-site in a more typical hardscape condition without structural soil. The results show that the park trees planted within hardscape dominant plazas using structural soil to expand the effective root zone were performing at a rate greater than the park trees planted within landscape areas without soil compaction issues. Moreover, this rate of productivity was 2 times greater than the rate observed for control trees within typical urban conditions.

Table 1. Rate of Net Photosynthesis Observed in Selected Trees

Planting Conditions	**Tree Species**	**Rate of Photosynthesis**
Trees in Landscape	*F. velutina, P. kawakammii*	16.4 *u*mol/m^2/s
Trees in Structural Soil	*P. chinensis*	18.6 *u*mol/m^2/s
Trees in Typical Urban Condition	*P. chinensis*	9.9 *u*mol/m^2/s

In Civic Space Park, it appears that structural soil has made a clear improvement in the rate of photosynthesis occurring within the trees. Increased net photosynthesis also relates to increased tree growth and a greater ability of trees to mitigate high levels of atmospheric CO_2 associated with urbanization. The design and installation of structural soil was determined in the field during construction, so there were not details with the specific quantity of soil available. However, the research team was able to consult with the material supplier for the project who indicated that only a minimal amount of structural soil was utilized. For each tree he estimated a volume of 4ft extending in each direction (Figure 2) around the root ball. A much larger amount could have been utilized as he has observed that in just 5 years the tree roots have already grown to the extents of the structural soil.

Figure 2. From left to right installation of structural soil and growth of trees in 2009. Images courtesy Richard 'Woody' Dunwoody, Jr.

Leaf gas exchange of *Pistacia chinensis* (Chinese pistache), *Fraxinus velutina* (Arizona ash) and *Pyrus kawakamii* (Chinese evergreen pear) were analyzed using a LI-6200 infrared gas analyzer operating in closed system mode. With the exception of the Chinese evergreen pear, trees that were sampled were the same as those that were used to record shaded air temperatures (Figure 3). Trees selected were similar in size, age, leaf surface area, and health. The most recently physiologically mature sun-adapted leaves were chosen for measurements. Two to seven leaves per tree were sampled. Data were recorded between 10:00 am and noon on June 5, 2014. This time frame was selected because it was the earliest time of day that all of the trees were equally exposed to sunlight, reducing the chance that photosynthesis rates would be impacted by availability of sunlight.

All environmental and physiological data were analyzed using JMP8 statistical software (http://www.jmp.com/software/jmp8/).

Figure 3. Key plan of trees selected for net leaf gas exchange and temperature logger locations.

Social Performance Benefits

PB 4	Hosts an average of 43 free public events per year, including movie screenings, concerts, art galleries, and wellness events like community yoga.

The City of Phoenix provides regular programming in Civic Space Park throughout the year. Events hosted by the City and their partners are listed on the Facebook page for the park. The research team culled through these events generating a list of activities for the last three years. Based upon that list of events we generated a total of hosted events since 2012. This list does not include privately permitted events or those solely organized by ASU.

Table 8. Civic Space Park Events 2012-2014

2012	2013	2014	Total
68	40	21	129

PB5	Attracts an average of 559 visitors on a weekday morning in the low summer season. Of these, 63% engaged in optional activities and 12% also engaged in social activities.

The methodology for observing site visitors to the park was derivative of Jan Gehl's observations on public space as well as methodologies developed in previous LAF Case Studies. The basis of these types of observations is that visitors to the park will engage in 3 general types of activities: necessary, optional, and social. A successful public space has a greater percentage of both optional and social activities. Civic Space is an urban park that tends to be more active during the week when adjacent businesses are open. For this reason we planned our observations for three weekdays from 8:30 am – 12:30 pm. Each visitor was recorded, identifying their location, activity, and classifying their activity as necessary, optional, or social.

Summary of Visitor Observations

Date	Total Visitors	Percent Optional	Percent Social	Percent Pedestrian
05/30/14	638	67%	7%	27%
06/06/14	493	47%	18%	50%
06/11/14	547	74%	11%	21%
Average	559	63%	12%	33%

Over the observation days a large number of visitors were observed walking through the park to get to popular destinations such as the Central Station Transit Stop and ASU Recreation Center/YMCA. These pedestrian (or cyclist) visitors were not identified as optional visitors as it was not practical to determine if their actions were necessary or optional. For visitors who did spend an extended amount of time in the park, the LED light plaza, amphitheater, and shaded turf areas were the most popular places to linger. It was also apparent that the park, including the A.E. England Building, is a heavily programmed space. On 2 of the 3 observation days special events were being hosted in the building, bringing an influx of visitors to the park.

A significant limitation of this investigation was that our observations were limited to the summer. The number of visitors observed during this study was probably not representative of park use throughout the year. Two factors contribute to this problem 1) High temperatures reduce the number of optional visitors; 2) Many of the park users are ASU students who do not live on campus during the summer. The heat also presented a challenge to the research team, and is in part why observations occurred in the morning. To get a more complete picture of the social benefits provided by this park observations should be extended to busier times of the year.

It is also important to note that the plan for site observations required review and approval by the Arizona State University IRB Board. The data collected about visitors during observations was more limited than in some previous case studies; however, the research team found that streamlining the data collected allowed for a prompt review and approval process.

III. Cost Comparison

Details and quantities of structural soil for Civic Space Park were determined in field, therefore specific information regarding the quantity of soil used is not readily available. To project the cost of structural soil used on-site the research team used recommendations from the developers of CU Structural, a prevalent structural soil brand. The recommended quantity of structural soil is 2cu ft for each sf of canopy at mature growth. Only two types of trees are planted in hardscape areas *Pistacia chinensis* (Chinese pistache) and *Quercus virginiana* (Southern live oak). Chinese pistache has an expected canopy diameter of 30ft and area of 707sf. Live Oak has an expected canopy diameter of 40ft and area of 1,257sf. The expected volume of soil per tree was calculated for each tree type.

Chinese Pistache:

707 sf x 2 cu ft = 1,414 cu ft

Southern Live Oak:

1,257 sf x 2 cu ft = 2,514 cu ft

The research team received an estimated cost for CU Structural soil by a local supplier, to extrapolate the cost over the project site. Locally the cost, including delivery, is approximately $49 per ton with approximately 1.5 tons per cubic yard. The cost per cu yd was multiplied by the quantity required for each tree (converting from cu ft to cu yd) and the quantity required for each tree.

Chinese Pistache:

(52 cu yd x 1.5) x $49 x 13 trees = $49,686

Southern Live Oak:

(93 cu yd x 1.5) x $49 x 18 trees = $123,039

Total cost:

$49,686 + $123,039 = $172,725

Any addition of structural soil would be a cost addition to the project when compared with the free cost of utilizing the soil found on site. However, the addition does not address the added benefit of the potential improved health of trees. Leaf gas exchange measurements taken by the research team (refer to PB2) indicate that the trees in structural soil are twice as effective at photosynthesis than similar trees in a hardscape condition without structural soil. Healthier trees will be less expensive in the long run, requiring less maintenance and reducing the likelihood that they will need to be replaced.

IV. References and Resources

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