Spring 2013

Landscape Architecture Foundation Case Study Investigation and the Case of the Streetscape

Pamela Blackmore
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LANDSCAPE ARCHITECTURE FOUNDATION CASE STUDY
INVESTIGATION AND THE CASE OF THE STREETSCAPE

by

Pamela Blackmore

Thesis submitted in partial fulfillment
of the requirements for the degree

of

DEPARTMENTAL HONORS

in

Landscape Architecture
in the Department of Landscape Architecture and Environmental Planning

Approved:

Thesis/Project Advisor
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ABSTRACT

The demonstration of landscape performance benefits has become increasingly important in landscape architecture practice and in communicating to interdisciplinary audiences. This project introduces four built streetscape projects investigated in the 2012 Landscape Architecture Foundation Case Study Investigation (CSI) program, including a large-scale permeable pavement project in Charles City, Iowa, and American Society of Landscape Architects' award-winning projects in Missouri, California, and Colorado. Following the case studies, several compelling performance benefits of these projects are presented, such as safety and accessibility and water and energy conservation. The paper specifically illustrates the economic benefits and the data source used for performance assessment in two projects. The paper ends with a discussion on the lessons learned in the CSI program.
DEDICATION

This paper is dedicated to my family whose countless encouragements allowed me to persevere these past few years. Also to Yue Zhang who allowed me to work with her on this project and whose friendship I will always treasure. A special mention also for my professor and honors advisor, Bo Yang, who had unprecedented confidence in my abilities and opened many doors for my future. Also to my department head, Sean Michael, whose advice to “identify the pattern and break it” inspired me to join Honors. I am truly blessed to have had so many individuals invest their time and support when I needed it most.

Pamela Blackmore
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CONTENTS

<table>
<thead>
<tr>
<th>CONTENTS</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT</td>
<td>ii</td>
</tr>
<tr>
<td>DEDICATION</td>
<td>iii</td>
</tr>
<tr>
<td>ACKNOWLEDGMENTS</td>
<td>iv</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>vi</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>vii</td>
</tr>
<tr>
<td>CHAPTER</td>
<td></td>
</tr>
<tr>
<td>I.  OVERVIEW OF LANDSCAPE PERFORMANCE</td>
<td></td>
</tr>
<tr>
<td>ASSESSMENT AND THE CASE STUDY INVESTIGATION</td>
<td>1</td>
</tr>
<tr>
<td>II. THE CASE STUDIES</td>
<td>5</td>
</tr>
<tr>
<td>Cherry Creek North and Fillmore Plaza</td>
<td>5</td>
</tr>
<tr>
<td>Park Avenue/ US 50 Redevelopment</td>
<td>24</td>
</tr>
<tr>
<td>Charles City Permeable Streetscape</td>
<td>45</td>
</tr>
<tr>
<td>South Grand Boulevard Great Streets Initiative</td>
<td>61</td>
</tr>
<tr>
<td>III. CASE STUDY SYNTHESIS AND ECONOMIC ANALYSIS</td>
<td>83</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>89</td>
</tr>
<tr>
<td>AUTHOR'S BIOGRAPHY</td>
<td>97</td>
</tr>
</tbody>
</table>
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Traffic Volumes on Park Avenue from 2000 to 2009.</td>
<td>31</td>
</tr>
<tr>
<td>2. Land coverage calculations.</td>
<td>32</td>
</tr>
<tr>
<td>3. Park Avenue scenic resource view gain-loss evaluation.</td>
<td>35</td>
</tr>
<tr>
<td>4. Travel Route Rating for Unit 33 (the Strip).</td>
<td>38</td>
</tr>
<tr>
<td>5. Modeling results of existing storm sewers at street intersections.</td>
<td>52</td>
</tr>
<tr>
<td>6. Modeling results of proposed condition after applying the permeable pavement on the street.</td>
<td>54</td>
</tr>
<tr>
<td>7. Prototype modeling results of Hulin Street between Joslin and Iowa Streets.</td>
<td>55</td>
</tr>
<tr>
<td>8. Estimated emission rates in the current and proposed street models.</td>
<td>71</td>
</tr>
<tr>
<td>9. Estimated annual revenue increase over a 10-year period in South Grand.</td>
<td>75</td>
</tr>
<tr>
<td>10. Noise sources and their effects.</td>
<td>77</td>
</tr>
<tr>
<td>11. Economic benefits of four streetscape projects.</td>
<td>85</td>
</tr>
<tr>
<td>Figure</td>
<td>Page</td>
</tr>
<tr>
<td>--------</td>
<td>------</td>
</tr>
<tr>
<td>1. Streetscape project location, project size, and year of completion</td>
<td>4</td>
</tr>
<tr>
<td>2. Fillmore Plaza Before and After</td>
<td>5</td>
</tr>
<tr>
<td>3. Cherry Creek North Site Plan</td>
<td>18</td>
</tr>
<tr>
<td>4. Native plantings</td>
<td>19</td>
</tr>
<tr>
<td>5. Outdoor Lighting</td>
<td>20</td>
</tr>
<tr>
<td>6. Art in the District</td>
<td>21</td>
</tr>
<tr>
<td>7. Fillmore Plaza at Night</td>
<td>21</td>
</tr>
<tr>
<td>8. Wayfinding signage</td>
<td>22</td>
</tr>
<tr>
<td>9. Seating</td>
<td>23</td>
</tr>
<tr>
<td>10. Park Avenue Before and After</td>
<td>24</td>
</tr>
<tr>
<td>11. Predevelopment Conditions from Viewpoint 1</td>
<td>36</td>
</tr>
<tr>
<td>12. Simulation of Proposed Project from Viewpoint 1</td>
<td>36</td>
</tr>
<tr>
<td>13. Observed Travel Route Ratings of Roadway Unit 33</td>
<td>39</td>
</tr>
<tr>
<td>14. Park Avenue Site Plan</td>
<td>41</td>
</tr>
<tr>
<td>15. Pedestrian Network</td>
<td>42</td>
</tr>
<tr>
<td>16. Snow Melt System</td>
<td>42</td>
</tr>
<tr>
<td>17. Trail Network</td>
<td>43</td>
</tr>
<tr>
<td>18. Heavenly Gondola</td>
<td>43</td>
</tr>
<tr>
<td>19. Stormwater Management</td>
<td>44</td>
</tr>
<tr>
<td>20. Building Setbacks</td>
<td>44</td>
</tr>
<tr>
<td>21. Architectural Style</td>
<td>45</td>
</tr>
</tbody>
</table>
22. Charles City Before and After ................................................................. 45
23. Charles City Site Plan ........................................................................ 51
24. Typical Intersection ........................................................................... 58
25. The Four Best Management Practices (BMPs) used in Phase 1 .......... 59
26. Cobble Infiltration Areas .................................................................... 59
27. Alley Trench Grate ............................................................................ 60
28. Porous Unit Paving ............................................................................. 60
29. After Construction ............................................................................... 61
30. South Grand Before and After ............................................................ 62
31. Probability of pedestrian fatality as a result of impact speed ............ 69
32. Temperatures of various materials used on site ................................. 72
33. Relationship between vehicle speed and noise emissions ............... 76
34. People’s perceptions of South Grand .................................................. 78
35. South Grand Site Plan ........................................................................ 79
36. South Grand Perspective New Intersection ....................................... 80
37. Bulb outs at Intersections ................................................................... 80
38. Intersection Rain Garden ................................................................... 81
39. Sustainable Features .......................................................................... 81
40. Improvements for persons with disabilities ....................................... 82
41. Performance Benefits and Sustainable Features of streetscape projects ... 84
CHAPTER 1: OVERVIEW OF LANDSCAPE PERFORMANCE ASSESSMENT AND THE CASE STUDY INVESTIGATION

In 1999, Mark Francis wrote a report based on a research project he was commissioned to do for the Landscape Architecture Foundation (LAF). This report analyzed the pertinence of case studies for the advancement of the landscape architecture profession and developed a Case Study Method. Two of the final steps in the production of case studies recommended by Francis are that the completed case study be analyzed and the findings be disseminated and easily accessible for practitioners, academicians, and the public alike (Francis 1999). The process that Francis recommended consists of four steps: design the case study, conduct the case study, analyze the results, and distribute the results. He stressed the importance of having another party (academics, journalists, and users) involved in producing the case study to ensure objectivity. Francis also indicated the importance of taking a systematic approach to gathering information so that cases can be compared (Francis 2001).

This paper is an attempt to help fulfill the above recommendations. As part of the 2012 LAF Case Study Investigation (CSI) program, four streetscape projects were evaluated with an emphasis on quantifying the economic, social, and environmental benefits. Project analyses were conducted collaboratively by a Utah State University research team, the design teams (i.e., Design Workshop and Conservation Design Forum), city officials, and other parties based on the original performance objectives set out by the design teams. This paper discusses key economic performance benefits for each project, data sources, and examples of methodologies that were used to quantify
the economic benefits. It also provides insights into the improvements for future LAF CSI programs.

The LAF defines landscape performance as the measure of efficiency with which landscape solutions fulfill their intended purpose and contribute toward achieving sustainability (Landscape Architecture Foundation). In 2011, the LAF established a seminar research initiative—Landscape Performance Series (LPS)—to assess the value of high-performing landscape projects through quantifying environmental, social and economic benefits. LPS is designed to fill a critical gap in the marketplace and make the concept of “Landscape Performance” as well known as “Building Performance” (Landscape Architecture Foundation).

The LPS is not a rating system, but rather a hub that compiles information and innovations from research, professional practice, and student work about landscape performance. LPS presents the latest information on performance benefits and best design practices and is organized by four categories: Case Study Briefs, Benefits Toolkit, Fast Fact Library, and Scholarly Works. To date, in Case Study Briefs, 70 studies have been produced, within which 20 studies have been published online after a rigorous peer-review process. The remaining case studies are in review and/or in revision. The Benefits Toolkit provides 38 online tools for searchable calculation and measurements of landscape performance. The Fast Fact Library synthesizes key research findings of landscape performance benefits and allows an interactive discussion platform. Finally, Scholarly Works selects latest research published in prominent journals.
Under the LPS research umbrella, the CSI program was launched in the summer of 2011, conducted again in 2012, and is expected for the years to follow. CSI is a unique research collaboration that brings together academia and the industry to investigate and document the benefits of exemplary, high-performing built projects. The LAF sent out request for proposals for collaboration. Ten research teams were selected across the United States, composed of landscape architecture faculty members (served as Research Fellows), research assistant(s) (e.g., students), and firm practitioners (http://www.lafoundation.org/research/landscape-performance-series/case-studies/).

The 2011 CSI program exemplifies the performance benefits of best design practices, balancing project types, scales, and geographic locations. The 2012 CSI program further poised the LAF on the research front via becoming more rigorous in case study selection, encompassing a broader spectrum of sustainability metrics (e.g., projects must document social, environmental, and economical benefits), and emphasizing the importance of social benefits, which has yet to become a strength of landscape architects.

This paper introduces the performance benefits of four built streetscape projects investigated in the 2012 CSI program. These projects are: Charles City Permeable Streetscape in Charles City, Iowa (Conservation Design Forum and Charles City 2009; Yang et al. 2012a); Cherry Creek North Improvements in Denver Colorado (Design Workshop, Inc. 2011; Yang et al. 2012b); South Grand Boulevard Great Streets Initiative in St. Louis, Missouri (ASLA 2011; Yang et al. 2012c); and Park Avenue Redevelopment in South Lake Tahoe, California (Design Workshop, Inc. 2010; Yang et al. 2012d). The first one, designed by Conservation Design Forum, is one of the largest
permeable pavement projects in the United States. The remaining three are designed by Design Workshop, all of which are American Society of Landscape Architects' award-winning projects. Project locations are shown in Figure 1.

Figure 1. Streetscape project location, project size, and year of completion.
CHAPTER 2: THE CASE STUDIES

Case Study 1: Cherry Creek North and Fillmore Plaza

Figure 2. Fillmore Plaza before and after

Designer: Design Workshop, Inc.

Land Use: Retrofit and Mixed-use

Project Type: Streetscape Courtyard/Plaza Retail

Location: Fillmore Plaza, Denver, Colorado 80206

Size: 78 acres (16 blocks)

Budget: $18.5 million

Completion Date: 2010 - Phase 1; 2011 – Phase 2

Project team

Lighting Design Consultant: Patrick B. Quigley Associates

Electrical Engineering Consultant: SSG MEP (formerly Scanlon Szynskie Group, Inc.)

Irrigation Consultant: HydroSystems-KDI, Inc.

Traffic Consultant: Fehr and Peers

Horticultural Specialist: Bloomin' Designs
Program Manager: NV5 (formerly Nolte Associates)
General Contractor: The Weitz Company
Unit Paver and Stone Wall Contractor: Gallegos Corporation
Landscape Contractor: ValleyCrest Landscape Development
Electrical Contractor: Weifield Group
Environmental Graphics Contractor: Urban Fabrication
Surveyor: Engineering Service Company
Geotechnical Testing: Ground Engineering
Concrete Wall Renovation Specialist: Restoration Concrete, Inc.
Concrete Paving Contractor: Clem 'N' Sons Concrete
Arborist/Tree Care: Swingle Lawn Tree and Landscape Care
Demolition Contractor: OE Construction Corporation
Traffic Control: Highway Technologies
Major Product Suppliers: Endicott Clay Products, Kornegay, Landscape Forms, Miracote, Neenah
Foundry, Pavestone

Case Study Brief Prepared By:
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August 2012
References & Resources

Cherry Creek North: The New North is Here

ASLA Colorado Chapter Merit Award for Design, 2011 (Fillmore Plaza)
International Downtown Association Downtown Merit Award, 2011 (Cherry Creek North)
Engineering News Report: Redesigned Fillmore Plaza in Denver Serves Multiple Purposes (2011)
Life on Capitol Hill: CCN Facelift set to start (2009)

Overview

The 16-block Cherry Creek North retail district was designed to be Denver's premier outdoor shopping area. Yet deteriorating infrastructure, tired aesthetics and competition from an adjacent indoor mall had led to steady decline. Fillmore Plaza in the heart of the district was no longer a desirable public space since being closed to vehicular traffic in 1987. The new streetscape strengthens the retail environment, preserves the district's history and character, improves identity, beautifies the area, provides new lighting, improves signage, and adds 20 "Art and Garden Places" for shoppers to relax and linger. The redesigned Fillmore Plaza is now a vibrant hybrid street closed off to traffic only during planned pedestrian events.

Role of the Landscape Architect

The landscape architect created guiding principles, designed the site, reviewed the quality of construction, and headed a diverse team of specialists in environmental
graphics, transportation planning, civil engineering, lighting design, electrical engineering, structural engineering, and irrigation design. In seeking public involvement and consensus, the design team held monthly meetings with extensive stakeholder input.

**Sustainable Features**

- Fillmore Plaza was reopened to vehicles as a hybrid two-way street. Retractable stainless steel bollards block vehicular traffic through the Plaza for special events. To accommodate both large and small events, the northern half is curbless, has no on-street parking and provides a relatively level area for functions. The southern half, with a 4" rolled curb section and 10 on-street metered parking spaces, has been designed for larger tents and event staging.
- 21,700 new plants, including 196 new trees were planted in the District. 5 mature red oaks and 2 mature locust trees were preserved and transplanted to other locations in the District.
- A computer-controlled, centralized "smart" irrigation system conserves water by eliminating leaks and water loss, preventing overspray, and more efficiently and accurately measuring of the amount of water needed for optimum plant health.
- A linear trench drain in Fillmore Plaza captures runoff and conveys it to an underground stormwater treatment vault where it is detained and filtered before being released into Denver’s storm sewer system. The vault, located under Fillmore Street south of 2nd Avenue, can manage runoff from up to a 5-year storm. Any excess will bypass the structure internally and externally (depending on the intensity) and exit the site at other downstream inlets.
• LED lights on 360 new pedestrian light fixtures, 83 banner poles and 21 directories save energy and reduce light pollution. One-bulb, custom light poles improve the quality of the pedestrian environment at night. The mercury-free LED street lamp bulbs are safe for landfills.
• 20 new "Art and Garden Spaces," which contain signature art features, benches, tables and chairs, create distinct areas throughout the district, enrich the pedestrian experience, and encourage people to relax and linger.
• 40 single-stream recycling receptacles are paired with trash receptacles at intersections to encourage recycling and reduce impact on local landfills.
• 160 pedestrian light poles, 12 benches, 10 trash receptacles, and 2,450 cubic yards of organic materials from the existing street were donated to local communities for reuse.
• Bike racks installed throughout the District make it convenient to navigate by bicycle. Two B-cycle stations were located within the District as part of Denver's bicycle sharing program.
• More than 53 new street signs, 37 street identification banners, 46 new marketing banners, 17 new parking directory signs, and 21 new free-standing directory map structures enhance navigation and walkability in the District.

Challenge
Threatened by high on-going maintenance costs, deteriorating infrastructure, tired aesthetics and competition from an adjacent indoor mall that drained retail dollars from the stores and activity from the pedestrian realm, the design team faced the challenge of enlivening this stagnant retail district, with an emphasis on Fillmore Plaza. Not all
stakeholders agreed on the design direction for Fillmore Plaza, with some wanting the space reopened to vehicular traffic and others wanting the plaza to remain solely pedestrian. If reopened, the new Fillmore Plaza would need to function both as a two-way street and as a hub capable of hosting large and small events. Another challenge was that retail needed to stay open during construction with access to the stores maintained.

**Solution**

It was determined that the retail in the district was suffering from lack of access and exposure to shoppers. Through extensive visioning, public outreach, and multiple iterations, the design team was able to come up with a design that appealed to all stakeholders. Fillmore Plaza was redesigned as a hybrid street, open to two-way traffic with retractable stainless steel bollards that could close the street to vehicular traffic for events. The design would increase pedestrian space, enhance amenities, and strengthen the retail environment. All retail shops remained open during construction with a 5-ft pathway accessible to each entrance. Movable signs showed changes to parking and access, and weekly meetings informed retail owners of upcoming alterations.

**Cost Comparison**

- Over half of the spray-irrigated turf grass area was replaced with drip-irrigated, water-wise perennials and shrub. This reduces annual water consumption for irrigation by 3,376,000 gallons, saving $17,600. The low-water plants are estimated to save an additional $10,000 per year in reduced maintenance costs.
Lessons Learned

• Since this was a renovation project, there were unforeseen objects under the ground, which created obstacles that altered the final design. Some of the biggest obstacles were the existing tree roots, which required adjustments to the planting and hardscape areas, causing project delays and change orders. The initial goal was to provide hardscape access to all of the new smart meters via an 18"-wide step-out strip behind the curb. However, in some instances the tree roots were in conflict with these strips. After deliberation from different city agencies, preserving the roots took priority, and the strips were removed. This has created additional maintenance due to foot traffic in the turf areas and shrub beds near the parking meters.

• Local skateboarders grew fond of the existing planter walls once they were resurfaced. Subsequently the Business Improvement District chose to install stainless steel 'blades' cut into the walls with 3' on-center spacing. This has seemed to deter widespread damage to the walls.

Landscape Performance Benefits and Methodology

*Increased the District sales tax revenues by 16% (over $1 million) in the first year after construction. This was more than double the rates of increase for both the city and the entire Denver Metro Area.*

Based on 2010 year-end sales tax receipt figures, the Cherry Creek North BID received $7,389,285 in sales tax, which is a 16% increase compared to 2009
($6,363,315). This rate more than doubled the surrounding areas. Compared to 2009, sales tax receipts in 2010 increased 6.5% in Colorado, 7.1% in the Denver Metro Area, and 6.5% in the City of Denver. The calculation of this performance benefit is listed below.

\[
\frac{($7,389,285 - $6,363,315)}{$6,363,315} = 16%
\]

\[
16% ÷ 7.1% = 2.25 \text{ (more than doubled)}
\]

*Decreased retail vacancy rates from 13.6% in 2009 to 7.2% in 2012.*

The walkable and desirable new streetscape keeps the District strong in a competitive retail environment. According to the Aggregate Historical Vacancy Report and Cherry Creek North BID Economic Indicators, the vacancy rate in 2011 was 9.8%, which has declined by 3.8% from 2009 (13.6%). The vacancy rate was further declined to 7.2% in March, 2012, the lowest value since 2008. It is also worth mentioning that the District has 1,053,174 SF retail space. There has been no increase in retail square footage since 2008.

*Reduced crime in the District by 39%, from 180 incidents in 2009 to 110 in 2011.*

“This is something everyone knows: A well-used city street is apt to be a safe street. A deserted city street is apt to be unsafe.”-- Jane Jacobs
The upgraded infrastructure and new lighting system created a safe environment for pedestrians. In addition, the 20 new "Art and Garden Places" create distinct areas throughout the District enriching the pedestrian experience, reinforcing the unique character of the District, and encouraging people to take a moment to relax and linger. These small open spaces increase the vitality of the District and make it safer to pass through.

This crime result is based on the dot counting from the Denver Crime Statistics & Maps. The crime statistics use National Incident Based Reporting System (NIBRS), an incident-based reporting system in which agencies collect data on each single crime occurrence. The crime number in this 16-block District is largely reduced from 180 in 2009 to 110 in 2011.

Projected to reduce mid-day air temperatures by 6°C (11°F) as a result of increasing tree canopy on the site by 49%.

Measured from the site base map, there were 528 existing trees within the project boundary. The project installed an additional 258 shade trees. The calculation here is based on the 10-year projected outcome. Canopy size of a large deciduous tree is about 250 SF, and an ornamental deciduous tree is about 175 SF. Assuming that the quantity of the street trees is split 50/50, then the average shaded area is 212.5 SF per tree. Therefore the total additional shaded area is:

\[ 212.5 \text{ SF per tree} \times 258 \text{ trees} = 54,825 \text{ SF} \]
Temperatures are lower under tree canopies due to shading and evapotranspiration. Maximum mid-day air temperature reductions due to trees are in the range of 0.04°C to 0.2°C per percent canopy cover increase (Nowak). This study has two assumptions: (1) 50% of the trees are large deciduous trees and the other 50% are ornamental deciduous trees, and (2) The site’s mean air temperature will on average drop 0.12°C with every 1% increase in canopy cover.

Shaded area before construction: 212.5 SF/tree × 528 trees = 112,200 SF
Projected 10-year outcome after construction: 112,200 SF + 54,825 SF = 167,025 SF
Increased percentage of shaded area: 54,825 + 112,200 = 48.9%
Reduction of air temperature due to the increase of tree canopy: 48.9 × 0.12°C = 6°C

*Reduces annual water consumption for irrigation by 3,376,000 gallons, saving $17,600 annually, by replacing over half of the spray-irrigated turf with drip-irrigated, water-wise perennials and shrubs.*

All of the following calculations in this project (except for the property value calculation) used 2008 as the baseline year and 2011 as the comparison year. The project replaced over half of the spray-irrigated turf with drip-irrigated, water-wise perennials and shrubs, that reduced annual landscape water consumption from 9,582,000 gallons in 2008 to 6,206,000 gallons in 2011 (data from Hydro Systems, Inc.). Denver utility tracking spreadsheets showed that 2008 winter irrigation consumption (October 28 through May 2) was 0 gallons, and summer (May 3 through Oct 27) was 9,582,000 gallons. In 2011, after the landscape improvements, winter-water
consumption totaled 378,000 gallons, and summer 5,828,000 gallons. The amount of water budget saved in this project is calculated as follows:

Irrigation water rate in Denver is $1.20 per 1,000 gallons in the winter (October 28 through May 2), and $4.81 per 1,000 gallons in the summer (May 3 through Oct 27). Water savings were calculated by subtracting water costs in 2011 by 2008:

$$4.81 \times 9,582 - (1.20 \times 378 + 4.81 \times 5,828) = 46,089 - 28,486 = 17,603$$

*Reduces annual energy consumption for outdoor lighting by 223,000 kilowatts, saving $12,700 in energy and $1,000 in maintenance and material costs each year.*

The project uses full-cutoff lights and LED lights to reduce the energy cost. The full cutoff lights are more effective than other fixtures, since light that would otherwise have escaped into the atmosphere may instead be directed towards the ground (Wikimedia Foundation). Therefore, the use of full cutoff fixtures can allow for lower wattage lamps to be used in the fixtures, producing equal or sometimes a better effect. In this project, the pedestrian light pole design has reduced the number of lamps per pole from three to one because of using full-cutoff lights. The LED lighting also contributes to the energy savings in this District. Typically the LED lights will use less than 10% electricity of the replaced incandescent bulb.

Based on the Scanlon Szynskie Group lighting consultant’s power consumption spreadsheet, energy consumption decreased from 420,756 kW in 2008 to 197,806 kW in 2011. Thus the energy savings in this project are:

$$420,756 \text{ kW} - 197,806 \text{ kW} = 222,950 \text{ kW}.$$
The annual capital cost saving is calculated by subtracting the 2011 cost ($24,901.84) from the 2008 baseline cost ($37,635.70). The result is $12,733.86.

The project installed LED lights on 83 banner poles and 21 directories. LED lights have a very long lifespan, usually greater than 50,000 hours, which is at least four times of conventional outdoor lighting. As a result, the District does not need to replace bulbs as often, which in turn reduces the quantity of lights and offsite storage costs. These costs total approximately $1,000 per year. Detailed numbers were provided by Cherry Creek North Business Improvement District (BID).

Removes up to 80% of solids in the stormwater runoff from Fillmore Plaza using an underground water treatment vault.

A CDS® (continuous deflective separation) stormwater treatment vault is installed in Fillmore Street south of 2nd Avenue to treat the 5-year storms and to discharge the treated runoff into Denver's stormwater drainage system. Runoff captured from the trench flows through the diversion weir which allows bypass to occur when discharge exceeds the capacity of the stormwater treatment vault. The CDS system uses induced vortex to separate and trap debris, sediment, and oil and grease. Floatable and neutrally buoyant contaminants are held within the separation chamber while negatively buoyant debris is stored in the sump.

The CDS system is effective in removing the pollutants in the stormwater. Laboratory evaluations show that the CDS units are capable of removing 70% of the free oil and grease from stormwater (Contech CDS Operations and Maintenance
Guidelines for CDS Units. Typically in the United States, CDS system are designed to achieve an 80% annual solids load reduction based on lab generated performance curves for a gradation with an average particle size of 125-microns (um) (Contech CDS Guide).

**Saved $188,000 by reusing 331 light pole footings and bases in place on the site.**

The unit price of a new footing was approximately $550. The total cost of 331 new footings is:  

$$550 \times 331 = 182,000$$

The demo cost of removing a light pole from its base is $142, and the cost for removing a light pole and its base is $160. Therefore the cost for removing strictly the base is $160 - $142 = $18. This resulted in savings of $18 \times 331 = 5,958 (around $6,000) for base removal in this project. Therefore, the total savings in light pole footings and bases are:

$$182,000 + 6,000 = 188,000$$

**Methodology for Cost Comparison**

Over half of the spray-irrigated turf grass area was replaced with drip-irrigated, water-wise perennials and shrubs. This reduces annual water consumption for irrigation by 3,376,000 gallons, saving $17,600. The low-water plants are estimated to save an additional $10,000 per year in reduced maintenance costs. In addition, the low-water landscaping requires less maintenance than turf. Calculated by the irrigation system designer, the annual operating budget was reduced by approximately $10,000. Therefore, the total saving annually would be:  

$$17,603 + 10,000 = 27,603$$
Additional Images

Figure 3. Site Plan: The new 16-block Cherry Creek North retail district in Denver, Colorado has been redesigned to resurrect the vitality and character for which it was known.

Figure 4. Native Plantings: Over half of the District’s landscaping has been converted from spray-irrigated turf to drip irrigated, water-wise perennials and shrubs.

D. A. Horchner /Design Workshop, Inc
Figure 5. Outdoor Lighting: Inefficient and outdated pedestrian lights were replaced with more energy-efficient light fixtures.

D. A. Horchner /Design Workshop, Inc.
Figure 6. Art in the District: 20 “Art and Garden Places” throughout the District provide a sense of surprise and added potential for shoppers to remain in the District longer.

Jamie Fogle /Design Workshop, Inc.

Figure 7. Fillmore Plaza at Night: The color-changing LED lights on the Fillmore Plaza vary based on the annual holidays and events throughout the year. The December holiday season is showcased with red, green and white color variations.

Jamie Fogle / Design Workshop, Inc.
Figure 8. Wayfinding Signage: Improved way-finding system enhances the walkability throughout the District and makes it easier for pedestrians to navigate.

D. A. Horchner /Design Workshop, Inc.
Figure 9. Seating: Additional benches and trees create green and comfortable places for people to linger.

D. A. Horchner /Design Workshop, Inc.
Case Study 2: Park Avenue/ US 50 Phase 1 Redevelopment

Designer: Design Workshop, Inc.

Land Use: Commercial Mixed-use

Project Type: Streetscape Courtyard/Plaza Retail

Location: Park Avenue, South Lake Tahoe, California 96150

Size: 34 acres

Budget: $260 million

Completion Date: 2003

Project Team

Master Plan: Design Workshop, Inc.

Transportation Consultant: LSC Transportation Consultants, Inc. Master Plan


Case Study Brief Prepared by:

Research Fellow: Bo Yang, PhD, Assistant Professor, Utah State University
Overview

The town of South Lake Tahoe experienced undisciplined development, which created traffic congestion, limited connectivity to recreational assets, and negatively impacted the scenic and environmental quality of Lake Tahoe and the region. In response, strict environmental regulations were developed, which subsequently ceased development activities. Faced with serious environmental and economic problems, residents, officials, and developers jointly revised development regulations and worked to strategically deploy development monies to give the town a new future. Today, the town's Park Avenue Corridor with its wide sidewalks, interconnected plazas, consistent architecture, gondola, intermodal transit center, street furniture, and integrated stormwater management is a national model for redevelopment that promotes economic vitality, improves the natural environment, and creates a strong sense of place.
Role of the Landscape Architect

The landscape architect developed the master plan for the site and led a team of architects, civil engineers, transportation planners, market researchers, and economists to develop the urban design plan, gondola terminal, pedestrian and vehicular streetscape, and five public open spaces. The landscape architect also negotiated with the regional planning agency and assisted in rewriting regulations.

Sustainable Features

• Visual clutter, including outdoor billboards, irregular street walls, and eclectic architectural styles, was replaced with consistent building massing, signage, awnings and overhangs, which protect and enhance views of the Carson Range.
• Building setbacks along US 50 were increased to 50 ft. This minimum setback helps preserve views and ensures that the roadway receives solar exposure between 10am and 3pm throughout the year.
• Sidewalk widths were increased from 6 ft. to 12-15 ft. to create a comfortable, safe, and enjoyable environment for pedestrians. Driveway curb cuts were reduced from 15 to 2, eliminating many points of conflict between pedestrians and vehicles. Street trees, planted areas, and street furniture such as benches, trash receptacles, and street lights were added. As a result, the area has become a walking destination.
• Overhang areas were incorporated into new buildings to provide shelter from rain, snow, and direct sunlight, creating a more pleasant year-round experience for pedestrians.
• Open space, trails, bike paths and parks were created to increase recreational opportunities. These include a 0.3-mile, 50-ft wide public promenade, the 1.4-acre
Gondola Plaza, and an ice skating park. All of them are connected through a dense pedestrian network that serves hotel guests, shoppers, and tourists. Plazas are full of amenities, such as kiosks, directories, fire pits, swimming pools, a playground, and ample seating.

• A new 1.3-acre Intermodal Transit Center consolidates public and private transportation systems totaling 11 bus lines. The 4,610 sf. building has a visitor information center, ticketing services, and public restrooms.

• The new 10,000-ft Heavenly Gondola connects Park Avenue with the Heavenly Ski Resort, increasing access to year-round recreation and reducing traffic congestion, particularly in the winter. With the capacity to transport 3,000 people per hour, the gondola provides access to the ski resort for 20% of winter visitors.

• Two stormwater detention basins were created to manage runoff from up to a 20-year, 1-hour storm event. A 1-acre, onsite detention basin treats around 20% of the total runoff and is located at the northeast corner of the intersection of US 50 and Pioneer Trail. A 3-acre, offsite detention basin treats the remaining 80% of runoff and is located west of Park Avenue between Black Rock Road and Meadow Road.

• The new facilities included an automatic snowmelt system with the capacity to handle 170,778 square feet of sidewalks and plazas. Runoff from snowmelt in the plazas is collected, conveyed, and treated in the stormwater system. Because of the savings in labor, equipment and fuel, the snowmelt system paid for itself in just four winters.

• 112 mature Jeffrey pine trees were preserved on the site. The native Jeffrey pine provides vital wildlife habitat due to the food value of its seeds and nesting value of tree cavities or sheltered branches.
- Dwarf, non-mowed turf varieties like Aurora Hard Fescue and Mokelumne Fescue cover 5.9 acres of the project since they require little maintenance. High-traffic groomed-turf areas were used only minimally to reduce irrigation and fertilization needs.
- Irrigation was installed and is managed to minimize runoff to stormwater management facilities. In potential runoff areas, edging materials are 1 in higher than the surrounding grade to contain any excess irrigation water.
- The fertilization plan requires Biosol or an equivalent organic nitrogen fertilizer to be used at a rate not exceeding 1.3 lbs. per 1,000 square feet per year. This is a 58% reduction in the normal application rate for groomed turf. Fertilizer is applied with a drop type spreader to minimize broadcasting on adjacent beds and walks. Onsite wells monitor groundwater for nitrogen loading.

**Challenge**

The design team was charged with crafting an environmentally sustainable vision for South Lake Tahoe's future that would revive portions of the community that were derelict. Previous ill-planned development had led the Tahoe Regional Planning Agency (TRPA) to implement stringent development regulations, which required preservation of view sheds and limited land coverage in order to reduce stormwater runoff and its subsequent impacts on the water quality and clarity of Lake Tahoe.

**Solution**

The design team convinced the TPRA officials that some development regulations conflicted with the goals of preserving the scenic and environmental quality. Together, they revised the regulations to accommodate taller development (height limit increased from 32 to 76 ft.) with smaller footprints and higher total building square
footages. To preserve views to the mountains and Lake Tahoe, these buildings have a setback distance of 50 ft. from the highway, which effectively decreases their apparent heights. To reduce the impacts of stormwater runoff on the lake, pretreatment vaults, water quality detention basins and constructed wetlands were incorporated.

**Cost Comparison**
- By using 5.9 acres of slow-growing turf grass instead of conventional high-maintenance turf and requiring that Biosol or an equivalent organic nitrogen fertilizer be applied instead of conventional fertilizer, fertilizer use is reduced by 70%, saving an estimated $880 annually.

**Lessons Learned**
- A public/private partnership and public investment in redevelopment at this scale can successfully encourage additional private development. As improvements and installations were constructed, surrounding land owners almost immediately started improving their properties, as well.
- A $9 million parking structure was built on the eastern edge of the project, hidden from view in an effort to reduce the negative visual impact that parking structures typically cause. The structure, which was paid for with city bonds, is not generating the projected revenues for two reasons: (1) Because it is not highly visible, first-time tourists to the area do not know that the structure exists, and thus they park in nearby surface lots. (2) There is a fee to park in the structure, whereas nearby lots are free. Many tourists and skiers park in the free lots -- sometimes for an entire day -- occupying spaces meant for patrons of local businesses.
• By constructing a scale model of the site using the existing regulations, the design team was able to convince the TRPA that the regulations they had established would be counterintuitive to the agency's goals and objectives. The model illustrated three essential principles: (1) The building height limit of 32 ft. encouraged greater land coverage, eliminating space that could use to create plazas, parks, and pedestrian areas. (2) Taller buildings and larger setbacks from the road could preserve and enrich mountain views. (3) TRPA's prohibition of below-grade construction prevented concealment of parking. Without the visual aid of the model, the design team's claims would not have been accepted by the agency, and the resulting design would have been drastically different.

Landscape Performance Benefits and Methods

*Reduced the peak month Average Daily Traffic (ADT) and annual ADT on Park Avenue by 24% and 23%, respectively, between 2001 and 2009.*

Traffic volumes in South Lake Tahoe vary with the season. Generally, the traffic is highest during the mid-summer periods (July and August). Winter traffic levels tend to be lower than summer traffic levels. California Department of Transportation (Caltrans) data show that the highest peak-month Average Daily Traffic (ADT) volumes in South Lake Tahoe were found in the Park Avenue and US 50 intersection. Park Avenue is the busiest roadway in South Lake Tahoe. It serves residential traffic as well as recreational
traffic associated with the various hotel and retail uses located in the Stateline area. It also connects US 50 with the Lakeside Marina and commercial centers.

The design team, expanding on the community’s desire for a gondola to the Heavenly Ski Resort, proposed a Consolidated Transportation System (CTS) that unified public and private transit in South Lake Tahoe. The transit center is located near the base of the gondola, promoting pedestrian movement and allowing users to eliminate use of personal automobiles. The construction of this project started in 2001 and was completed in 2003. A comparison of historical Caltrans data on Park Avenue for the period from 2000 to 2009 is shown in Table 1. As illustrated in this table, significant traffic volume decreases for both peak month ADTs and annual ADTs were observed after construction. During 2001 to 2009, the peak month ADT on Park Avenue decreased from 50,000 to 38,000, which is a 24% reduction from 2001. The annual ADT decreased from 41,000 to 31,500, which is a 23% reduction from 2001, making the average annual change 2.9%.

Table 1. Traffic Volumes on Park Avenue from 2000 to 2009.

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Month ADT</td>
<td>38,000</td>
<td>41,000</td>
<td>43,000</td>
<td>43,000</td>
<td>43,500</td>
<td>45,000</td>
<td>46,000</td>
<td>50,000</td>
<td>50,000</td>
<td>50,000</td>
</tr>
<tr>
<td>Annual ADT</td>
<td>31,500</td>
<td>33,000</td>
<td>35,000</td>
<td>35,500</td>
<td>36,000</td>
<td>37,500</td>
<td>37,500</td>
<td>41,000</td>
<td>41,000</td>
<td>41,000</td>
</tr>
</tbody>
</table>

Source: California Department of Transportation (http://traffic-counts.dot.ca.gov/).

The cause of the reductions is three-fold. The first is the implementation of the CTS. The second is the implementation of the Heavenly Gondola. The Gondola allows Stateline lodging guests who previously drove or rode shuttle buses to ski base areas, to instead walk a short distance to access the ski area. The last is recessionary years of
2007-2009 saw a reduction in tourism travel, declines in employment, reduced hotel occupancy, and population decreases resulting in reduced traffic volumes.

*Reduces runoff from a 2-year, 24-hour rainfall event by 500,000 gallons by reducing the total impervious surface on the site by 20%.*

The clarity of Lake Tahoe has been a major concern for many years in the Lake Tahoe region. Since 1967, to test the clarity of the lake, a 25-cm white disk, called Secchi disk, has been lowered from a boat into the water. A measurement is taken of the depth that it is no longer visible, which is called the Secchi depth. This depth has been steadily decreasing. Particles and sediments being transported to the lake through stream and stormwater runoff are reducing this clarity.

To improve Lake Tahoe's water quality, stormwater runoff was reduced onsite by decreasing the amount of impervious surfaces and two stormwater detention basins were created. Impervious surfaces were replaced with landscaped vegetation that promotes infiltration. Before redevelopment, impervious surfaces covered 97% of the surface area. This project, as shown in Table 2, increased the landscaped area by 42.3%.

**Table 2. Land coverage calculations.**

<table>
<thead>
<tr>
<th></th>
<th>Existing total land area (SF)</th>
<th>Proposed total land area (SF)</th>
<th>Existing impervious area (SF)</th>
<th>Proposed impervious area (SF)</th>
<th>Existing landscaped area (SF)</th>
<th>Proposed landscaped area (SF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total area</td>
<td>1,637,773</td>
<td>1,487,124</td>
<td>1,437,980</td>
<td>1,153,904</td>
<td>199,792</td>
<td>346,170</td>
</tr>
<tr>
<td>Percent change</td>
<td>9.2% reduction</td>
<td>19.8% reduction</td>
<td>42.3% increase</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Adapted from Park Avenue Development Proposed Land Coverage
Calculations L 5.3. (Design Workshop)

To calculate the runoff reduction, a curve number (CN) of 98 (e.g., with percent of impervious cover similar to paved parking areas, roofs, driveways) was used. The hydrologic soil group does not impact the CN when the percentage of impervious surfaces are high (for instance, Hydrologic soil A, B, C and D all have the same CN for paved parking areas, roofs, and driveways). The rainfall depth used was 2.97 inches, which is taken from the National Oceanic and Atmospheric Administration (NOAA) Station Fallen Leaf, which is the closest to the site (http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=ca) (Harris & Dines, 1998). The 2-year, 24-hour rainfall event was used.

Runoff volume in acre-feet was calculated for each impervious cover, and then the difference was calculated and converted to gallons. The CN formulas used are:

\[ S = (1000/CN)^{-1} \]

\[ Q = [P - (0.2x S)]/(P + (0.8x2.2)), \text{ where} \]

- \( S \) = potential maximum retention in inches
- \( P \) = rainfall depth in inches from a 24-hour duration storm
- \( Q \) = depth of direct runoff in inches.

Total existing runoff:

7.4 acre-feet; New runoff after redevelopment: 5.85 acre-feet

Runoff reduction:

\[ 7.4 - 5.85 = 1.55 \text{ acre-feet} \times 325,851 \text{ gallons/acre-ft.} = 505,000 \text{ gallons} \]
Increased the total visible area of the natural environment by 10%. For all views of the Carson Range that were blocked by new development, the design created new views in other areas of the project site.

The scenic quality of the Lake Tahoe Basin was recognized as one of the most important assets of the region. Thus it was essential that the redevelopment did not block additional views to the surrounding landscapes. The project needed to meet “No net loss in views of the scenic resource (i.e. mountain and ridgeline).” Some views of the Carson Range were blocked by new buildings in the redevelopment plan. However, new views were opened up with the removal of the existing buildings on-site. With the replacement of all buildings except one along the east side of US 50 between the Embassy Suites Hotel and Park Avenue, this project changed the views significantly.

For all visible areas of the Carson Range lost because of this project, the designers had to ensure views to the Carson Range in other areas of the project site. Even with the increased height of structures in the new development, the designers were able to increase the quantity of visible area of the natural landscape. The process they followed, which was approved by the Environmental Impact Statement (EIS) consultant and Tahoe Regional Planning Agency (TRPA), is as follows:

The project team created a set of 26 three-dimensional computer-assisted design and drafting (CADD) simulations of the proposed design from specific viewpoints. These simulations were converted into line drawings, transferred onto transparency sheets and overlaid onto photographs of existing conditions taken from the same viewpoints. Then, using a planimeter, they measured the visible natural landscape area under the existing
conditions and the proposed conditions. The net gain or loss was the difference between the measured existing visible areas and the potential visible areas of the natural landscape. To ensure accuracy, both areas were measured twice, and then averaged. The following table lists the averages.

As shown in Table 3, a net gain between Embassy Suites Hotel and Park Avenue is achieved in the project. A total area of 1,644 cm² is visible in the study area after the project was installed. The increased visible gain area is 9% or 145 cm².

Table 3. Park Avenue scenic resource view gain-loss evaluation

<table>
<thead>
<tr>
<th>Image #</th>
<th>Before (cm²)</th>
<th>After (cm²)</th>
<th>Net gain (cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>64.75</td>
<td>143.00</td>
<td>78.25</td>
</tr>
<tr>
<td>2</td>
<td>77.35</td>
<td>25.95</td>
<td>-51.40</td>
</tr>
<tr>
<td>3</td>
<td>71.65</td>
<td>48.45</td>
<td>-23.20</td>
</tr>
<tr>
<td>4</td>
<td>70.25</td>
<td>37.95</td>
<td>-32.30</td>
</tr>
<tr>
<td>5</td>
<td>12.00</td>
<td>106.40</td>
<td>94.40</td>
</tr>
<tr>
<td>6</td>
<td>0.00</td>
<td>127.25</td>
<td>127.25</td>
</tr>
<tr>
<td>7</td>
<td>19.05</td>
<td>77.75</td>
<td>58.70</td>
</tr>
<tr>
<td>8</td>
<td>35.25</td>
<td>36.45</td>
<td>1.20</td>
</tr>
<tr>
<td>9</td>
<td>35.25</td>
<td>91.65</td>
<td>56.40</td>
</tr>
<tr>
<td>10</td>
<td>18.80</td>
<td>51.50</td>
<td>32.70</td>
</tr>
<tr>
<td>11</td>
<td>67.05</td>
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</tr>
<tr>
<td>12</td>
<td>75.30</td>
<td>47.10</td>
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</tr>
<tr>
<td>13</td>
<td>75.85</td>
<td>2.85</td>
<td>-73.00</td>
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<td>14</td>
<td>81.85</td>
<td>4.45</td>
<td>-77.40</td>
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<tr>
<td>15</td>
<td>41.00</td>
<td>2.35</td>
<td>-38.65</td>
</tr>
<tr>
<td>16</td>
<td>10.80</td>
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<td>24.00</td>
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<td>23</td>
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<td>46.20</td>
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</tr>
<tr>
<td>25</td>
<td>152.00</td>
<td>181.35</td>
<td>29.35</td>
</tr>
<tr>
<td>26</td>
<td>14.40</td>
<td>23.85</td>
<td>9.45</td>
</tr>
</tbody>
</table>

Total 1499.25 1643.78 144.53
Figures 11 and 12 demonstrate the simulation process used at viewpoint 1 (see Table 6) to determine whether visible area of the Carson Range would be lost or gained as a result of the redevelopment.

Figure 11. Predevelopment Conditions from Viewpoint 1. Source: Draft EIR March 4 1996, p 265.
Figure 12. Simulation of Proposed Project from Viewpoint 1. Source: Draft EIR March 4 1996, p 267.

*Increased the scenic quality of the roadway, as measured by the Tahoe Regional Planning Agency’s Travel Route Rating, which increased from 7.5 in 1996 to 14 in 2006.*

Another method used to evaluate the scenic quality of an area is the Travel Route Ratings. This system was adopted by the TRPA in 1971, is consistent with the Forest Service methods, and is an effort to rate the visual experience along a travel route for both natural and man-made components (http://tahoemonitoring.org/people/viewscape/351.html). The system identifies distinguishable landscape segments differentiated from surrounding areas because of their individual scenic traits and gives each a corresponding scenic threshold.

The scenic quality thresholds were set by the TRPA to gauge the scenic impact of future development. Each unit was evaluated and given a threshold number that represents a minimum scenic standard that all development in the unit must maintain or attain. This standard is a composite number based on six criteria: (1) man-made features along the roadway and shoreline, (2) physical distractions to drive along the roadways, (3) roadway characteristics, (4) view of the lake from the roadways, (5) general landscape views from the roadways and shoreline, and (6) variety of scenery from the roadways and shoreline. Each unit is given 1-5 points for each criteria based on how well they satisfy the criteria, with 1 representing poor scenic quality and 5 good
scenic quality. This means that composite ratings for units can range from 5-30. Ratings are designated based on observation by trained scenic quality professionals.

The TRPA originally identified 46 roadway units and 33 shoreline units. Roadway units are areas visible by motorists travelling along major roads in the area. Shoreline units are landscape units seen from the lake. This Park Avenue project area falls within Roadway Unit 32 and 33. The threshold for this project was set at 15, but has been increased to 15.5. On the 30 point Roadway Unit scale, this project has its goal to achieve a minimum of 15.5 points. When the Environmental Impact Report (EIR) was being completed in 1996, the Roadway Unit had a rating of 7.5. In 2006, the unit rating reached 14 points. The TRPA has measured the composite travel route ratings since 1982. Table 4 gives the travel route rating points given for each criterion. Other factors that contribute to the increased rating are also described in this table.

Table 4. Travel Route Rating for Unit 33 (the Strip).

<table>
<thead>
<tr>
<th>Year</th>
<th>Threshold Composite</th>
<th>Man-Made Features</th>
<th>Roadway Distractions</th>
<th>Road Structure</th>
<th>Lake Views</th>
<th>Landscape Views</th>
<th>Variety</th>
</tr>
</thead>
<tbody>
<tr>
<td>1982</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1991</td>
<td>7</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>1996</td>
<td>7.5</td>
<td>1</td>
<td>1.5</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2001</td>
<td>11.5</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>1.5</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2006</td>
<td>14</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>1.5</td>
<td>2.5</td>
<td>1</td>
</tr>
</tbody>
</table>

1991 Comments: Increase in landscape views subcomponent due to demolition of unsightly foreground structures permitting visual access to mountain backdrop.

1996 Comments: The site design and architectural quality of several remodeled and redeveloped uses (e.g., McDonald’s, Fantasy Inn), combined with the removal of several older structures and related cur cuts and signs, have slightly improved the roadway distractions subcomponent.

2001 Comments: Major improvements in this unit have occurred in the last five years. Improvements that increase both the man-made features and roadway distractions scores include: beginning implementation of the Park Ave Project, completion of the Embassy Suites Vacation Resort and marina buildings, several hotel remodels along the strip, and completion of the linear park and the drainage features with their park-like appearance. The lake view near the marina is improved with better view access due to improved site design. This unit is not in threshold attainment.

2006 Comments: This unit continues to improve with completion of the Park Ave project and Raley’s Shopping Center. Landscape views continue to improve as the native vegetation installed along wildwood has matured.

The project site encompasses 33% of Roadway Unit 32. But the project occurs only on one side of the road. Therefore, half of the rating (half of 33% i.e., 16 %) for Unit 32, can be attributed to this project.

The description of the unit was given as "cluttered commercial with virtually no views out to the natural environment". Additional comments about elements degrading the scenic quality of Roadway Unit 32 were: “The visual problems are those typical of strip development: sign proliferation, inadequate landscaping, and the visual prominence of the automobile. The overall effect is a visually cluttered and confusing environment that fails to take advantage of the scenic value of its natural setting" (Draft Environmental Impact Report, March 4, 1996. p 263). Figure 13 below shows the progression of the Travel Route Ratings of Roadway Unit 33.

![Travel Route Rating](http://tahoemonitoring.org/people/viewscape/351.html)

Figure 13. Observed Travel Route Ratings of Roadway Unit 33. Tahoe Monitoring. (n.d.). Travel Route Ratings for Shoreline Travel Units. Retrieved from Travel Route Ratings for Shoreline Travel Units: [http://tahoemonitoring.org/people/viewscape/351.html](http://tahoemonitoring.org/people/viewscape/351.html)
Reduces fertilizer consumption by 70% by using slow-growing turf grass and organic fertilizer, which saves an estimated $880 annually.

The University of California Agriculture and Natural Resources recommend the fertilizer application rate for the traditional turf grass as 1 lb. per 1,000 square feet, 4 times a year (i.e., 4 lbs./1,000 square feet/year). In comparison, this project uses approximately 1.3 lbs. of Biosol or other organic fertilizer per 1,000 square feet/year.

The site has 5.9 acres (257,004 square feet) of dwarf turf grass (Aurora Hard Fescue, Mokelumne Fescue, or other types). Biosol costs around $83 for a 55 lb. bag from a California distributor. A 40 lb. bag of traditional fertilizer from Lowe’s costs $54.

Fertilizer cost savings

Traditional turf grass fertilizer cost:

\[
4 \text{ lbs./1,000 sq. ft./yr.} \times \frac{257,004}{1,000} = 1,028 \text{ lbs.}
\]

\[
\frac{54}{40} = \$1.35/\text{lb.}; \quad \$1.35/\text{lb} \times 1,028 \text{ lbs.} = \$1,387/\text{yr.}
\]

Dwarf turf grass with Biosol fertilizer cost:

\[
1.3 \text{ lb./1,000 sq. ft./year} \times \frac{257,004}{1,000} = 334 \text{ lbs.}
\]

\[
\frac{83}{55} \text{lb} = \$1.51/\text{lb.}; \quad \$1.51/\text{lb} \times 334 \text{ lbs.} = \$504/\text{yr.}
\]

Fertilizer consumption reduction: \(\frac{1,028 \text{ lbs.} - 334 \text{ lbs.}}{1,028 \text{ lbs.}} = 68\%
\)

Annual fertilizer cost savings:

\[
\$1,387 - \$504 = \$883
\]
Cost Comparison Methods

By using 5.9 acres of slow-growing turf grass instead of conventional high-maintenance turf and requiring that Biosol or an equivalent organic nitrogen fertilizer be applied instead of conventional fertilizer, fertilizer use is reduced by 70%, saving an estimated $880 annually.

See methods for Performance Benefit #5.

Additional Images

Figure 14. Park Avenue Site Plan: The site plan includes Phase I (34 acres) and Phase II (19 acres). Phase I includes the portion that is east of Highway 50 (below US 50 in this image). Design Workshop, Inc.
Figure 15. Pedestrian Network: Native plantings flank a vast pedestrian network, which was made possible through taller development with smaller building footprints. Design Workshop, Inc.

Figure 16. Snow Melt System: A snow melting system reduces winter maintenance demands on 170,000 sf. of sidewalks and plazas. Design Workshop, Inc.
Figure 17. Trail Network: The redevelopment created open space, trails, bike paths and parks, which provide year-round recreation opportunities.

Design Workshop, Inc.

Figure 18. Heavenly Gondola: The 10,000-ft Heavenly Gondola provides access to the Heavenly Ski Resort. Located adjacent to the Intermodal Transit Center, it provides a viable alternative to vehicular traffic. Design Workshop, Inc.
Figure 19. Stormwater Management: A 3-acre, offsite detention basin filters stormwater runoff before it enters Lake Tahoe. Design Workshop, Inc.

Figure 20. Building Setbacks: Building setbacks along US 50 were increased to 50 ft. The setback area accommodates wide heated sidewalks, landscape buffers, public plazas, street furniture, and art exhibits. Design Workshop, Inc.
Figure 21. Architectural Style: All exterior building materials are consistent with the Tahoe Regional Planning Agency Design Guidelines. Wood timbers, stones and other natural materials are used to embody the “alpine rustic” character and enhance the visual appeal. Design Workshop, Inc

Case Study 3: Charles City Permeable Streetscape Phase 1

Figure 22. Charles City Before and After (Source Conservation Design Forum)
**Designer:** Conservation Design Forum

**Land Use:** Residential Retrofit

**Project Type:** Streetscape Transportation

**Location:** Hulin Street and N. Joslin Street, Charles City, Iowa 50616

**Size:** 5 acres (16 blocks of street ROW)

**Budget:** $3.7 million

**Completion Date:** 2009

**Project Team**

Landscape Architect/Civil Engineer: Conservation Design Forum

Installation Contractor: Wick’s Construction

**Case Study Brief Prepared By:**

Research Fellow: Bo Yang, PhD, Assistant Professor, Utah State University

Research Assistant: Yue Zhang, MLA candidate, Utah State University

Research Assistant: Pamela Blackmore, BLA candidate, Utah State University

Firm Liaisons: Thomas Price and Sarah Alward, Conservation Design Forum

August 2012

**References & Resources**

Conservation Design Forum: Charles City Permeable Streetscape

Charles City Green Streets Green Infrastructure Guide

ASLA Green Infrastructure & Stormwater Management Case Study

Iowa Environmental Focus: Charles City- Paving a more sustainable Iowa (2011)

Governor’s Environmental Excellence Award for Water Quality, 2011
Overview

The Charles City, Iowa, Green Street project addressed serious issues with street deterioration and nuisance street and adjacent yard flooding for a 16-block residential area. The project combines durable permeable paving materials with sustainable stormwater Best Management Practices, while maintaining the historical character of the neighborhood. By integrating stormwater management, the City was able to leverage additional funding that would not be available for conventional street reconstruction. Because of the success and the lessons learned in design and maintenance, the project has spurred additional phases in adjacent neighborhoods and serves as an important blueprint for others considering similar sustainable stormwater systems.

Role of the Landscape Architect

The landscape architect/civil engineer worked with Charles City to develop a comprehensive plan that addressed the crumbling streets and flooding problems. They prepared models and evaluated the existing and proposed roadway designs to determine the expected performance of the permeable streetscape.

Sustainable Features

- The permeable roadway surface consists of interlocking precast concrete unit pavers on a gravel bed. Water infiltrates between the pavers at a rate of 2 inches per hour, to the gravel storage below.

- A 24-inch deep layer of gravel with 36% porosity provides water storage below the pavement. In the center of the roadway, the gravel deepens to approximately 42 inches with a 6-inch perforated pipe running through it at a depth of 24 inches. Directly beneath
the gravel is a layer of geotextile filter fabric, a layer of silty-sand subgrade soil, and then a 36-inch layer of sugar sand subgrade soil. During large storm events, as the water level rises in the gravel storage, it enters the pipe through the perforations and is conveyed to the existing storm sewer system.

• Cobble infiltration areas are used at the corners of all intersections. Excess water from the permeable street runs down the gutter and is channeled into the cobble infiltration area through a curb cut. The water infiltrates through the layer of cobble then an 8-inch layer of gravel before entering the gravel storage below the permeable pavement system. The cobble infiltration areas have a design infiltration capacity of 100 inches per hour. If water accumulates in the cobble infiltration areas, it will enter an elevated storm inlet and be conveyed to the existing storm sewer system.

• Amended soil infiltration areas were added in the space between the curb and sidewalk along all of the streets to capture and infiltrate runoff from adjacent yards and sidewalks. Lined with turf and sloped to 4 inches below the top of the curb, the infiltration areas detain water and allow it to infiltrate into the amended soil, a mix of topsoil, sand, and compost. The gravel storage below the permeable pavement of the roadway extends beneath the amended soil infiltration areas. Excess water flows over the curb to the gutters, where it is conveyed to the cobble infiltration areas.

• Alley trench grates were installed across alley aprons on Spriggs Street and Hulin Street to infiltrate runoff and prevent sediment from backyards and the unpaved alleys from clogging the permeable pavement of the roadway. Water flows from the alley into the metal trench grate, through a 4-inch deep gravel filter layer, and then into the gravel storage layer, which extends from under the street.
• The roadway was narrowed from 44 to 31 feet. This design reduced the pavement surface, increased vegetated area, and increased the volume of soil available for trees.

**Challenge**

Landscape maintenance was a major concern for the design team as the long-term maintenance budget would be limited. Ideally, a wider range of vegetated stormwater management features such as roadside bio retention swales, intersection curb extensions, and rain gardens would be used. However, substantial maintenance would then be needed to weed, supplement plantings, and remove leaves and other debris to prevent clogging. The permeable unit pavers would also require diligent maintenance to remain functional for their design life.

**Solution**

Rather than typical rain garden plantings of perennial grasses and forbs, amended soil infiltration areas were planted with turf so that they can be mowed by residents, just as they were prior to the street reconstruction. For the intersections, cobblestone infiltration areas were selected instead of rain gardens due to the lower maintenance requirements. A strict maintenance regime was developed to maintain the permeability of the pavement, with guidelines that include no use of sand and minimal use of salt for winter maintenance. In addition, top soil can never be used in the amended soil infiltration areas, only potting soil.

**Cost Comparison**

• The project uses permeable interlocking concrete unit pavers as a high-performance,
cost-effective pavement, which saves approximately $395,000 in construction and permitting costs when compared to cast-in-place porous concrete for the 5,670 linear feet of streets that were replaced.

- By preserving 192 of the existing street trees, the City saved $57,000 over the cost of removing them and installing new trees.

Lessons Learned
- The cobble infiltration areas used in this first phase collected debris, which reduced the effectiveness of the system. Because they were deemed to require too much maintenance, these infiltration areas were discontinued in the second phase and an alternative system was utilized with curb intakes at the back of the curb. Instead of having a direct connection between the storm sewer system and the intake, storm water runoff enters the intake structure and is directed into the rock sub base where it infiltrates into the soil. During large rain events when runoff exceeds the infiltration rate, there is an overflow connection to the storm sewer system. Weep holes in the bottom of each intake structure allow water to empty out of the structure and into the soil to eliminate standing water at the bottom of the intake.

Landscape Performance Benefits and Methods

*Reduced stormwater peak flows by at least 75% for 10-year storm events and 40% for 100-year storm events.*
Note: Figure 23 below shows the location of the permeable streets and the intersections. All the streets mentioned in this Methodology section are indicated.

Figure 23. Charles City Site Plan Conservation Design Forum

Poor drainage and ponding were the major issues in this project. In most of the intersections, the capacity of the dilapidated, existing storm sewer system cannot meet its targeted design capacity. Additional runoff was intended to drain into the gutters along the streets. The intersection of Joslin and Hulin is a low spot. Surface runoff drains toward this intersection and it often times causes ponding in this area. In large storms, excessive runoff eventually reaches the high point on Joslin Street, between Hulin and Ferguson. This was the case in 2008 that the entire intersection was inundated and some private yards were also severely flooded.

The existing peak flow rates and storm sewer capacities are shown in Table 1. A Hydro CAD model was developed by using the NRCS Curve Number (CN) method and the unit hydrograph methodology. The soil type in the study area is Hydrologic Soil
Group B. The rainfall amount and frequency information is derived from the Midwest Climate Center Research Report 92.03. As shown in Table 5, two existing storm sewers could not meet the capacity of 2-year design storms; four of them could not meet the capacity of 10-year design storms and none of them presents a 100-year storm capacity.


<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Howard &amp; Hulin</td>
<td>8.00</td>
<td>0.42</td>
<td>1.68</td>
<td>2.00</td>
<td>3.00</td>
<td>1.00</td>
<td>12.12</td>
<td>1.00</td>
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<td>2.00</td>
<td>2.70</td>
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<td>16.91</td>
<td>1.00</td>
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<td>2.00</td>
<td>80.42</td>
<td>1.00</td>
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<td>Iowa &amp; Ferguson</td>
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<td>2.5</td>
<td>0.70</td>
<td>2.00</td>
<td>1.92</td>
<td>1.00</td>
<td>5.79</td>
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* Full flow capacity with no surcharging
Flow rates that exceed storm sewer capacity

Focusing on this issue, Conservation Design Forum developed a new green street system, which consists of permeable pavements, cobble infiltration at intersections, and engineered parkway bio retention swales. The green street system increases substantially the overall infiltration capacity. As a result the system captures excess runoff and mitigates the flooding problem of Charles City.

The Hydro CAD model was used to evaluate the influence of the proposed permeable pavement design on the existing stormwater sewer system. The permeable pavement and bio retention systems were tested in the model. The CNs that were used for the proposed conditions are presented below (Charles City Green Streets Evaluation and Design Report, 2009):

Permeable Pavilion Surface: 98 (NRCS TR-55, paved parking lots, roofs,
driveways)
Unconnected Impermeable Surface: 98 (NRCS TR-55, unconnected impervious surfaces)
Open Space: 61 (NRCS TR-55, lawns, grassy open areas)

Runoff volume is generated based on the above CNs. Then runoff is treated and drains into the gravel beneath the permeable pavement system. Several assumptions were made to construct the model (Adapted from Charles City Green Streets Evaluation and Design Report, 2009, P.11):

• Amended soil infiltration areas: The designed infiltration capacity of the amended soil is 2 inches per hour. The swale surface is 4 inches below the top of curb to provide time for infiltration.

• Permeable pavement surface: The designed infiltration capacity is 2 inches per hour.

• Cobble infiltration area: The designed infiltration capacity of the gravel surface is 100 inches per hour and the gravel surface is 6 inches below the gutter line.

• Gravel storage: The gravel storage beneath the permeable pavement has a porosity ratio of 36%. Based on the permeability test, the average infiltration capacity of the sandy soils below the silty-sand surface is 1.4 inches per hour. This study used a conservative infiltration capacity of 0.88 inches per hour. The excessive runoff will drain along the street right-of-way that is covered by gravel. The hydraulic conductivity of the gravel storage layer is 0.13 ft./s. Drainage through the gravel storage space was modeled based on Darcy’s Law. Hydro CAD modeling was conducted based on the above assumptions. The proposed peak flow reduction is shown in Table 6.
Table 6. Modeling results of proposed condition after applying the permeable pavement on the street


<table>
<thead>
<tr>
<th>Storm Sewer</th>
<th>2-year Event</th>
<th>10-year Event</th>
<th>100-year Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Howard &amp; Hulin</td>
<td>8.00</td>
<td>0.42</td>
<td>0.36</td>
</tr>
<tr>
<td>Howard &amp; Ferguson</td>
<td>12.00</td>
<td>2.5</td>
<td>0.36</td>
</tr>
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<td>18.00</td>
<td>5.4</td>
<td>0.00</td>
</tr>
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<td>Iowa &amp; Ferguson</td>
<td>12.00</td>
<td>2.5</td>
<td>0.16</td>
</tr>
</tbody>
</table>

* Full flow capacity with no surcharging

Flow rates that exceed storm sewer capacity

For the 2-year and 10-year storm events, peak flows are reduced at least 75% at all the locations except on Johnson (where most of the flow it receives actually comes from areas outside the project). The peak flow reduction is less for the 100-year events but reduction rates are at least 40% at all the locations except on Johnson and at the intersection of Iowa and Ferguson.

*Reduced the runoff volume by over 60% up to the 10-year 24-hour storm event, and over 30% for the 100-year 24-hour storm event. This eliminated the need to replace downstream storm sewers, thereby reducing infrastructure costs and neighborhood disruption.*

This result is achieved by applying the proposed project to a prototype model to determine the runoff volume and rate reduction of Hulin Street between Joslin Street and Iowa Street under the same assumption mentioned above. As shown in Table 7, the proposed permeable pavement system can achieve zero discharge up to the 2-year
storm event. For the 10-year event, the runoff volume is reduced by over 60% and the peak discharge is reduced over 90%. Even for the 100-year event, the runoff volumes and rates can be reduced by over 30%.

Table 7. Prototype modeling results of Hulin Street between Joslin and Iowa Streets


<table>
<thead>
<tr>
<th></th>
<th>Rainfall</th>
<th>Existing</th>
<th>Proposed</th>
<th>% Reduction</th>
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<tr>
<td><strong>6-Month Event</strong></td>
<td></td>
<td></td>
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<tr>
<td>Runoff volume (inches)*</td>
<td>1.91</td>
<td>0.28</td>
<td>0</td>
<td>100%</td>
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<tr>
<td>Runoff Rate (cfs)**</td>
<td>-</td>
<td>0.59</td>
<td>0</td>
<td>100%</td>
</tr>
<tr>
<td><strong>1-Year Event</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Runoff volume (inches)*</td>
<td>2.36</td>
<td>0.45</td>
<td>0</td>
<td>100%</td>
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<tr>
<td>Runoff Rate (cfs)**</td>
<td>-</td>
<td>0.79</td>
<td>0</td>
<td>100%</td>
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<tr>
<td><strong>2-Year Event</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Runoff volume (inches)*</td>
<td>2.98</td>
<td>0.75</td>
<td>0</td>
<td>100%</td>
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<tr>
<td>Runoff Rate (cfs)**</td>
<td>-</td>
<td>1.1</td>
<td>0</td>
<td>100%</td>
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<td><strong>10-Year Event</strong></td>
<td></td>
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<tr>
<td>Runoff volume (inches)*</td>
<td>4.38</td>
<td>1.59</td>
<td>0.59</td>
<td>63%</td>
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<tr>
<td>Runoff Rate (cfs)**</td>
<td>-</td>
<td>1.7</td>
<td>0.12</td>
<td>93%</td>
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<tr>
<td><strong>100-Year Event</strong></td>
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<tr>
<td>Runoff volume (inches)*</td>
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<td>32%</td>
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<tr>
<td>Runoff Rate (cfs)**</td>
<td>-</td>
<td>3.3</td>
<td>2.2</td>
<td>33%</td>
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</table>

* Based on 24-hour rainfall
** Based on critical duration storm

** Expected to improve water quality by reducing the need for winter salt application by up to 75% because snowmelt and stormwater can infiltrate. This should also lead to savings in the city’s winter operations budget.**

This information is based on the University of New Hampshire Stormwater Center (UNHSC) research (2009). UNHSC found that permeable paving may reduce salt use by up to 75% compared to conventional paving, because permeable paving allows snowmelt and stormwater to infiltrate. No salt application is required for porous pavement to achieve an equivalent friction factor and traction as the normally treated
conventional pavement. This is because porous pavement has a higher frictional resistance than conventional pavement (UNHSC, 2007).

Before construction, Charles City used salt for snow melt on the conventional asphalt in winter. The alternative permeable pavement will reduce the amount of salt that would be applied (and the associated costs) and will reduce the pollution level in runoff. Therefore, similar environmental and economic benefits are expected in this project, as shown in the UNHSC study.

_Saved $57,000 by preserving 192 street trees instead of removing them and installing new trees._

In Phase I, the project preserved 192 trees onsite. Estimated by the project manager, the unit cost ranges from $250 to $350 for removing an existing tree and installing a new tree. This price doesn't include the cost of purchasing new trees from a nursery. Assuming an average cost of $300, the project saves more than $57,600 compared to installing new street trees.

\[
$300 \times 192 = $57,600
\]

_Secured $731,000 in additional funding to implement this major street reconstruction project — funding that would not be available for conventional street reconstruction._

The project received $631,000 under the American Recovery and Reinvestment Act State Revolving Fund (ARRA-SRF) “green reserve” provisions. The project was also
awarded $100,000 from the Iowa Department of Natural Resources (DNR) I-Jobs grant that assisted in design and construction of the permeable pavements (ASLA Green Infrastructure and Stormwater Management Case Study, Case 191).

Cost Comparison Methods

The project uses permeable interlocking concrete unit pavers as a high-performance, cost-effective pavement, which saves approximately $395,000 in construction and permitting costs when compared to cast-in-place porous concrete for the 5,670 linear feet of streets that were replaced.

Based on the Charles City Green Streets Evaluation and Design Report, the estimated unit cost of a permeable paver road is $530/LF to construct the road cross section proposed for Charles City. The estimated unit cost of porous concrete road is $590/LF. The above price includes removal of the existing pavement and installation of the stone base, required drainage, curbs, and the permeable pavers. The project covers 6 streets and the overall length in this project is 5,669 LF. The Contingency and Design and Permitting Fees rates are 10% and 6%, respectively. Therefore the overall costs savings are:

\[
($590/\text{LF} - $530/\text{LF}) \times 5669 \text{ LF} + ($590/\text{LF} - $530/\text{LF}) \times 5669 \text{ LF} \times 16\% = $395,000
\]

By preserving 192 of the existing street trees, the City saved $57,000 over the cost of removing them and installing new trees.

See method for Landscape Performance Benefit #4.
Additional Images

Figure 24. Typical Intersection: Site plan of a typical intersection demonstrates the flow of stormwater and the Best Management Practices (BMPs) that comprise the stormwater management system. Conservation Design Forum

Charles City Green Streets Rainwater Treatment System Overview

Figure 25. The Four Best Management Practices (BMPs) used in Phase 1. Conservation Design Forum
Figure 26. Cobble Infiltration Areas: Cobble infiltration areas at street intersections capture stormwater runoff from the sidewalks and gutters. When the capacity of the cobble infiltration areas is exceeded, water enters the existing storm sewer through an elevated inlet. Conservation Design Forum

Figure 27. Alley Trench Grate: Stormwater runoff from the alleys flows into alley trench grates, preventing sediment clogging the permeable pavement of the roadway. Conservation Design Forum
Figure 28. Porous Unit Paving: Rain falling on the roadway surface infiltrates through the permeable pavement and into the gravel storage beneath. Runoff from adjacent yards flows into amended soil infiltration areas and down to the gravel storage.
Figure 29. After Construction: The permeable pavement and a cobble infiltration area along Kellogg Avenue just after completion.

Conservation Design Forum
Case Study 4: South Grand Boulevard Great Streets Initiative

Figure 30. South Grand Before and After Design Workshop, Inc.

**Designer:** Design Workshop, Inc.

**Land Use:** Commercial Retrofit

**Project Type:** Retail, Streetscape, Transportation

**Location:** South Grand Boulevard and Arsenal Street, St. Louis, Missouri 63118

**Size:** 6-Block Corridor

**Budget:** 3 million

**Completion Date:** 2011

**Project Team**

Land Planner: Design Workshop, Inc.

Transportation Planning: Nelson Nygaard, TND Engineering

Civil Engineering: Horner and Shifrin, Inc.

Market Analysis: RCLCO Art Planning: Via Partnership, LLP

Public Engagement: Hudson and Associates, LLC

Stormwater: University of Georgia School of Environmental Design
Street Trees: Jim Urban Cost
Estimating: Kwame Building Group
Site Surveying: Kowelman Engineering, Inc.
Irrigation and Planting Design: Austin Tao and Associates

**Case Study Prepared By**
Research Fellow: Bo Yang, PhD, Assistant professor, Utah State University
Research Assistant: Yue Zhang, MLA candidate, Utah State University
Research Assistant: Pamela Blackmore, BLA candidate, Utah State University

**References & Resources**
2010 Central States ASLA Honor Award
2011 ASLA professional Award
South Grand Boulevard Great Streets Initiative
Riverfront Times
Complete Streets Are Great Streets with Room for All
Urban Review St. Louis, South Grand: From the Gilded Age to "Great Street" The Architects Newspaper, Sustainable Streetscape
Sustainable Cities Collective: St. Louis leads with model project for smart, green streets
Landscape Architecture Magazine: The Measured Response
South Grand: From Good to Great
Overview

Culturally-diverse South Grand Boulevard is a historic district of St. Louis noted for its multitude of international restaurants. It is a growing commercial and residential area selected as one of four Great Streets Initiative pilot projects in the St. Louis region in 2009, demonstrating the character of the local neighborhood. The project, which was scrutinized by local government officials, brings people together and strengthens transit, walkability, recreation, and sustainability, while promoting a safe street environment. South Grand Boulevard applies innovative green solutions to reduce stormwater loading at moderate cost and in a manner that provides additional environmental benefits.

Role of the Landscape Architect

The landscape architect designed and produced construction documents, collaborating with an extensive team of Market Analysts, Transportation Planners, Civil Engineers, and Art Planners. The landscape architect focused on understanding the context of the project and key issues, developing a systematic approach for comprehensive community involvement.

Sustainable Features

- Reduced road width and bulb-outs at intersections shorten crosswalk distances from 56' to 37'. This design reduces traffic speed and improves pedestrian and driver safety.
- Tactile crosswalk striping, accessible ramps, visual and audio cues, and detectable warnings and signalization improve ADA accessibility on site. The project now meets federal requirements for accessibility along the corridor at 100% of the intersections. ADA accessibility was of special concern because of the project's close proximity to the
Missouri Schools for the Deaf and Blind. This study area is used by these students to familiarize themselves with urban environments.

- Recycled and reused 100% of the materials removed during construction, reducing landfill waste. The recycled concrete, bricks and asphalt were used for sub bases and trenching fill. This redevelopment project reused the good, existing sub soils, site furnishings, granite curbing, and bricks onsite.

- Sidewalk width was increased from 6.5 feet to 15 feet. This led to an increase of around 1,000 square feet of outdoor dining space. Seating was increased from 0 to 337 seats, providing gathering and social spaces infused with energy, encouraging people to spend more time in the project area. There was a significant amount of street dining prior to the project. However, it directly interfered with the travel path on the sidewalk. When the sidewalk is wider, the pedestrian realm is organized to create an intuitive travel path separate from the dining spaces. Last, there is also room for the significantly larger tree wells.

- Pervious surfaces were used in sidewalks. This project is one of the first that implemented porous paving materials in St. Louis, which is under court order to improve the City's combined sewer system.

- In Phase 2 of the project, rain gardens will be placed at all intersection bulb-outs and tree pits containing native perennials and forbs which infiltrate and filter stormwater, reduce water usage, and improve stormwater quality by eliminating fertilizer use.

- Soil volume for each tree was increased from 100 to 1,000 cubic feet, enhancing tree growth, health conditions, and longevity.
• The project uses 100% planting materials that are native to Missouri and locally available. Designed with seasonal interest, the added vegetation is expected to increase the populations of birds and butterflies. In addition, these plants conserve water and are durable to withstand the harsh street conditions.

**Challenge**

The design team was crunched for time, with only four months to gain community approval and produce the construction documents to prevent losing funding for the project. With a multicultural population, it was important to produce a space to accommodate their needs as well as those of business owners, commuters, pedestrians and residents.

**Solution**

In order to streamline the approval process, online surveys, keypad polling, and special interest meetings were utilized to enable the public to voice their concerns and ensure endorsement of the project. Within these surveys, nine options were presented for consideration. A pilot test was performed of the selected street configuration that guaranteed expected results would take place and give the public verification that their concerns would be met. A hotline was set up so that commuters unable to attend community meetings could voice their concerns by leaving a message. In this way, major decisions were placed in the community's hands.

**Cost Comparison**

• The project is predicted to achieve a total annual tree benefit of approximately $8,911 compared to the current tree benefit of $3,921 by switching from the existing Honey Locust to Homestead Elm and Sycamore.
Lessons Learned

• With nine street alternatives, it was essential to evaluate the proposed project based on the objectives identified by the users. Since no alternative was 100% perfect, tradeoffs had to be made to satisfy the issues of highest priority identified in a poll of the involved parties, including the pedestrian realm, economic development, and visual appearance.

• Some city officials opposed many elements of the proposed design—narrowing the road, rain gardens, smart parking meters, smart street lighting (tied to a computer that monitors the condition of the lights), and porous pavement. A stronger case must be made to officials who have the power to determine the future of projects.

• The design team was not contracted to oversee the project construction, and thus several aspects of their design were changed without their consultation. It is imperative for the design team to be engaged during construction for successful implementation of original design intent.

Performance Benefits Methods

*Expected to reduce traffic accidents by 85% due to dropping traffic speed from 42 mph to 25 mph (projected), resulting in an expected $3 million annual savings to the City. The probability of pedestrian fatality upon vehicular impact dropped from 100% to 25%.*
South Grand Boulevard exists as one of St. Louis' primary north-south arterials. The high vehicular speed averages 42 mph which fosters an unsafe environment for pedestrians who wish to cross the street and for cyclists who wish to travel alongside vehicles. In 2009, more than 110 traffic accidents were recorded within the study site. Reducing vehicular speed through lane reduction, traffic-calming techniques, and increasing walkability of sidewalks were the major foci of this project.

Speed is an aggravating factor in the severity of all crashes. On average, each 1 mph reduction in speed may reduce accident frequency by 5% (Taylor, 2000). The relationship between speed and the outcome of a crash is directly related to the kinetic energy that is released during a collision (E=1/2mv^2). The more kinetic energy absorbed in a collision, the greater the potential for injury to vehicle occupants and pedestrians hit by the vehicle.

In this project, traffic speeds are expected to reduce from an average of 42mph (68 km/h) to 25mph (40 km/h). Therefore, the reduction in accidents would be:

\[(42 \text{ mph} - 25 \text{ mph}) \times 5\%/1\text{mph} = 85\%\]

A 40% decrease in speed can result in a 65% reduction in the kinetic energy of a vehicle. Calculations are shown below:

\[\frac{E_2}{E_1} = \frac{\frac{1}{2}mv_2^2}{\frac{1}{2}mv_1^2} = \frac{v_2^2}{v_1^2} = \frac{25^2}{42^2} = 0.35 (35\%)\]

Walz et al. (1983) analyzed the relationship between the impact speed and the potential pedestrian injury severity. The probability for survival for a given Injury Severity Score (ISS) was estimated from 952 cases (Interdisciplinary Working Group for
Accident Mechanics, 1986). The data were combined to relate the probability of death to impact speed (Figure 31).


According to the National Highway Traffic Safety Administration (2000) and adjusted to 2010 dollars, the minimum cost of a crash is about $44,000. This includes costs typically absorbed by local governments (police department, emergency services, property damage). The median total cost is about $319,000. This estimate includes quantified economic impacts with the emotional impact that affects the lives of crash victims and their families. On average, 90 accidents occur annually along this section of
South Grand Boulevard from 2004 to 2009. Therefore, the average accident cost ranges from $3,960,000 to $28,710,000 per year.

Based on the above analysis, accidents will be reduced by 85% compared to the existing condition. Taking 90 crashes per year and multiplying by 85% yields 76 fewer crashes. This would generate a savings of between $3 million to $24 million per year.

\[
\begin{align*}
\$44,000 \times (90 \times 85\%) &= \$3,300,000 \\
\$319,000 \times (90 \times 85\%) &= \$24,400,000
\end{align*}
\]

**Projected to reduce vehicle emissions by 50% as a result of reducing delay and improving signal timing.**

Several studies indicate that effective signal timing and coordination can reduce on-road emissions. The Institute of Transportation Engineers (2009) showed that improved traffic signal timing can reduce fuel consumption by 10% and reduce harmful emissions up to 22%.

In the South Grand project, the transportation engineers utilized the program SimTraffic to calculate the current and future emission rates (based on the proposed 3-lane design model). The study results show that under similar speed levels, vehicles travelling on the 4-lane configuration produce greater harmful emissions and use more fuel than the 3-lane configuration. This is because the poor signalization timing at traffic signals in the 4-lane configuration causes traffic congestions and longer delays.

The estimated emission rates were determined in the SimTraffic program and presented in Table 8.

<table>
<thead>
<tr>
<th></th>
<th>Current 4-lane emission</th>
<th>Proposed 3-lane emission</th>
<th>Reduction rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>HC (g)</td>
<td>112</td>
<td>35</td>
<td>69%</td>
</tr>
<tr>
<td>CO (g)</td>
<td>3050</td>
<td>1369</td>
<td>55%</td>
</tr>
<tr>
<td>NOx (g)</td>
<td>364</td>
<td>169</td>
<td>53.5%</td>
</tr>
</tbody>
</table>

Abbreviations: HC, hydrocarbon; CO, carbon monoxide; NO, nitrogen oxides.

Projected to reduce the peak temperature in the street environment by 7.8 degrees through high-albedo materials, increasing planted areas and increasing tree canopy coverage. This would result in a saving of 7-14% in electric demands.

Surface materials largely affect surface temperatures and thus the surrounding air temperatures. Measurements taken on South Grand in early September are shown in Figure 32, demonstrating that asphalt has the highest peak temperature (122 degree), while grass has the lowest temperature (75 degree).
The project increases vegetative cover and uses high-albedo (reflective) surface materials to reduce the impacts of the urban heat island (UHI) effect. White concrete porous paving is used on site to minimize heat storage and absorption. The average air temperature in the street is projected to be reduced by 7.8 degrees Fahrenheit as a result of replacing asphalt with high-albedo pervious concrete. Moreover, increasing planted areas and tree canopy coverage also contribute to the UHI effect reduction.

$$105.1 \degree F - 97.3 \degree F = 7.8 \degree F$$
Typically, electric demand of U.S. cities increases about 1-2% per Fahrenheit degree (3-4% per Celsius degree) increase in temperature (McPherson and Rowntree, 1993). Therefore, the project is estimated to save 7.8% to 15.6% electric consumption in cooling.

Projected to sequester an additional 51,000 pounds carbon dioxide and to capture an additional 500,000 gallons of stormwater per year by replacing the existing Honey Locust with Homestead Elm and Sycamore. The native species also reduce the fertilizer pollution and Nonpoint Source Pollution from runoff.

Carbon dioxide (CO2) sequestration

Urban trees can reduce atmospheric carbon dioxide (CO2) in two ways: directly through sequestration of CO2 and indirectly through lowering the demand for heating and air conditioning, thereby reducing emissions associated with electric power and natural gas. Accounting for CO2 emissions from tree decomposition and tree-related maintenance activity, the reduced atmospheric CO2 by street trees in St. Louis are shown as follows (data from online National Tree Benefit Calculator):

- Honey Locust at mature size: 312 pounds per tree
- Homestead Elm at mature size: 714 pounds per tree.
- Sycamore at mature size: 620 pounds per tree

This project is expected to reduce an additional 42,500 pounds of CO2 by replacing the existing 71 Honey Locust trees with 49 Sycamore and 48 Homestead Elm
trees. This result is calculated by subtracting the existing CO2 emissions from the proposed values.

- Annual CO2 reduction from existing trees: 312 pounds x 71 = 22,152 pounds
- Annual CO2 reduction from this project: 714 pounds x 48 + 620 pounds x 49 = 64,652 pounds
- 64,652 - 22,152 = 42,500 pounds

**Stormwater**

Each Homestead Elm at mature size would capture approximately 12,515 gallons of stormwater per year. Each Sycamore would capture 7,829 gallons of stormwater per year. And each mature Honey Locust would capture 6,815 gallons of stormwater per year.

Therefore, the existing street trees would capture approximately 483,865 gallons of runoff.

- 6,815 gallons x 71 = 483,865 gallons

The proposed project would capture 984,341 gallons of water.

- 12,515 gallons x 48 + 7,829 gallons x 49 = 984,341 gallons

The increased amount of stormwater captured in the new project would be:

- 984,341 gallons - 483,865 gallons = 500,476 gallons

*Projected to increase revenue by 19% over a 10-year period, ultimately increasing entrepreneurial investment and employment.*

This analysis was conducted by Design Workshop (Table 9).
Table 9. Estimated annual revenue increase over a 10-year period in South Grand
(Source: Design Workshop, Inc.)

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Revenue</td>
<td>204.0</td>
<td>207.8</td>
<td>211.6</td>
<td>215.4</td>
<td>219.2</td>
<td>223.0</td>
<td>226.8</td>
<td>230.6</td>
<td>234.4</td>
<td>238.2</td>
</tr>
<tr>
<td>(Million dollars)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Revenue Increase (%)</td>
<td>1.9%</td>
<td>3.8%</td>
<td>5.7%</td>
<td>7.6%</td>
<td>9.5%</td>
<td>11.4%</td>
<td>13.3%</td>
<td>15.2%</td>
<td>17.1%</td>
<td>19.0%</td>
</tr>
</tbody>
</table>

Dropped the noise level from an average of 68dB to below 60dB as a result of the reduced traffic speed. The current noise levels fall within the range that allows a comfortable conversation. The design thus enhances the sidewalk environment and promotes restaurant business.

The study site is at the hub of the St. Louis International Community. Seven restaurants are located along South Grand in this six-block section. Through widening the sidewalks, more room was made for outdoor dining. It was important to create a comfortable and quiet environment that allows people to communicate easily. The goal of this project was to recreate an attractive pedestrian and outdoor dining environment which in turn will lead to increased revenue for the business owners. Therefore reducing the noise level to an acceptable range will not only enhance human comfort, but also stimulate economic outcomes.

Before this design, the noise level in South Grand was about 68 dB and occasionally increased to over 77 dB because of trucks and buses. This project was designed to reduce traffic speed from 42 mph to 25 mph. This results in a reduction of
noise levels from 68 dB to below 60 dB in normal traffic conditions (Figure 33). From a study conducted by Purdue University (Table 10), 60 dB provides a quiet and comfortable environment for conversation.

Figure 33. Relationship between vehicle speed and noise emissions. Source: Ruby Hendricks, 1995, Use of California Vehicle Noise Reference Energy Mean Emission Level (Calveno REMELS) in STAMINA2.0 FHWA Highway Traffic Noise Prediction Program, Technical Advisory, Noise, TAN 95-03, p.3.
Table 10. Noise sources and their effects. (Source: Purdue University Department of Chemistry, www.chem.purdue.edu/chemsafety/)

<table>
<thead>
<tr>
<th>Noise Source</th>
<th>Decibel Level</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Garbage disposal, dishwasher, average factory, freight train (at 15 meters). Car wash at 20 ft. (89 dB); propeller plane flyover at 1000 ft. (88 dB); diesel truck 40 mph at 50 ft. (84 dB); diesel train at 45 mph at 100 ft. (83 dB). Food blender (88 dB); milling machine</td>
<td>80</td>
<td>2 times as loud as 70 dB. Possible damage in 8 h exposure.</td>
</tr>
<tr>
<td>Passenger car at 65 mph at 25 ft. (77 dB); freeway at 50 ft. from pavement edge 10 a.m. (76 dB). Living room music (76 dB); radio or TV-audio, vacuum cleaner (70 dB).</td>
<td>70</td>
<td>Arbitrary base of comparison. Upper 70s are annoyingly loud to some people.</td>
</tr>
<tr>
<td>Conversation in restaurant, office, background music, air conditioning unit at 100 ft.</td>
<td>60</td>
<td>Half as loud as 70 dB. Fairly quiet</td>
</tr>
<tr>
<td>Quiet suburb, conversation at home. Large electrical transformers at 100 ft.</td>
<td>50</td>
<td>One-fourth as loud as 70 dB.</td>
</tr>
</tbody>
</table>

*Increased annual tax revenue more than 14% in the first year after redevelopment.*

The Community Improvement District tracked the sales tax revenues and indicated that there was a 14% increase in tax revenues in the first year after project construction. This rate is even 2% higher than the original projection by Design Workshop.

*Enhanced street aesthetics and increased people's satisfaction. 81% of the participants feel that the visual appearance of South Grand will be good or very good after the project is fully constructed; a 268% increase compared to the survey results prior to the construction.*
The project integrates art into the designed elements of the streetscape. To ensure the aesthetic quality, the project dedicates 1% of the construction budget to promote art. From the public survey results, more than 80% of the people surveyed like the new appearance of the proposed South Grand. This is a 268% increase compared to people's reflection on the existing South Grand.

\[(81\% - 22\%) + 22\% = 268\%\]

Figure 34. People's perceptions of South Grand. Results from 2009 keypad polling

Source: Design Workshop, South Grand Master Plan Book. p.33.

Cost Comparison

*The project is predicted to achieve a total annual tree benefit of approximately $8,911 compared to the current tree benefit of $3,921 by switching from the existing Honey Locust to Homestead Elm and Sycamore.*
According to the City of St. Louis, MO, Street Tree Resource Analysis (completed in March, 2009 by Davey Resource Group), the total annual benefits of the existing Honey Locust trees were about $55 per tree. The proposed Homestead Elm and Sycamore trees at mature sizes will provide an annual benefit of about $105 and $79 per tree, respectively (National Tree Benefit Online Calculation).

Measured from the CAD map, there are 71 Honey Locust trees on site. These Honey Locust trees were replaced by 48 Homestead Elm and 49 Sycamore. The total benefits were calculated as follows.

Annual benefits from the existing trees:

\[ \$55.22 \times 71 = \$3920.62 \]

Annual benefits from the tree replacements:

\[ \$105 \times 48 + \$79 \times 49 = \$8911 \]

Additional Images

Figure 35. South Grand Site Plan: The redesigned 6 Block Corridor. Design Workshop, Inc.
Figure 36. South Grand Perspective New Intersection: The new road section contains two bike lanes, 2 travel lanes, on-street parking on both sides of the road, and a turning lane. The space saved from removing one of the travel lanes allows for wider sidewalks. Design Workshop, Inc.

Figure 37. Bulb outs at intersections reduce crossing distances for pedestrians. Design Workshop, Inc.
Figure 38. Intersection Rain Garden: Of highest priority for this project was to increase pedestrian safety. Reduced number of travel lanes, wider sidewalks, and this bulb out rain garden provide a friendlier pedestrian experience. Design Workshop, Inc.

Figure 39. Sustainable Features: Narrowing the roadway from four lanes to three lanes allowed for wider sidewalks and dining areas, bike lanes, and enlarged tree wells. To solve stormwater issues, permeable pavement is used in parking stalls, porous concrete is used on sidewalks, and the enlarged tree wells contain rain gardens that allow water to infiltrate. Design Workshop, Inc.
Figure 40. Improvements for persons with disabilities: Accessible parking stalls improve access to the site for all users. Design Workshop, Inc.
CHAPTER 3: CASE STUDY SYNTHESIS AND ECONOMIC ANALYSIS


The CSI program uses multiple categories that subdivide case study information. Among these categories are “Performance Benefits” and “Sustainable Features”. Performance Benefits are the meat of the case study and showcase projects’ actual sustainability successes. In order to be classified as a performance benefit, there must be quantified data to support the claim. Sustainable Features, on the other hand, are aspects of a design that promote sustainability, usually presented as a description of design features and expected effectiveness of performance.

The four streetscape projects were assessed by Performance Benefits and Sustainable Features and their corresponding metrics, shown in Figure 2.
Several compelling performance benefits of these projects include safety and accessibility, visual resource and aesthetics enhancement, and water and energy conservation. For example, the social benefits of the South Grand Boulevard showcase intriguing features. Landscape architecture firm Design Workshop worked with the Missouri School for the Deaf and the Missouri School for the Blind, the major schools in the project site, to improve ADA accessibility at all intersections to 100%. Revised streetscape design and visual and audio cues help orient the visual and hearing impaired students and allow them to familiarize themselves with urban environments. In addition, as a result of the revised design, the traffic speed was reduced from 42 mph to 25 mph, and the probability of pedestrian fatality on vehicular impact was reduced from 100% to 25% (McLean et al. 1997). Related benefits include an 85% decrease in traffic accidents and an expected $2.69 million savings in medical care for the city of St. Louis over the next 25 years (Yang et al. 2012c).

The most challenging aspect is perhaps to measure the performance and estimate the economic value of certain landscape projects. A common way of doing this...
is through the process of monetization, which transforms the direct and indirect benefits into a dollar value (Macdonald et al. 2009). Although not every performance benefit can be or should be represented in monetary value, a comparison between different alternatives is an effective and persuasive way to demonstrate performance of exemplary projects and their contribution to environmental stewardship, economy, and society as a whole (U.S. EPA 2012). Table 11 shows detailed data sources used to assess the economic benefits of the four streetscape projects.

Table 11. Economic benefits of four streetscape projects.

<table>
<thead>
<tr>
<th>Case Study</th>
<th>Performance Benefits</th>
<th>Data Source</th>
</tr>
</thead>
</table>
| Cherry Creek North Improvement and Fillmore Plaza | • Increased the District sales tax revenues by 16% (over $1 million) in the first year after construction.  
• Decreased retail vacancy rates from 13.6% in 2009 to 7.2% in 2012.  
• Reduces annual water consumption for irrigation by 3,376,000 gallons, saving $17,600 annually.  
• Estimated to save an additional $10,000 per year in reduced maintenance costs.  
• Reduces annual energy consumption for outdoor lighting by 223,000 kilowatts, saving $12,700 in energy and $1,000 in maintenance and material costs each year  
• Saved $188,000 by reusing 331 light pole footings and bases in place on site | Sales Tax Revenues: Cherry Creek North BID year-end financial statement  
Vacancy Rates: Cherry Creek North Economic Indicators  
Water Consumption: Denver Utility Tracking Spreadsheets  
Reduced Landscape Maintenance Cost: Irrigation System Designer  
Outdoor Lighting Energy Consumption: Scanlon Szynskie Group (lighting consultant)  
Annual Lighting Maintenance and Material Costs  
Reused Light Pole Footing Cost |
Discussion

The LPS research initiative and the CSI program in specific, have by all means solidified LAF’s leadership in advancing landscape architecture research. The landscape architecture profession cannot rely on other disciplines to generate empirical
knowledge. In this sense, LPS and CSI are making headway in promoting original research and evidence-based design.

In addition to the successful stories presented above, the research team has the following observations and recommendations. First, the evaluation of streetscape project performance, similar to other sustainable projects assessment, is an intertwined, multi-disciplinary effort (Brown and Corry 2011; Culbertson and Martinich 2012). Although the research team hopes to have a unique, omniscient perspective supported with accurate and readily available project information, the constraints of time and resources may limit the extensiveness of the case studies. As Francis (2001) indicated that cost is a major limiting factor when producing a quality case study, with limited travel funding and project sites scattered across the United States, the research team did not have the opportunity to travel to the sites. This restricted the team’s understanding of each site, giving limited interaction with clients and users.

Second, the case study production is primarily conducted in the summer months. This limited time frame may also reduce the quality of the study. For instance, there was minimal time to capture additional data, so some benefits could not be assessed, even though the team understood that they could have been analyzed with more time. This may not be a good image to other disciplines suggesting that “cheap, quick” research is being performed in landscape architecture.

Moreover, this produces results countering what Francis had indicated would be one of the benefits of case study research. He believed that case studies are a medium for the landscape architecture profession to publicize their work for increased visibility to other disciplines (Francis 2001). What is encouraging is that LAF has
reported increased visibility with 2012 activity on the LPS website, doubling 2011’s activity. LAF also indicated that the most visited portion of the LPS website in the past year is the Case Study Briefs (http://www.lafoundation.org/news-events/blog/).

Third, the methods and tools that are currently being used may hamper the quality of the case studies, particularly the generalizability of the case studies. The available tools oftentimes lead to assessments that are rather general, resulting in suspicion of reliability. Some more complex methods and tools are difficult for individuals without advanced skills to replicate. Another constraint is difficulty in paralleling across case studies because inconsistent data have been collected resulting in incommensurable data (Francis 2001). One aspect that is leading to varying data is that of competing objectives (Culbertson and Martinich 2012). Because no two projects are identical, dissimilar objectives for each project create differing processes and outcomes, making it difficult to compare case studies. If baseline data are captured using standardized methods, this aspect can be vastly improved.

Fourth, it is important to mention the necessity to conduct long-term assessment and/or monitoring of the case project, in addition to the “one-time shot” landscape performance analysis. A research team consisting of the same authors of this paper is currently conducting a 5-year monitoring study of stormwater quality in the Daybreak community in South Jordan, Utah. To its credit, Daybreak is published in the 2011 CSI program and it is one of the most discussed CSI case studies (Yang and Goodwin 2011).
Conclusion

Case studies show the advancements and contributions made by the profession. Not only is the landscape profession as a whole benefiting from CSI, but participating firms and students are also reaping rewards. Firms taking part in CSI benefit from the unbiased post occupancy evaluation of their work. These case studies promote the firm’s sustainable practices. Students are learning new methods to gauge the quality of their own work including methods and tools that may not be covered in their curricula. Students are also given opportunities to network with practitioners in order to better understand sustainable solutions to difficult design problems. The CSI program gave the students a unique, inspiring and interesting experience. As a result of the CSI experience, they will never approach design the same way again. Finally, to make a lasting impact, it is important for future CSI teams to disseminate research findings in peer-reviewed venues and approach a large audience.

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AUTHOR'S BIOGRAPHY

Pamela Blackmore, raised in Winfield, Alberta, Canada, and Centennial Park, Arizona, graduated in 2006 from the Centennial Park Academy. In high school, she took advanced placement and college classes at Mohave Community College. After graduating from high school, she continued at the community college and worked at a family landscape installation and maintenance company until she transferred to Utah State in 2009. After taking 1 year of online and distance education classes, she moved to the Logan campus and officially started the undergraduate program in Landscape Architecture and Environmental Planning.

Pam matriculated into the program in one year and has many accomplishments in her final two years of study. Pam has worked on research in Daybreak, Utah, and also with the Landscape Architecture Foundation. She has co-authored a peer-reviewed publication and presented at a national conference. She was awarded multiple awards for her work including: LAEP Undergraduate Student Contribution to the Field of Theory or Practice for the year 2012-2013; Utah State University Olmsted Scholar for the year 2012-2013; BLA Senior Faculty Medal 2013; Utah Chapter of the American Society of Landscape Architects Honor Award; Utah State University Honors Program 2013 Joyce Kinkead Outstanding Honors Scholar Award; and one of the three Landscape Architecture Foundation 2013 National Olmsted Scholar Finalists.

Pam has been awarded a Fellowship to participate in a Case Study Investigation with the Landscape Architecture Foundation this summer. She will also continue
researching water quality issues with Dr. Bo Yang. After working for a couple years, she plans to attend graduate studies and remain in the Intermountain West.