Cascade Garden – Aspen, CO
Methodology for Landscape Performance Benefits

Environmental

Sequesters nearly 31,200 lbs of carbon annually in the 44 mature globe willow trees and 18 Colorado blue spruce trees that were transplanted during construction.

Willow trees and transplanted Colorado blue spruce trees on-site were counted and measured (DBH at 4.5 ft from ground). These measurements were entered into the tree value calculator (http://www.treebenefits.com/calculator/).

The aggregate carbon reduction of the willow trees is 28,604 lb annually. The spruce trees reduce carbon by 2,586 lb annually.

28,604 + 2,586 = 31,190 lb annually

Limitations

1) Even years later, the transplanted trees did not appear to be as healthy as other trees of the same species on the property. It may be that they have lost some ability to reduce atmospheric carbon due to the stress of being transplanted.
2) Many of the willow trees were had multiple trunks. This study treated each trunk as it own individual tree as there is no option in the tree value calculator to accommodate this feature.

Creates ideal trout habitat conditions with dissolved oxygen levels at or greater than 7 ppm and water temperature at or less than 60°F, following the pond redesign. Trout could not be sustained previously.

The landscape architect worked with an aquatic consultant to improve the existing pond so that year-round trout habitat could be provided. The pond was deepened to fourteen feet and lined; oxygenators, vegetation cover, dead tree trunks, and other structures intended as rainbow and brown trout habitat were added.

Many factors are important for successful trout habitat. Data were obtained by speaking with an aquatic specialist and performing on-site analysis. According to Kendra Holmes of the aquatic consultant on the project, Aqua Sierra, after the project was installed dissolved oxygen levels were measured and recorded as greater than 7 ppm. On a visit to the site on June 17, 2013, water temperature, alkalinity, pH, and hardness were measured in four different locations using an aquarium thermometer and test strips. Measurements were taken from the furthest downstream position first, working upstream, to ensure the disturbed pond bottom did not impact water quality tests. The results are presented in Table 1.

OBJECTID	on-site pH	Depth	Temperature	Time	Alkalinity	TSS (mg SS/)L	Hardness
2882| 1	7.5	3 inches	59	1:35	130	32	124.20
2883| 2	7.5	3 inches	60	1:50	150	18	118.01
2884| 3	7.5	18 inches	NA	1:50	NA	22	125.28
2885| 4	7.8	3 inches	60	1:53	175	18	136.05
2886| 5	7.5	3 inches	58.5	2:00	120	14	118.62
2887| 6	NA	18 inches	NA	2:00	NA	33	117.61

These results can be compared to ideal trout habitat requirements shown in Table 2 below. A comparison reveals that all on-site samples were within suitable ranges.

Table 2. Suitable water quality parameters for trout. Adapted from (Boren, Baker, Cowley, & Hurd, 2003)

Parameter	Level
pH	6.5-8.5
Alkalinity	10-400 ppm
Hardness	>20 ppm
Dissolved Oxygen	5-12 ppm

Water temperature is one of the most critical factors for trout survival. Research indicates that rainbow trout survive in temperatures ranging from 33-78 degrees Fahrenheit, with optimum growth occurring between 50-55 degrees. Brown trout survive in 33-72 degrees Fahrenheit with optimum growth between 48-55 degrees Fahrenheit (Boren, Baker, Cowley, & Hurd, 2003).

The water temperature data from Table 1 was interpolated in GIS using the Kriging method to show lateral temperature trends throughout the pond. Figure 1 shows these trends in the pond and the sampling locations.

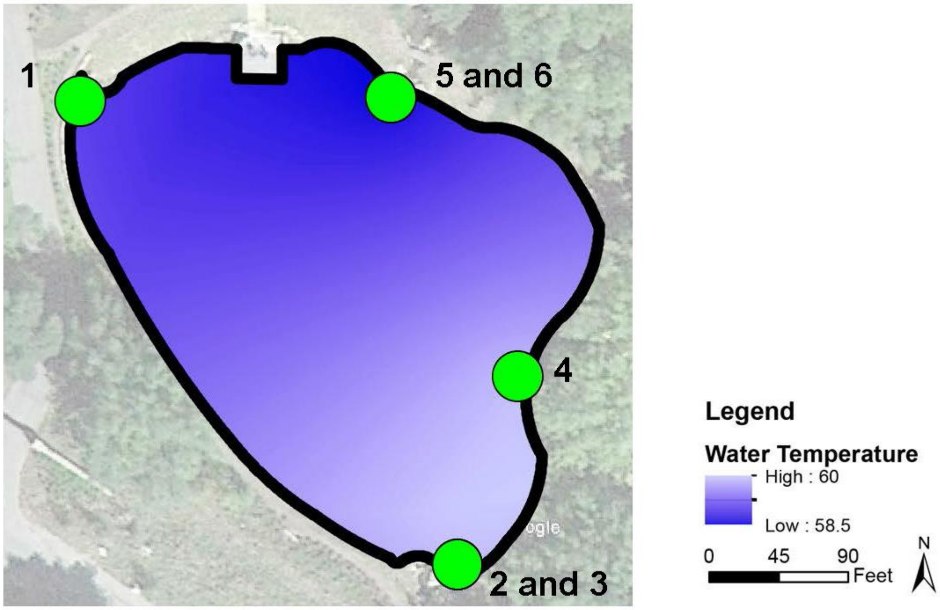


Figure 1. Water quality sampling locations #1-6 and water temperature interpolation

While temperatures were not in the "optimum" range, it is important to note that the samples were taken near the edge of the pond, in shallow water representing the worst case scenario. Information from Aqua Sierra indicated that the pond was last stocked in May of 2012, and trout were visible to the researchers.

Limitations:

1) The data gathered represents a single sample on a sunny June day. More samples on other dates would need to be tested to give a better idea of year round suitability.
2) The aquarium test strips used did not have very precise scales and some judgment was left to researchers.
3) Rainbow trout tend to hybridize with native cutthroat trout species and brown trout tend to replace native cutthroat trout species, and thus stocking non-native trout species can have unanticipated consequences on native trout. However, the Colorado Division of Wildlife has considered these potential threats and created regulations regarding stocking private ponds. It is legal to stock salmonids into private ponds, provided it is not within critical habitat areas. (U.S FWS, 2009)

Reduces the project's landfill burden by over 3,700 cu ft by donating material from the existing home to Habitat for Humanity. The recycling of the pine logs alone reduced the total amount of CO2 equivalent produced by approximately 22 tons.

Data on what was removed from the existing home was received from the contractor, including quantities, descriptions, and sizes. Some items did not have a size, so an estimate was made based on accompanying photographs. The total volume of material donated was assessed by multiplying the length, width, and height of each item, then totaling those results

The average weight for pine timber used in construction was obtained from the American Wood Council (available from http://www.awc.org/pdf/WSDD/wsdd.pdf, page 9). The weight for Western White Pine is 27.2 lb/cu ft. The volume of pine logs donated was 847.25 cu ft and the total weight was 23045.15 lb, or 11.52 tons.

Using the EPA's Waste Reduction Model (WARM) calculator (http://epa.gov/epawaste/conserve/tools/warm/Warm_Form.html), the effect of recycling the 11.52 tons of wood compared to sending it to the local landfill (local landfill is 13.1 miles from the site)

was assessed using the tool. It was found that approximately 20 metric tons of carbon dioxide equivalent were saved.
20 metric tons = 22 short tons

Limitations

1) The data on what was removed from the home is not all-inclusive. Anecdotal reports suggest that other material was also removed, including a trampoline and copper roofing. While these items may not have been donated, it does lead one to suspect that the inventory was not complete.
2) The volume of items such as lamps and ceiling fans was estimated from photographs as the items themselves were not measured at the time and not available to researchers when the study was being conducted.
3) The carbon dioxide equivalencies of the logs were calculated using a tool that considers them as lumber, which though a close approximation, is not exactly the same.

Reduces irrigation and fertilizer needs by nearly 60% by replacing 5,020 sf of turf with native plants . This saves over 75,000 gallons of water and eliminates the need for 30 lbs of fertilizer annually.

Existing turf was determined by surveys, photographs and AutoCAD files of the property prepared for demolition of the existing house.

Existing turf on the property covered approximately 8,650 sf.

Current turf on the property was determined through planting plans for the current property.

Current turf on the property covers 3,630 sf.

8,650 – 3,630 = 5,020 or a reduction of approximately 5,020 sf of turf.

Irrigation water naturally flowing through the site is detained in the on-site pond. Some of this irrigation water is recirculated through a stream course and cascade above the pond using a pump that is turned on only when homeowners are present. Irrigation water is pumped out of the pond and applied to turf areas through a standard irrigation system.The current maintenance contract for the turf areas on the property calls for one inch of irrigation per week during the 24 weeks of the maintenance (snow-free) season and two pounds of fertilizer per 1,000 square feet three times per year for turf grass.

2 lb / 1,000 sf X 3 times per year = 6 lb / 1,000 sf per year
6 X 8.65 = 51.9 lb of fertilizer were needed in previous condition
6 X 3.630 = 21.78 lb of fertilizer are needed in current condition
51.9 – 21.78 = 30.12 lb of fertilizer saved annually
30.12 / 51.9 = 0.58 or 58% reduction in fertilizer use
1 in per week X 24 weeks = 24 in
24 in = 2 ft
2 X 8,650 = 17,300 cu ft of water needed to irrigate previous condition
2 X 3,630 = 7,260 cu ft of water needed to irrigate current condition
17,300 – 7,260 = 10,040 cu ft of water saved annually
1 cu ft = 7.48 gallons
7.48 X 10,040 = approximately 75,099 gallons of water saved annually

Limitation

1) The surveys used to discover the amount of turf previously existing on site mark the lawn areas as “approximate” and thus are not exact figures.

Social

Blocks approximately 97.8% of unwanted views with earth berming, plantings, and retention of mature trees to reduce visibility of traffic on the nearby road from key points on the

property.

The procedure below followed the methodology developed by Clay and Marsh (1997) and Chen *et al.* (2009).

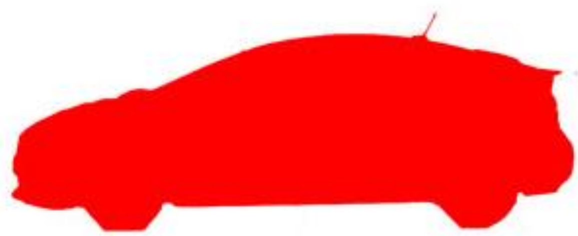
Panoramic photographs were taken from a key point on the property: the seating area on the middle tier of the patio (Figure 2). This location was chosen for its obvious use by the homeowner as a primary area from which to enjoy the scenic view of the mountains over the pond.

Figure 2. Panoramic photograph showing the view from the patio

The photographs were taken as a red Toyota Prius drove down the road directly abutting the south edge of the property. A photograph of the Pruis was also taken (Figure 3).

Figure 3. Photograph of Toyota Prius

Figure 4. Color Overlay matching the Prius' outline



The photograph was imported into Adobe Photoshop where a color overlay was applied to give the car a solid color. The image was flipped vertically to match the direction of travel of the Prius in the panoramic photo (Figure 4). The image was resized in Photoshop to match the scale of the car as it appears in the photograph. The image of the car was then copied and pasted repeatedly to create a swath from one end of the property to the other that is representative of the total area the vehicle would occupy when traveling on the road (Figure 5). This is the visual area that would

Figure 5. The line of travel swath layered atop the panoramic photograph

be occupied by a vehicle if no buffer were present between the viewer and the road.

The histogram feature in Photoshop was used to measure the number of pixels present in the swath layer (Figure 6). This is the number of pixels that would be visible if no buffer were present.

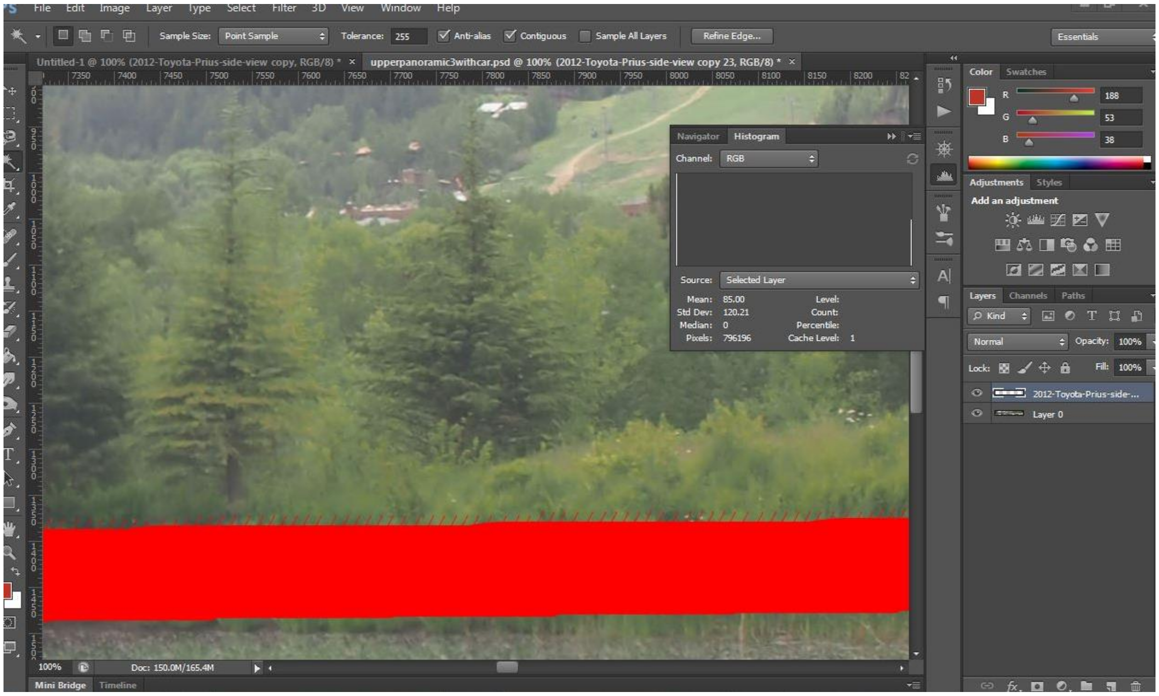


Figure 6. Pixel count for the selected layer (the traffic swath)

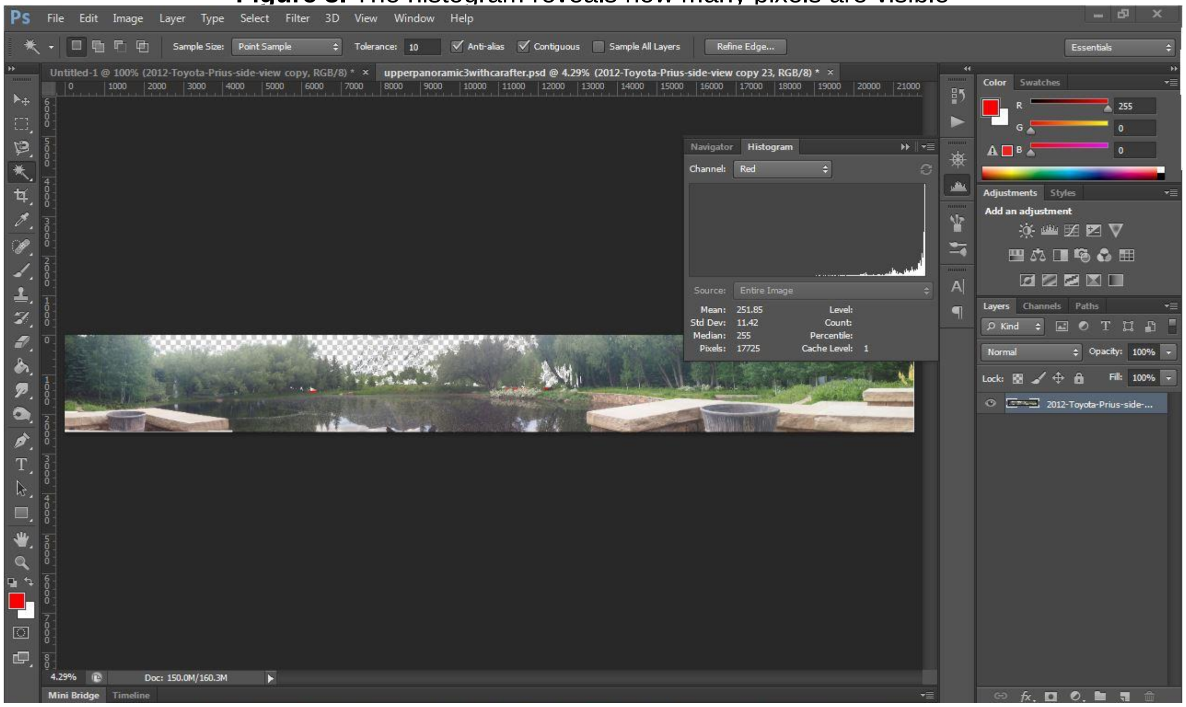
There are a total of 796,196 pixels in the swath. Note that the Cache Level on the Histogram has been set to 1 to ensure that the entire layer is being evaluated, not a random selection (to save time Photoshop will often survey a random selection of pixels to create the histogram, thus limiting the count to ¼ or ½ the actual number present).

The swath layer was moved underneath the panorama layer and the wand tool, set on a very low tolerance, was used to erase those parts of the panorama image that lie on the far side of the road (Figure 7). This revealed the swath in just those areas that are not covered by berms, plantings, fences, or gates on the property.

Figure 7. Removing the background revealed the visible parts of the traffic swath.

Finally, the layers were merged and the visible parts of the traffic swath were selected. The histogram function was used again to determine how many visible pixels from the swath remained (Figure 8).

Figure 8. The histogram reveals how many pixels are visible



A total of 17,725 pixels are visible.
17,725 / 796,196 = 0.02226 or approximately 2.2%.
100% – 2.2% = 97.8% of the view of traffic is blocked.

Limitations

1) The use of the Toyota Prius as a metric for the traffic swath is a limitation. Obviously other types of vehicles (trucks, motorcycles, etc.) would yield different results. We chose the Prius because it is a popular, average-sized vehicle and because that was the only car available at the time of the study.
2) The distance from the point of photography to the road, while nearly constant, is not perfectly so. Therefore, the scale of the car would vary slightly, becoming smaller and less visible towards the edges of the photograph while we relied on a standard size for our swath.

Cost Comparison Methodology

By installing a ground source heat pump to provide renewable energy, the design avoided approximately $97,000 dollars in current Pitkin County Renewal Energy Mitigation Program fees. Purchase and installation of the unit totaled $83,000. Annual maintenance of the pump costs $1,500 annually when averaged over the five years since installation, which is competitive with maintenance costs of traditional commercial units.

The ground source heat pump provides renewable energy for the snowmelt system and spa. The total square footage of the spa and snowmelt areas was determined by measuring their area on construction documents. The totals are as follows:
Spa = 108.75 sf
Snowmelt = 2095.31 sf

The calculator used to assess current Pitkin County Renewable Energy Mitigation Program (REMP) fees is available from http://www.aspenpitkin.com/Departments/Community-Development-Pitkin-County/Building/Building-Energy-Codes/.

Total fees: $97,183.47

According to the landscape architect, the heat pumps are manufactured by Water Furnace and cost approximately $28,000 to install. The cost of drilling, field pipe, and grout was an additional $55,000. The annual maintenance cost of the units is approximately $1,500 annually averaged across the past five years (since installation) which is competitive with traditional commercial systems.

$28,000 + $55,000 + $1,500 x 5 = $90,500 total cost to date.

Limitations

1) The calculations are based on current Pitkin County REMP calculations. The calculations for the date of installation were not available, and though comparable would likely have been less.
2) The figures used for the cost of installation and maintenance are estimates from the landscape architecture firm, not exact figures.

References

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Chen, B., Adimo, O.A. and Bao, Z.Y. (2009). Assessment of aesthetic quality and multiple functions of urban green space from the users' perspective: The case of Hangzhou Flower Garden, China. Landscape and Urban Planning 93: 76-82.

Clay, G.R. and Marsh, S.E. (1997). Spectral analysis for articulating scenic color changes in a coniferous landscape. Photogrammatic Engineering and Remote Sensing 63(12): 1353-1362.

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