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## **Comparison of the Stormwater Benefits and Costs of Urban Street Trees versus Stormwater Treatment Rain Gardens**

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Mike Kelly, P.E., Angela Hansen  
City of Austin  
Watershed Protection Department, Parks and Recreation Department  
Environmental Resource Management Division

### **ABSTRACT**

*Austin City Council requested staff to quantify the storm water benefits of urban trees to evaluate a proposal to transfer Drainage Utility Funds to the Parks and Recreation Department for tree planting and maintenance. Staff used existing literature and accepted calculation methods to perform a volumetric comparison of tree canopy versus rain gardens. Using City of Austin cost data, staff was able to compare the relative costs and benefits of urban trees vs. rain gardens as storm water management tools.*

### **INTRODUCTION**

On September 11, 2012, Austin City Council passed a budget amendment/resolution that directed staff to: a) conduct a study regarding the feasibility of using Drainage Utility Funds for the maintenance and irrigation of trees in the Public Right of Way; and b) report the results of the study to Council within 90 days.

The investigation was initiated to review excerpted data from a 2008 Parks and Recreation Department (PARD) report entitled "Annual Stormwater Benefits of Public Trees by Species". The report estimates the total rainfall interception for individual tree species and a total dollar value for the rainfall interception performed by urban street trees. Based on these results, it was suggested that urban trees provide a direct dollar value in stormwater services and therefore the Drainage Utility Funds could be used to plant and maintain trees to perform stormwater functions. However, a complete copy of the 2008 PARD report and sufficient supporting information were not available to corroborate or refute the numbers presented in the summary table.

After the Council Resolution, WPD staff conferred with staff from PARD's Urban Forestry Program, the City Arborist's office and City Council Member Tovo's office. This collaborative workgroup decided to evaluate the relative efficiency and cost of urban tree canopy in comparison to traditional stormwater management practices for reducing stormwater runoff. The results of the comparison may be used in evaluating proposals to dedicate funds derived from the Drainage Utility Fee to PARD tree care and maintenance programs.

## **METHODS**

Three methods for quantifying the volume of stormwater intercepted by urban tree canopy are available to staff: 1) direct measurement; 2) use of computer simulations (i-tree, STRATUM) or other mathematical models; 3) reliance on studies performed by others in areas with similitude to Central Texas climatic conditions. Direct measurement is not feasible within the allotted time and would be prohibitively expensive. Computer models require data inputs that the City does not currently possess and would also require time and funding not available for this evaluation. Therefore, staff performed a review of available scientific literature incorporating both research studies and computer simulations to validate the numbers provided by the PARD 2008 report. Staff were unable to recover any supporting information (reports or STRATUM computer models) relating to the aforementioned 2008 PARD report or the table, "Annual Stormwater Benefits of Public Trees by Species." Therefore, direct confirmation or refutation of the methodology used to generate the 2008 report table has not been possible to date and staff performed an analysis independent of the PARD report.

Ideally, state of the art models to predict tree canopy stormwater interception for mature, evergreen (live oak) trees in Austin would be available for use. These models would serve as a means to further evaluate the accuracy of the literature data and the PARD 2008 data. Several studies performed on Edwards Plateau live oaks and juniper trees are available in the literature. The results of this empirical research, however, are reported in units of depth of canopy stormwater interception per tree per year or per storm. In order to translate these depth values to stormwater volume for comparative purposes, the Canopy Surface Area for representative mature evergreens in Austin must be known. Unfortunately, the Arbor Pro (2008) report did not contain this information. Staff used sample tree canopy measurements and an online canopy surface area calculator (Treeworld.info) to estimate Canopy Surface Area for Austin. Using the surface area estimates with the literature values for annual canopy interception yielded per tree stormwater interception volumes that were an order of magnitude higher than the literature values provided (McPherson *et al.* 2005, Xiao *et al.* 2002, Thurow *et al.* 1987). Therefore, staff examined documented literature values for annual tree stormwater interception for comparison with traditional stormwater controls. The highest literature value of 1,742 gallons of stormwater intercepted per year per tree was used for comparison.

Having estimated annual average stormwater capture volume for trees, staff needed to determine a cost basis for comparing the cost/benefit of trees versus stormwater ponds using known cost figures for pond construction. The only data that staff could identify for establishment of trees was the figure of \$434 (PARD) per tree to purchase, plant, irrigate, mulch and prune for a period of three years, considered the time it takes to nurture a tree until it can survive on its own. A tree does not perform the full stormwater functions of interception that have been quantified in the literature until the canopy is mature. Therefore, in reality there is a time gap measured in years between the time a tree is established and the time it takes to reach maturity and begin to realize its interception potential.

The next step involved using the stormwater model developed by Adams and Papa (2000) to characterize the effectiveness of a volume-based stormwater BMP in terms of annual runoff capture (and by extension, pollutant removal). The Adams and Papa (2000) model allows the user to design a stormwater pond and calculate how much runoff over the course of a year the pond will capture. Staff modeled the performance of several small rain gardens that have been designed and built over the past two years to determine how much runoff they capture. Runoff captured by rain gardens is infiltrated into the ground where pollutants are effectively removed. Because rain that is intercepted by tree canopy

never makes it to runoff, the pollution associated with urban runoff is reduced proportionate to the amount of water intercepted. The goal is to compare the amount of runoff that is either treated by stormwater rain gardens or prevented by trees.

## RESULTS

Modeling the rain gardens at One Texas Center and those constructed on Rio Grande as part of the Bike Boulevard yielded the following results (Table 1):

**Table 1. Capture Volume of Two COA Stormwater Ponds and Number/Cost of Trees Necessary for Equivalent Capture .**

	annual volume (in)	annual volume (ft <sup>3</sup> )	annual volume (gal)	Area (ft <sup>2</sup> )	CDA (acres)	Cost (\$)	# trees (at 2000 gal/tree)	Cost for 3 year estab. (\$)	Increase in cost of trees vs. ponds (%)
<b>Rio Grande @18<sup>th</sup> Rain Garden</b>	5.1	18513	138477.2	400	1.1	23800.0	79.5	34500	40
<b>OTC Rain Garden</b>	12.62	45810.6	342663.3	1165	0.7	45000.0	196.7	85371	90

The results show that each rain garden is capable of capturing more runoff than a single tree can prevent. It takes between 80 and 200 trees to perform the same role as a rain garden, with the number increasing as rain garden size and contributing drainage area increase. Using the cost data supplied by PARD and multiplying by the number of trees allows a cost comparison between building a rain garden and planting and establishing trees. For the two rain gardens studied, it will cost between 40% and 90% more to plant trees versus building a rain garden for equivalent capture. In addition, the trees will not immediately perform their stormwater function upon expenditure of the funds. The trees will be established but will need to grow for at least ten years before the canopy is big enough to realize significant canopy interception.

## CONCLUSION

The investigation of the cost effectiveness of tree establishment/maintenance versus traditional stormwater management ponds produced the following conclusions:

- 1) A typical rain garden can capture and treat stormwater more cost effectively than an equivalent number of trees on an average annual basis.
- 2) Trees perform a quantifiable function in stormwater management. The current investigation focused on the interception value but demonstrated that there are other functional benefits that are not well-documented or easily quantifiable.
- 3) The City of Austin should continue to investigate and quantify the role of urban forests, specifically in Austin, TX, in providing environmental services including stormwater management, urban heat island reduction and climate protection.

Therefore, staff does not recommend that Drainage Utility Funds be transferred from the Watershed Protection Department to the Parks and Recreation Department for tree establishment. However, Watershed Protection Department and Parks and Recreation will continue to collaborate on ways to combine stormwater management with tree planting and establishment to realize their synergistic benefits.

## **References**

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