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A Cost-Benefit Analysis of the Meadow Creek Stream Restoration Project

Meadow Creek is a stream with a drainage area of approximately 5,800 acres that originates on Observatory Hill on the campus of the University of Virginia. A part of the Rivanna River watershed, Meadow Creek flows east through the Albemarle County and the City of Charlottesville before joining the Rivanna River, which is itself a part of the greater Chesapeake Bay watershed. The City of Charlottesville has designated a 9,000ft stretch of meadow creek as the site for an intensive stream restoration project. The project, which will also include the conservation of 72 acres of land as a forested riparian buffer, is designed to address the designation by the Virginia Department of Environmental Quality of Meadow Creek as an impaired waterway. This impairment is caused primarily by increased sedimentation due to erosion. The completion of this project will result in a stabilized stream, with improved water quality and enhanced wildlife habitat. The purpose of this paper is to perform a cost-benefit analysis of the proposed restoration project, to determine if it is a viable use of City funds.

Introduction:

In a natural setting, rivers and streams create floodplains that slow flow into streams during storm events, dissipating energy and reducing erosions. However, in urban environments, watersheds contain impervious surfaces, such as parking lots, which prevent water from draining into the ground. This causes rainwater to drain instead into storm water systems and hence into rivers and streams at a faster than natural rate. This results in higher peak flows, volumes and velocities in streams and rivers than would naturally occur. This is the case with Meadow Creek, which follows through a predominately urban area before emptying into the Rivanna River, though the site set aside for stream restoration is in a suburban development. Additionally, Meadow Creek was artificially straightened in the past - this further reduces the Creek's to dissipate water energy, as streams normally form meanders as they travel through the countryside, which slow flow and reduce erosion. The net result of the urban environment through which Meadow Creek predominately flows is a high energy flow that

causes stream bank erosion, scouring of the stream bed and excessive sedimentation. In addition to carrying pollution, these sediments can become suspended in the stream water, causing fish to suffocate and blocking out the sunlight.

In order to restore Meadow Creek to a more natural condition and to prevent the harmful effects caused by increased erosion and sedimentation, the City of Charlottesville is planning a restoration project which will entail the following steps being taken:

1) Reduce steep height of stream banks
2) Realign stream channel
3) Add meanders and in-stream habitat structures
4) Plant trees to create a buffer
5) Permanently protect Meadow Creek and buffer land with conservation easements

Precedents for this project exist within the city limits. In 1999 the City successfully completed a similar stream restoration project on a 1,200 foot stretch of Moore's Creek, which is a stream very similar in nature to Meadow Creek, though in a location described by the Virginia Department of Environmental Quality as "mixed urban/suburban/rural" as opposed to the "urban" location of Meadow Creek. The banks of Moore's Creek were six to seven feet above the stream level and required significant leveling, while the stream itself was described as "channel platform adjusted with rock and root wads on meanders, with several grade control structures in each meander." The final cost of the Moore's Creek project, which is now the centerpiece of the City's Azalea Park, was $208 per linear foot of stream restored.

Costs:

Three potential costs of the restoration of Meadow Creek will be examined here, including land acquisition, the actual construction of the project, and the cost of lost development potential.

The acquisition of land for the Meadow Creek restoration has been an ongoing project for years. The basis for the eventual 72 acre site is the 28.3 acre Greenbrier Park, which was

deeded to the City in 1965 and which forms the eastern half of the Meadow Creek Restoration. Two additional lots were donated to the City in 2001 and 2009, and the City purchased a fourth, 3.3 acre lot in 2011 for $20,000. The purchase of an adjacent, 4.4 acre lot is currently pending. For the purposes of this project, it is assumed that the 4.4 acre lot will be purchased for the same price per acre as the 3.3 acre lot, which is given as $20,000/3.3acres = $6060.61/acre. A summary of land acquisition expenses is given in Table (1).

Table 1:

Parcel	Cost
28.3 acres (Greenbrier Park)	Donated, 1965
13 acres	Donated, 2001
18 acres	Donated, 2009
3.3 acres	$20,000
4.4 acres	$26,666.67 (assumed)
Total Area: 67 acres	$46,666.67

Construction costs for stream restoration are strongly correlated to the type of environment the stream flows through, with rural settings being relatively cheap to conduct restoration work in, while urban environments are typically much more expensive settings in which to do restoration work. The reason for this is that urban environments tend to impose much greater constraints on the amount of workspace available for a particular project, and available land area is perhaps the single largest determining factor in deciding what kind of restoration technique to use. The Virginia Department of Environmental Quality has produced a document, The Virginia Stream Restoration and Stabilization Best Management Practices Guide, which provides a thorough introduction to the various techniques available for stream restoration, as well as the average cost per foot of stream associated with each technique. An example of the cost information available in the Best Management Practices Guide is given as Table (2) below.

Table (2) can be used to estimate a general range for the cost of the Meadow Creek Restoration. The stretch of Meadow Creek to be restored lies in a forested buffer area between

commercial and residential developments, and so can neither be described accurately as rural or urban. In particular, the is plenty of room to relocate the stream channel so as to restore its connection to the original Meadow Creek floodplain. This is important, as the stabilization in place of channels in heavily urbanized locations can be very expensive. However, the stretch of stream to be restored does pass close to several commercial and residential structures, and in addition contains a section of the city sewer system, therefore some level of constraints do exist on the site.

Table 2: Estimated Cost of Representative Stream Restoration Projects

TYPICAL STREAM CHANNEL PROJECT CHARACTERISTICS AND CONSTRUCTION COSTS PER LINEAR FOOT

(assuming a second –third order stream)

Typical Projects	Per Linear Foot Construction Costs	Comments
Rural watershed requiring fencing and riparian buffers, and cattle watering	$25-75	Cost can be lower if implemented by volunteers or agency staff
Rural watershed requiring a priority one or two relocation (construct new floodplain and channel)	$50-100	No constraints to constructing new channel, readily available materials nearby
Suburban/Urban stream requiring bank stabilization, grade structures with some utility and similar constraints	$90-250	Stabilization in-place, and limited ability to salvage local materials increases costs
Urban watershed, highly confined channel stabilized in-place, requiring utility relocations, outfall repairs, with many constraints	$250-400	Urban constraints, utilities and outfalls result in high costs

Source: Costs were derived from a review of a range of projects, but individual project costs can be highly variable. Construction costs include labor, material, equipment and installation, but excludes design costs.

Given these parameters and the costs given in Table (2), the Meadow Creek Restoration could be estimated to cost between $50 and $250 per linear foot of stream, which is a rather large range. A more precise cost estimation can be made by using the cost of the Moore's Creek

Restoration, conducted by the City of Charlottesville in 1999, as representative of the average cost of the proposed Meadow Creek Restoration. While the Moore's Creek project was much smaller than that planned for Meadow Creek (only 1,200 feet compared to 9,000 feet), Moore's Creek was in similar condition to the unrestored Meadow Creek, and is located on similar terrain. The Best Management Practices Guide uses Moore's Creek as an example of a successful project, and gives the cost of the project to be $250,000 for a 1,200 foot project, for a unit cost of $208 per foot. As this project was completed in 1999, inflation needs to be taken into account when applying this cost as an estimate for the Meadow Creek project. Inflation over the period from 1999 to 2011 was 34.53%. When the price of the Moore's Creek project is adjusted for inflation, it becomes $336,325 and the unit cost is $280.27 per foot.

The one main difference between the Moore's Creek and Meadow Creek sites is that the Moore's Creek site was readily accessible, as it existed within the City's Azalea Park, whereas the Meadow Creek project lies wholly within an area of marginal land lying between commercial and residential developments, with very little, if any, available road frontage. This means that an access road will need to be cut through what is mainly heavily forested terrain. Additionally, land on each side of the creek will need to be cleared so the stream channel can be moved and meanders added - trees will be replanted as the final stage of construction. Therefore the cost of clearing the worksite of trees is not insignificant and must be accounted for. A examination of various industry online forums shows that the average price of clearing land in this part of the country is $5,000 per acre. When minor bends in the stream are discounted, the length along which land will need to be cleared is about 7,000 feet. Assuming that, on average, the site will need to be cleared a total of 150 feet back from the existing channel to allow for the type of heavy construction equipment needed (indeed, plans call for moving the channel more than 200 feet to the south of its current path in some places), then the total area to be cleared can be estimated to be approximately 1,050,000 square feet, or 24 acres. At a price of $5,000 per acre, the total cost of clearing the project site can be estimated to be $120,000. Total costs for construction, including site clearance, are summarized in Table (3).

Table 3: Construction Costs

Activity	Cost	Unit Cost
Tree Clearing	$120,000	$5000/acre
Restoration Work	$2,522,430	$280.27/foot
Total	$2,642,430	----

Along with the costs of construction, the City of Charlottesville will also incur annual costs from the maintenance and monitoring of the site after its completion. The Virginia Best Management Practices Guide states that parties involved in stream restoration, "should anticipate expending up to 10-20% of the original construction costs on maintenance" during the first two years. For the purposes of this report, the cost of maintenance will be taken to be 15% of the cost of the restoration work spread out evenly over the first two years after completion of the restoration project. Additionally, the City of Charlottesville plans to conduct long-term monitoring of the site for 10 years after the project's completion. In North Carolina, where such monitoring practices are well established, the costs of monitoring restored streams are estimated to be $7,500 to $10,000 per year. For this report, the cost of monitoring will be taken as $5,000 per year, as monitoring practices for restored streams in Virginia are currently not as well established as they are in North Carolina, though they are becoming more and more common. A summary of costs for site maintenance and monitoring are given in Table (4).

Table 4: Long-Term Costs

Activity	Cost	Duration
Site Maintenance	$189,182/year	2 years
Site Monitoring	$5,000/year	10 years

The final cost to be accounted for is the loss of potential earnings from the development of the project area for either commercial or residential use. This report will take the loss of income from potential development to be zero, for the following reasons. To the north of the project site, commercial and residential developments have been pushed to within less than

200 feet of Meadow Creek in some areas - there is not enough land area suitable for building on the north side of Meadow Creek for any further development to take place. While there is a considerable distance between Meadow Creek and the residential development to the south, the houses currently in place effectively block the project site from any roads from which further spurs of development could be started. Therefore, development of the project site for anything other than parkland is impractical, and the income forgone from its development as such is taken to be zero.

It could also be important to attempt to take into account the cost of the restoration project to those living near the site in terms of noise pollution and travel inconveniences for the periods during which construction is being completed. However, no studies of projects similar enough in nature to the Meadow Creek restoration could be found to perform a cost-transfer with. Therefore, these costs will not be factored into the results of this study, though they should be included in additional analyses of this project.

Benefits:

Three sources of potential benefits from the Meadow Creek Restoration project will be investigated in this report, including income from construction, increased revenue to the City from property taxes, and the intangible benefits to the City's residents of living and working near parkland.

Income from the construction of the project is the easiest benefit to estimate. Labor income has been steady at 75% of construction costs for many years, so the income from the construction of the project will be take to be 75% of the costs of clearing the site, the actual construction of the project, and the maintenance to the site in the years following project completion. However, this is itself is not a complete accurate picture of the economic benefit to the community of the project, as the income received by those participating in the project will be spent in other areas of the economy. To take into account this multiplier effect, the income to labor in each category will be multiplied by four, which is commonly accepted as a very modest approximation of the value of the multiplier effect. The total benefits from income from construction are given in Table (5)

Table 5: Benefits from Construction Income

Activity	Cost	75% of cost as Income	Accounting for multiplier effect
Clearing Trees	$120,000	$90,000	$360,000
Restoration Work	$2,522,430	$1,891,822	$7,567,290
Site Maintenance	$168,750/year	$126,563/year	$506,250/year

The creation of parkland near a residential area would be expected to raise the property values in that area, creating increased revenues for the City from property taxes. The property tax in the City of Charlottesville is $0.95 for every $100 of property value. Using the City's online property assessment tool, the average property value for the homes surrounding the project site was found to be approximately $75,000. It is very difficult to estimate the increase in property value that will result from the creation of nearby parkland - the available literature shows increases as varied as 3% - 20%. Given the relatively low value of the land in its current state, and that the presence nearby of similar streams and did not appear to impact the City's valuation of similar properties, it was decided to take the increase in property values from the completion of the Meadow Creek Restoration to be five percent. As approximately 60 homes border the construction site, the total increase in tax revenue is estimated to be $2,000 per year. The steps taken to arrive at this amount are given in Table (6).

Table 6: Estimation of Property Tax Increase

Property Tax	Average Property Value	5% Increase in Property Value	Number of Homes Impacted	Total Revenue Increase
$0.95/$100	$75,000	$3,750	60	Approx. $2000

The value to city residents of the parkland and restored stream system is particularly difficult to ascertain, as it requires performing a benefits transfer with a similar project in a similar city, that has had extensive contingent valuation (CV) surveys performed to determine the value to that city's residents of stream restoration. The most suitable related project that

could be found was the restoration of the River Skrene in Darlington, UK, as large town in the north of England. Despite its rather grand-sounding name, the River Skrene is of a comparable size to Meadow Creek, especially that part of it which flows through Darlington and which was the subject of the restoration project. A CV survey performed prior to the 1995 restoration of a two kilometer stretch of the River Skerne found that residents living in the vicinity of the proposed restoration site responded that they were willing to pay an average of £13.27 for stream restoration. Taking into account historical exchange rates and inflation, £13.27 in 1995 is the equivalent of $30.51 in 2011. The steps needed to arrive at this value are shown in Table (7). It was estimated that this willingness to pay would apply to the 100 households nearest to the proposed stream restoration, who were most likely to use the new parkland for recreation and whose property is in contact with the restoration site.

Table 7: Value of Parkland and Stream Restoration to City Residents

Willingness to Pay Darlington, UK 1995	1995 Exchange Rate	Inflation, 1995-2011	Willingness to Pay Charlottesville, US, 2011	Value to 100 Households
£13.27	$1.56/£1.00	47.41%	$30.51	$3,000

The benefit of increased biodiversity and improved ecosystem services from the restored Meadow Creek should also be considered in a cost-benefit analysis of the restoration project. No studies of a comparable project could be found to conduct a benefits-transfer, however, as the site under consideration is not very large, and is already heavily wooded and undeveloped, it seems unlikely that there will be any large improvements made to the terrestrial ecosystems through the Meadow Creek Restoration. Additionally, as flooding is not currently a great concern, the most readily available measure of improved ecosystem services does not apply to this case. Therefore, increased biodiversity and ecosystem services will not be quantified as benefits in this report, though further studies should be done to included these values.

Recommendations:

The final recommendation as to whether or not the Meadow Creek restoration should go forward will be determined through a comparison of the present values of costs and benefits for a period of time beginning with completion of the project in the winter of 2011/2012 and lasting ten years in duration (the period for which the city plans to conduct monitoring of the site). The present value of a cost or benefit to the project at some time in the future is given by Equation (1) below,

$$PV = \frac{FV}{(1+r)^t} \qquad (1)$$

where PV is the present value of the cost or benefit, FV is the future value of the cost or benefit, r is the rate of social discounting, and t is the number of time periods (years) in the future the cost or benefit takes place. The rate of social discounting used in this report is 0.03. The costs and benefits to the Meadow Creek restoration described in the preceding sections are given in tabulated form, along with their present values in Table (9). As can be seen in Table (9), the difference between the estimated benefits and costs to the proposed Meadow Creek restoration is over $5million. Note that even if the rate of social discounting or the number of years accounted for were adjusted, the net result would not change very much at all, due to the anomaly that after year three, costs and benefits per year, as currently estimated, are the same. Therefore, this paper recommends that the Meadow Creek restoration project be allowed to go forward, as the economic benefit to the City of Charlottesville over the ten-year duration of the project greatly outweighs the costs incurred.

Table 9: Comparison Present Values of Total Costs and Benefits

Year	Costs	Total Cost, Present Value	Benefits	Total Benefit, Present Value
0	Land: $46,667 Clear trees: $120,000 Construction: $2,522,430	$2,689,097	Income, trees: $360,000 Income, construction: $7,567,290	$7,927,290
1	Maintenance:	$168,689	Income,	$511,250

	$168,750 Monitoring: $5,000		maintenance: $506,250 Value of Park: $5,000	
2	Maintenance: $168,750 Monitoring: $5,000	$163,776	Income, maintenance: $506,250 Value of Park: $5,000	$496,359
3	Monitoring: $5,000	$4,576	Value of Park: $5,000	$4,576
4	Monitoring: $5,000	$4,442	Value of Park: $5,000	$4,442
5	Monitoring: $5,000	$4,313	Value of Park: $5,000	$4,313
6	Monitoring: $5,000	$4,187	Value of Park: $5,000	$4,187
7	Monitoring: $5,000	$4,065	Value of Park: $5,000	$4,065
8	Monitoring: $5,000	$3,947	Value of Park: $5,000	$3,947
9	Monitoring: $5,000	$3,832	Value of Park: $5,000	$3,832
10	Monitoring: $5,000	$3,720		$3,720
Total Present Values	------	$3,054,644	-------	$8,967,981

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