CITY OF Springfield

HDR

Integrated Planning Opportunities Alternatives Analysis – Detention Basin Retrofits

Springfield, Missouri

November 2019

Introduction

The City of Springfield (City), Greene County, and City Utilities of Springfield have developed an approach for integrated planning to best protect local environmental resources in an evolving regulatory landscape. The Integrated Plan (IP), titled "A Citizen Focused Approach," provides a holistic plan designed to prioritize investments based on the most effective solutions to address the most pressing problems that matter most to the community. Implementation of the IP includes a four-phased approach, which is designed to be iterative: 1) Assessment (What is the current status of the environment?), 2) Vision (Where do we want to be?), 3) Tactical (How will we get there?), and 4) Adaptive Management (What adjustments need to be made?).

Identifying and prioritizing the most effective solutions using the Sustainable Return on Investment (SROI) approach is a critical component of the tactical phase. The SROI process is an economic analysis method for analyzing triple bottom-line (i.e., economic, social and environmental) outcomes of investments and policies. This approach provides a comparison between the general cost of a solution to the benefits achieved so that a more informed investment decision can be made.

The SROI process was used here for estimating the sustainability value of detention basin retrofits, including social and environmental benefits and financial costs. The methodology entailed projecting the value of impacts over a 25-year planning horizon and applying a discount rate to bring future values into today's dollars. A description of this opportunity and details of the SROI analysis are provided below.

Opportunity Description

One of the most cost effective strategies for removing pollution from stormwater is the extended detention method. Extended detention basins have outlets designed to detain stormwater runoff for an extended time period (e.g., 24 hours). This effectively slows stormwater runoff velocity allowing time for solids to settle out of suspension, reducing discharge of sediment and correlated pollutants (e.g., nutrients and pathogens) to local waters. Additional pollutant removal may be achieved by adding landscaping features such as trees, shrubs and perennials. Not only can such vegetation improve infiltration and filtration (plant removal) of stormwater, but it also provides habitat for desirable wildlife species and provides ecological benefits.

Most of the existing stormwater detention basins in Springfield were designed with the single purpose of providing flood control. As such, these basins have a reduced ability to infiltrate and treat stormwater runoff. However, Springfield's Design Standards have evolved and currently target a smaller design storm than those used for design of older detention basins. Therefore, there is an opportunity to take advantage of excess volume to capture and treat the first flush of stormwater runoff.

For this SROI analysis, two alternatives are evaluated for a total of 178 basins identified as suitable for retrofits. The first option considers downsizing the outlet structure to achieve additional water quality treatment (extended detention). The second option considers downsizing the outlet structure, improving the infiltration rate of the basin, and adding a vegetative component (enhanced extended detention). The latter provides a landscaping benefit with the inclusion of trees, shrubs and perennials.

Stormwater Detention Basin Retrofits

Environmental and Social Benefits

The primary benefit of both types of basin retrofits is improved water quality. Water quality improvements were determined using a water quality index (WQI) approach. The WQI is a composite scoring system that evaluates the conditions of a waterbody on a scale of 0 to 10 based on different community priorities and indicators. The economic value of a change in water quality is determined by the number of people that benefit and an individual's "willingness-to-pay" for that change. A one point change to the WQI is worth about $40 for a direct user and $14 for in indirect user.

Changes to the WQI were evaluated based on effective pollutant removal rates associated with each of the extended detention retrofit opportunities (**Table 1**). Reductions to nutrients, suspended solids, toxics (represented by polycyclic aromatic hydrocarbons), bacteria as measured by *E. coli*, and trash will have a positive impact on a number of community priorities including aquatic life, waterbody aesthetics, primary and secondary contact recreation, and clean drinking water. As measured by the WQI, the normal and enhanced basin retrofits will improve water quality conditions for area waterbodies by 0.109 and 0.120 points out of ten (**Figure 1**).

In addition to water quality benefits, planting trees and adding landscaping features for the enhanced basis retrofits alternative will produce other social and environmental benefits. Economic literature has found that property owners place a premium on property located in close proximity to green space amenities. Properties located within 500 feet of detention basins with enhanced retrofits were estimated to have a one-time 2.5% gain in property value based on economic literature.

Table 1. Estimated Pollutant Reductions due to Extended Detention Retrofits in Area Waterbodies

Opportunity	Total Suspended Solids	Total Nitrogen	Total Phosphorus	*E. coli*	PAHs	Trash
Extended Detention	1.1%	0.5%	0.5%	0.9%	0.7%	6.9%
Enhanced Extended Detention	1.8%	1.4%	0.5%	1.7%	2.3%	6.9%

Note: Effective pollutant removal rates based on 178 detention cells treating about 2.7% of the urban area.

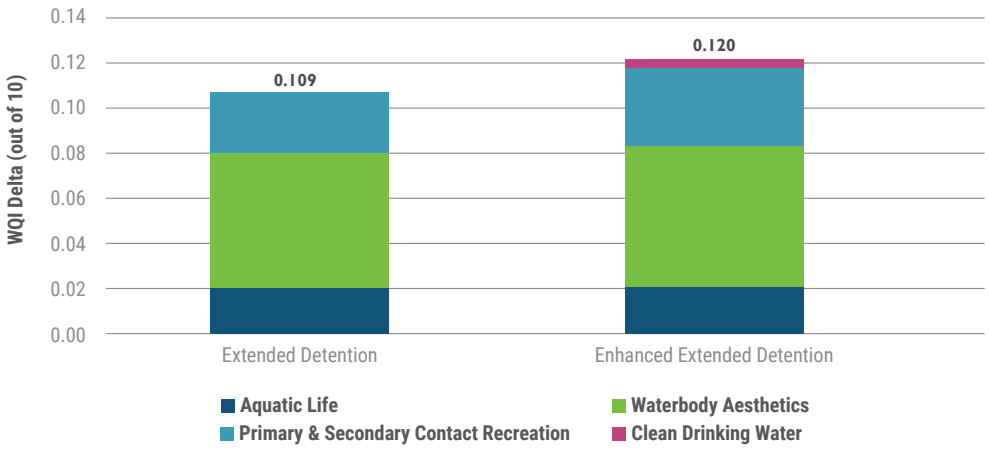

Figure 1. Changes to the Water Quality Index from Extended Detention Retrofits

Cost Considerations

The Center for Watershed Protection (2007)[1] developed base construction costs for new and retrofit stormwater practices. The retrofit costs are based on the water quality storage volume. For the extended detention option, the cost curve was modified to account for local construction costs and resulted in the following cost formula:

$$\text{Extended Detention Construction Cost} = 9.2 \times (WQv)^{0.78}$$

The extended detention construction costs include modification of the existing outlet structure, minor grading, and sodding. The costs do not include easements or other associated land rights. Since many of the basins have a small Water Quality Volume (WQv), the construction costs yielded unreasonably low estimates and hence a minimum construction cost of $2,500 was applied.

Operation and maintenance costs include mowing, weed control and trash removal, and are estimated at 10 percent of the retrofit cost. Major renovation will periodically be required to remove accumulated sediment, regrade the basin and seed the disturbed area. It is assumed the frequency of the major renovation would be 10 years and the water quality volume would be half full. The sediment removal is estimated as $20 per cubic yard and finish grading and seeding would be $2,500 per acre.

For the enhanced extended detention option, the bioretention cost curve is modified to account for local construction costs and resulted in the following cost formula:

$$\text{Enhanced Extended Detention Construction Cost} = 6.4 \times (WQv)^{0.99}$$

The enhanced extended detention construction costs include modification of the existing outlet structure, excavation of the existing basin floor, placing a filter bed, finish grading, landscaping, watering, and enhanced weed control for the first three years. The costs do not include easements or other associated land rights. Since many of the basins have a small WQv, the construction costs yielded unreasonably low estimates and hence a minimum construction cost of $20,000 was applied.

Operation and maintenance costs include mowing, trash removal, weed control and maintenance of the landscaped area which is estimated at $3,375 per acre. Major renovation will periodically be required to remove accumulated sediment, replace the upper foot of the filter bed, and re-landscape the disturbed area. It is assumed the frequency of the major renovation would be 10 years and the water quality volume would be half full. The sediment removal and filter bed replacement is estimated as $40 per cubic yard and finish grading and landscaping would be $5,000 per acre.

Table 2 presents the capital, annual operation and maintenance (O&M), and major renovation (MR) costs for extended detention and bioretention retrofits.

Table 2. Average Costs per Basin for Detention Basin Retrofits

Retrofit	Extended Detention	Enhanced Extended Detention
Construction Costs	$12,100	$88,800
Annual O&M	$1,200	$3,500
Major Renovation	$6,100	$12,100

*Once every 10 years

1 Center for Watershed Protection, Manual 3, Urban Stormwater Retrofit Practices, Urban Subwatershed Restoration Manual Series. August 2007.

SROI Results

Table 3 presents the final results of costs and benefits of detention basin retrofits. From a cost perspective, normal detention basin retrofits would require capital costs of around $1.9 million, net of residual value, whereas the capital costs net of residual value of enhanced retrofits plus amenities amounts to $14.1 million in present value terms. A variety of additional maintenance costs amount to $6.0 million for normal basin retrofits and a much higher cost of $15.2 million for enhanced basins. However, costs for the enhanced basins are offset by $11.3 million in present value terms due to property value gains.

The environmental impacts of normal and enhanced basin retrofits are primarily driven by water quality improvements. The estimated water quality benefits are $8.2 and $9.1 million, respectively. The enhanced basin designs are also estimated to generate an additional $0.2 million in benefits from tree planting.

Overall, the benefits of extended detention basin retrofits appear to just offset the costs with net positive benefits of $0.1 million and a benefit-cost ratio of 1.0. At the same time, the significantly more expensive enhanced retrofit designs create additional water quality and property value benefits, but these benefits do not appear to be high enough to justify the added cost. The total value of the enhanced basins is a negative $9.1 million and the benefit cost ratio is 0.69, suggesting that the enhanced designs are not cost effective.

Table 3. Summary of Present Value Costs and Benefits of Detention Basin Retrofits ($2018, Millions)

Types of Benefits and Costs	Detention Basin Retrofits – Extended Detention	Detention Basin Retrofits – Enhanced Extended Detention
Environmental		
Water Quality Impacts	$8.2	$9.1
Tree planting (all enviro., social benefits)	$0	$0.2
Social		
Property Value Gains	$0	$11.3
$ Costs		
Capital Expenditures	($2.1)	($15.3)
Residual Value of Capital Costs	$0.2	$1.2
Operations & Maintenance Impacts	($6.0)	($15.2)
Sinkhole Repair Expenditure Impacts	($0.1)	($0.2)
Public and Stakeholder Relations Impacts	($0.2)	($0.2)
Totals		
Financial Lifecycle Cost	($8.2)	($29.7)
Total Social, Environmental Benefits	$8.2	$20.6
Total Value - All Costs and Benefits	$0	($9.1)
Benefit-Cost Ratio	1.0	0.69

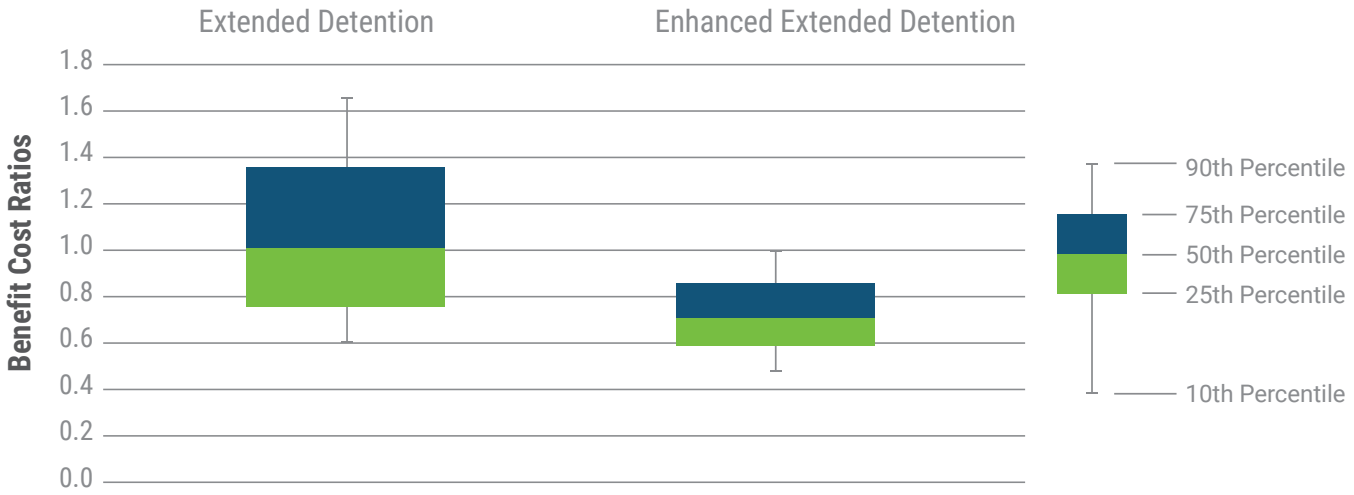

Figure 2. Range of Potential Benefit Cost Ratios for Detention Basin Retrofits

Figure 2 provides the best estimate of value created relative to cost by accounting for several uncertainties that can raise and lower the perspective on total value. The results indicated that while the expected value for normal basin retrofits approximately breaks even with costs, there is a large upside and downside range for this investment. The benefits per cost value of this investment could be less than 0.6 (with a 10 percent chance of this occurring). But, on the upside, it could generate as much as 65 cents more for every dollar spent above the breakeven point of the investment. The upside potential for the enhanced basin retrofits is at about the breakeven point of 1.0.

Summary

Of the approximately 1,500 existing detention basins throughout the City, it was assumed that 178 could be readily retrofitted with a new outlet structure, allowing for the capture and treatment of millions of gallons of "first flush" stormwater runoff. The capital costs of these retrofits would be approximately $1.9 million with a total life cycle cost of approximately $8.2 million once operation and maintenance is included. However, the total water quality benefits of retrofitting these basins would be approximately $8.2 million over the same period of time. It should be noted that these benefits and costs represent an aggregate value for all 178 basins. Presumably, some basins will be more cost effective than others. Retrofitting a select group of these basins will likely result in a much higher benefit for the corresponding cost.