CITY OF Springfield

HDR

Integrated Planning Opportunities Alternatives Analysis – Enhanced Nutrient Removal at the Southwest Wastewater Treatment Plant

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 further enhanced nutrient removal at the City's Southwest Wastewater Treatment Plant (SWTP), 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

The SWTP was designed and is operated to effectively treat municipal wastewater. Effluent from the SWTP is discharged into Wilson's Creek, which flows to the James River and then ultimately into Table Rock Lake. Elevated levels of plant nutrients (nitrogen and phosphorus) can detrimentally impact surface water quality by leading to excessive algal growth, commonly referred to as cultural eutrophication. The SWTP already has both biological and chemical phosphorus removal and biological nitrogen removal treatment processes. However, the City of Springfield and stakeholder members requested HDR evaluate the relative costs and benefits of upgrading the SWTP to additional nutrient removal.

Environmental and Social Benefits

The primary benefit of enhanced nutrient removal 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 an indirect user.

Enhanced nutrient removal at Southwest Wastewater Treatment Plant (SWTP)

Changes to the WQI were based on improved effluent quality at the SWTP that include reducing total phosphorus levels from 0.5 to 0.1 mg/L and total nitrogen from 20 to 3 mg/L. However, no process modeling was conducted to project these assumed effluent nutrient levels. Therefore, in-depth process evaluation is needed for implementation of additional enhanced nutrient treatment investments at the SWTP.

Because the SWTP is the dominant point source in the James River watershed, enhanced nutrient removal will significantly reduce instream nutrient loadings to its receiving waters, which include Wilson's Creek, James River and Table Rock Lake (**Table 1**). It is anticipated that such reductions will have a positive impact on reducing algal levels, which will provide benefits with respect to aquatic life, waterbody aesthetics, recreation, and clean drinking water. In terms of the WQI, it was estimated that enhanced nutrient removal will increase it by 0.953 points in Wilson's Creek, 0.280 points in the James River, and 0.011 points in Table Rock Lake (**Figure 1**).

Table 1. Estimated Reductions in Nutrient Loading Based on Upgrades to Enhanced Nutrient Removal

Location	Percent Reduction	
	TP	TN
Wilson's Creek	73%	83%
James River	31%	46%
Table Rock Lake	14%	15%

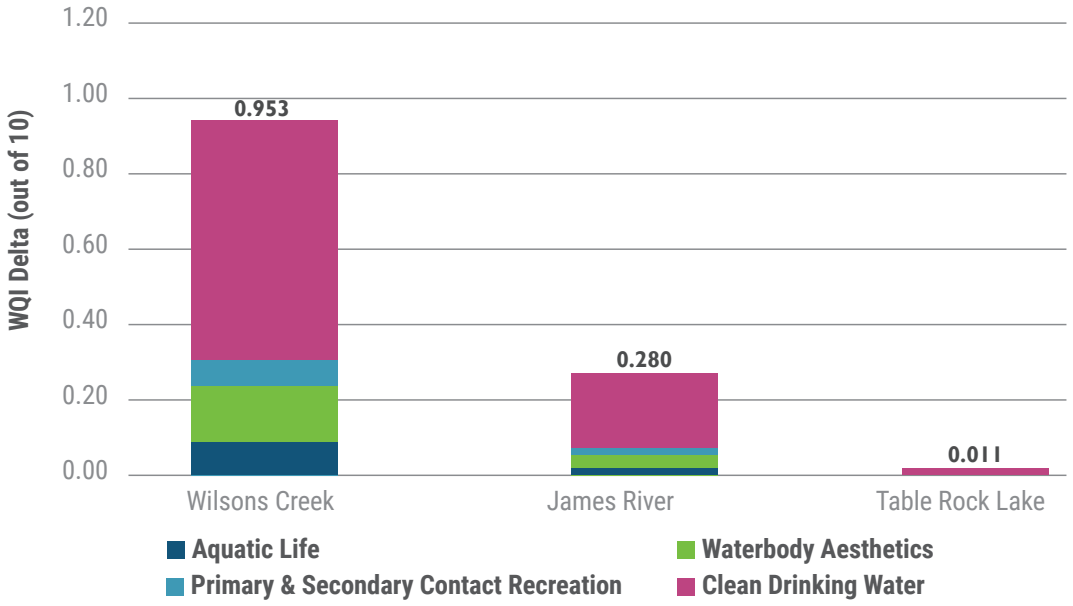

Figure 1. Change to the Water Quality Index from Enhanced Nutrient Removal

Cost Considerations

For the SROI analysis, capital costs for further enhanced nutrient removal were based on installation of additional anaerobic and anoxic reactors for biological phosphorus removal and denitrification. These process improvements were recommended during previous planning efforts to implement further nutrient removal at the SWTP and would need to be studied in more detail prior to implementation. Supplemental chemical addition of alum and methanol (carbon source) was also included in the evaluation. Capital costs for enhanced nutrient removal came from feasibility level engineering estimates performed during development of the City's Overflow Control Plan. The total capital cost is projected to be $29.9 Million.

Chemical costs were estimated for the incremental increase in alum required for phosphorus removal and the methanol needed for enhanced nitrogen removal. It should be noted that the SWTP currently has denitrification filters in one treatment train, but their operation has not been optimized. The City also currently has a source of free methanol. For the purpose of this evaluation, it was assumed that methanol would no longer be free. Alum and methanol dosing was based on preliminary process calculations and costs were based on current market values.

Biosolids management costs were based upon an increase in biosolids production of 20%, which was estimated from literature values for chemical phosphorus removal. In addition to other operation and maintenance costs, additional truck hauling would be required for biosolids handling and chemical hauling. Truck hauling is measured in terms of vehicles miles travelled (VMT). An increase in VMT has an environmental impact beyond the monetary costs incurred by the City which are captured in the operation and maintenance costs discussed above. The increase in VMT for biosolids management was based upon increasing the current VMT by 20%. Actual VMT were not available and were estimated based upon fuel usage. VMT for chemical costs were based upon the increased number of loads required for the increased dosages multiplied by the travel distance from the supplier. The size of a delivery and the location of the supplier were provided by the City.

Additional cost savings arise from reduced administrative and legal costs associated with lower Total Maximum Daily Load (TMDL) impairment impacts. This category relates to internal costs related to TMDL regulatory impacts, specifically attributed to administrative time and/or legal costs.

A summary of capital and annual costs is presented below in **Table 2**.

Table 2. Summary of Capital and Annual Costs ($2018, Millions)

Category	Capital Costs
Initial Capital Costs – Year 2018 ($M)	($29.9)
20-year Capital Replacement Cost – Year 2038 ($M)	($14.9)
Residual Value of Initial Capital Cost – Year 2043 ($M)	$29.4
Category	**Capital Costs**
Annual operating costs ($M / year)	($3.1)
Annual Trucking Costs for Biosolids and Chemical Hauling ($M / year)	($0.04)
Reduced Annual Impairment Costs ($M / year)	$0.01

SROI Results

Table 3 presents final results of costs and benefits of the treatment plant upgrades. The present value capital costs amount to about $23.2 million, including long-term residual value at the end of the analytical period. The total present value of O&M costs are more than twice that amount, at over $51 million in present value terms. In addition, costs for covering truck hauling service add nearly $0.8 million in present value terms over 25 years. A small amount of cost savings may be realized for reduced TMDL impairment responses, but these are relatively insignificant.

The social and environmental impacts of nutrient removal, and specifically for water quality improvements, could be substantial. The estimated value of water quality improvements is $26.4 million in present value terms. This value nearly offsets the capital and O&M costs to achieve the improvements. At the same time, the additional treatment leads to energy emissions and trucking impacts along the route to biosolids disposal sites, which lower the net benefits of the project by a combined amount of about $2.2 million in present value terms. The combined positive and negative benefits total $24.2 million in present value terms.

Table 3. Summary of Present Value Costs of Upgrading to Enhanced Nutrient Removal at the SWTP ($2018, Millions)

Types of Benefits and Costs	Detention Basin Retrofits – Extended Detention Plus Amenities
Environmental	
Water Quality Improvements	$26.4
GHG emissions (Reduced Benefits)	($1.3)
Social	
Air pollution impacts on health (Reduced Benefits)	($0.4)
Trucking Externalities (Reduced Benefits)	($0.5)
$ Costs	
Capital Expenditures (including residual value in year 2040)	($23.2)
O&M Costs	($51.7)
Truck hauling direct costs	($0.8)
TMDL Impairment (Reduced Costs)	$0.2
Totals	
Financial Lifecycle Cost	($75.5)
Total Social, Environmental Benefits	$24.2
Total Value - All Costs and Benefits	($51.3)
Benefit-Cost Ratio	0.32

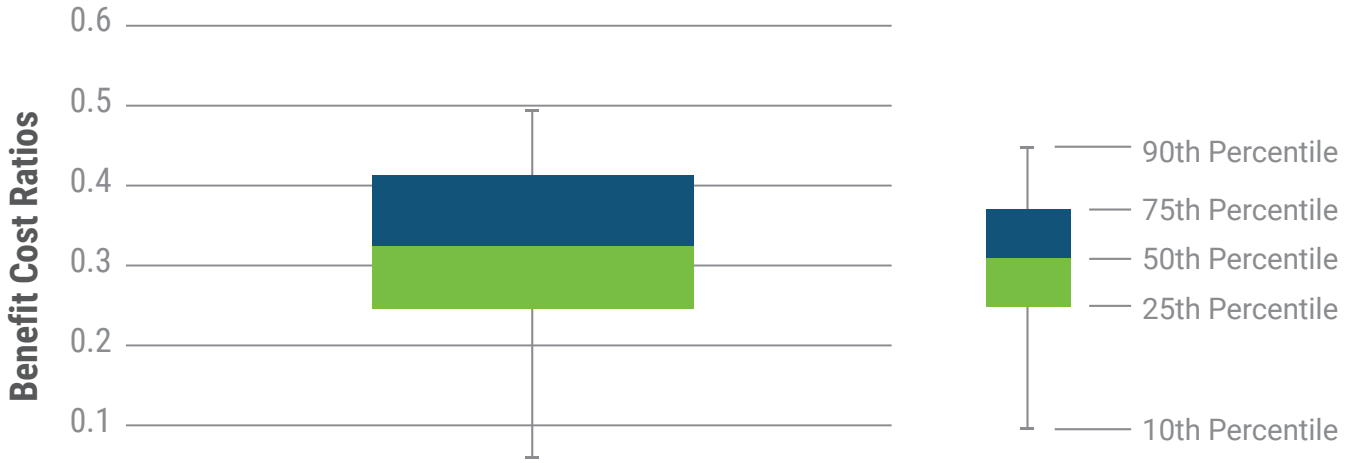

Figure 2. Range of Potential Benefit Cost Ratios for Enhanced Nutrient Removal at the SWTP

Overall, the total net value of treatment plant improvements would cost about $51.4 million more in lifecycle costs than it generates in benefits. The benefit-cost ratio of 0.32 is well below the breakeven point of 1.0. Figure 2 provides the best estimate of value created relative to cost by accounting for several uncertainties that can raise or lower the perspective on total value. The results indicate that while the expected net value for the improvements is around 0.32, potential benefits per cost value likely range between approximately 0.2 and 0.5 with a 10% chance of it being above or below that range.

Summary

The SROI pilot analysis suggests that the benefits of implementing additional enhanced nutrient removal at the SWTP are likely well below costs. However, these analyses are based upon relatively conservative cost assumptions, which could be significantly less than current assumptions. In addition, treatment strategies could be used to optimize the benefits compared to costs. For example, more cost-effective nitrogen removal without the additional cost of supplemental carbon could be implemented to help balance costs and benefits.