Columbia Wastewater and Stormwater IMP

Attachment N

This Page Intentionally Left Blank

Our Columbia Waters
Integrated Management Plan
Wastewater & Stormwater

Technical Memorandum 9 *Alternatives Decision Analysis Process*

Columbia Wastewater and Stormwater Integrated Management Plan

Columbia, Missouri
January 5, 2018

HDR
Geosyntec consultants
Shockey Consulting Services, llc
RV
TREKK DESIGN GROUP, LLC

This Page Intentionally Left Blank

Table of Contents

List of Figures

List of Tables

List of Attachments

Section 1. Introduction and Objectives

The City of Columbia, Missouri (City) is working to develop an Integrated Management Plan (IMP) for the City's Sewer and Storm Water Utilities. The goal of the IMP is to develop an adaptable and affordable long-term plan that addresses the City's wastewater and stormwater management needs and meets Clean Water Act requirements. The IMP will be developed based on guidance presented in US Environmental Protection Agency's (EPA) *Integrated Municipal Stormwater and Wastewater Planning Approach Framework*[1].

Early in the IMP process, the City and their project team worked to evaluate the City's environmental resources and infrastructure assets to better define the existing condition, performance, and needs of its systems. These needs assessments were useful in guiding initial prioritization of potential wastewater and stormwater improvements. Priorities were further refined during a series of community outreach meetings. Information developed from these activities formed the basis for identifying potential capital and programmatic alternatives that should be evaluated as part of the IMP. Outcomes from these efforts have been documented in the following technical memoranda:

- Technical Memorandum 5 – Wastewater Collection System Alternatives
- Technical Memorandum 6 – Wastewater Treatment System Alternatives
- Technical Memorandum 7 – Stormwater System Alternatives
- Technical Memorandum 8 – Community Outreach Results

The purpose of this memorandum is to document the approach and methods that HDR Engineering, Inc. (HDR) led consulting team and the City (hereinafter, the "project team") used to select the wastewater and stormwater programmatic and project alternatives that should be implemented to achieve objectives of the IMP. As discussed herein, the project team used a multiple criteria decision analysis (MCDA) tool to quantify anticipated benefits associated with implementing the various stormwater and wastewater alternatives identified and described in the Technical Memoranda listed above. These benefit scores were then evaluated with respect to projected costs to identify an optimized suite of stormwater and wastewater projects that provides the greatest benefit to the community per dollar invested. Pending an evaluation of community affordability (see Technical Memorandum 10), the resulting suite of optimized projects will reflect the wastewater and stormwater alternatives that the City will potentially implement under the IMP going forward. More details regarding the MCDA analysis are presented in the sections that follow.

[1] Stoner, N. and C. Giles. 2012. Integrated Municipal Stormwater and Wastewater Planning Approach Framework. June 5, 2012. Washington D.C.

Section 2. Alternatives Identification Review

The project team developed a series of alternatives and associated implementation costs to address wastewater treatment, wastewater collection, and stormwater management needs identified during early phases of IMP development. Results of these activities are summarized below. For a more detailed description of the alternatives identification process, please refer to Technical Memoranda 5, 6, and 7.

The goal of the alternatives identification process was to develop planning level estimates to characterize the expected additional level of investment required to address system needs, anticipated regulatory drivers, and City goals over the next 20 years (the IMP planning period). To facilitate this evaluation, wastewater and stormwater alternatives were grouped and analyzed by project category (Table 1).

Table 1. Project Categories Evaluated as Part of the IMP Alternatives Identification Process.

Wastewater Treatment	Wastewater Collection	Stormwater Management
• Wet Weather Improvements • Expanded Nitrification • Biological Nutrient Removal • Chemical Disinfection • Constructed Wetlands Improvements • Biosolids Rehabilitation • Biosolids Capacity Improvements	• Wet Weather Program Planning • Asset Management • System Renewal • System Capacity • Reducing Building Backups • Private Common Collector Elimination • System Expansion • Cleaning Program • Pump Station Repair • Annual Sewer Improvements	• Stormwater Planning • System Assessment and Cleaning • System Renewal • Flood Control • Stream Erosion • Runoff Treatment to Improve Water Quality • Stormwater Management Program

Cost estimates were developed for each project category to quantify the investments and resources needed ***in addition to*** those already managed by the Sewer and Stormwater Utilities. The cost estimates include potential additional capital costs, operation and maintenance costs, and costs associated with necessary planning or data collection activities needed over the 20-year IMP planning period. The three potential funding scenarios used to guide the analyses are broadly defined as follows:

- **Level 1 Funding (Level 1) –** Funding needed to **provide the minimum** level of service (LOS) that meets both community-wide expectations and **existing** regulatory requirements over the 20-year IMP planning period.
- **Level 2 Funding (Level 2) –** Funding needed to **exceed the minimum** LOS that meets community-wide expectations and **more proactively** meets existing regulatory requirements over the 20-year IMP planning period.
- **Level 3 Funding (Level 3) –** Funding needed to **address all** forecasted infrastructure needs, and proactively meet **both** existing and forecasted regulatory requirements over the 20-year IMP planning period.

The City's existing (as of 2017) annual Sewer and Stormwater budgets are approximately $24.4 million and $2.4 million, respectively, with stormwater set to increase through 2020. If the City were to maintain the existing programs and associated levels of funding over the 20-year IMP planning period, the City's total investment would be approximately $558 million (in 2017 dollars). The funding scenarios evaluated as part of the alternatives identification process indicate that significant additional investments will be needed to address system needs, regulatory drivers, and the City's goals over that same timeframe. Potential additional investment levels (in 2017 dollars) range from $315 million to $509 million for wastewater treatment and collection, and from $91 million to $289 million for stormwater management. When added to the City's existing programs, the potential total costs (in 2017 dollars) to address wastewater and stormwater needs over then next 20 years are between $966 million and $1.37 billion (Figure 1).

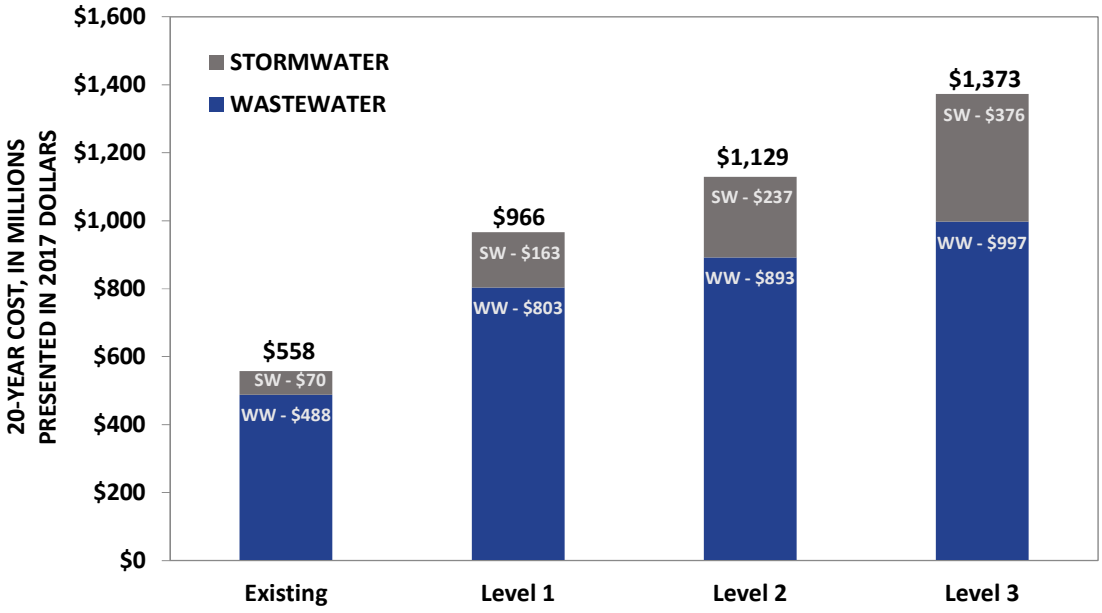

Figure 1. Summary of Potential Total 20-Year Wastewater and Stormwater Program Costs Identified during the IMP Alternatives Identification Process. Existing program costs were calculated assuming existing sewer and stormwater programs and associated budgets are maintained over the 20-year IMP planning period.

Section 3. MCDA Application

MCDA is a structured, quantitative technique used to solve planning problems that involve multiple decision criteria or objectives. When applied correctly, MCDA facilitates the critical thinking process in an open and transparent manner. Simplistically, an MCDA is conducted by scoring potential alternatives relative to a set of weighted criteria using a standardized rating system. After all alternatives are scored, the alternative with the highest total score should be the one that best addresses the underlying planning goals. By coupling MCDA scores with costs, the suite of alternatives that represents the best value can be identified.

A critical aspect of developing an MCDA tool is creating a decision framework that explicitly links the alternatives to the evaluation criteria, which represent the interests or priorities of the community (Figure 2). Sub-objectives are critical to the decision framework because they provide an objective means of linking alternatives to the community objectives. Once established, the framework enables decision makers to understand how the overall goal is linked to the individual alternatives and helps facilitate the scoring process.

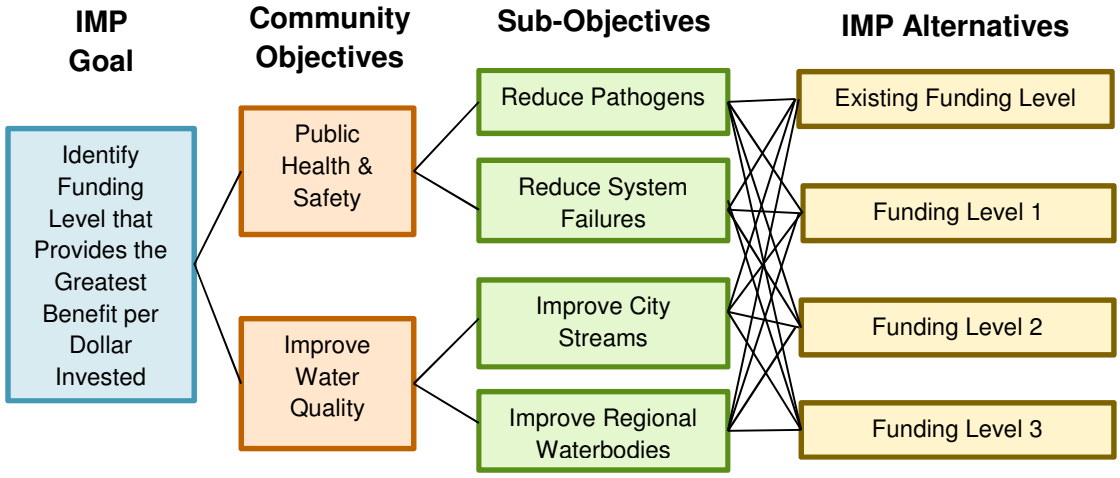

Figure 2. Conceptual Diagram of an MCDA Decision Framework. This diagram is for conceptual purposes only and does not reflect the final MCDA framework developed for the IMP.

The project team developed an MCDA tool to compare the existing and potential future levels of investment (Figure 1) and identify the level which appropriately balances overall costs with anticipated community benefits. The tool incorporates four basic components:

1. **Goal** - The goal of the MCDA evaluation was to select the funding level that provides the greatest benefit to the community.
2. **Alternatives** - The alternatives were defined by the project categories and funding levels described in Section 2.
3. **Weighted Evaluation Criteria** – Evaluation criteria represent the important issues or objectives that the alternatives are intended to address. In this MCDA, the evaluation criteria reflect important community objectives that were identified during outreach

activities conducted as part of the IMP process. The process used to identify and weight those commmunity objectives is explained in further detail in Section 3.1 below.

4. **Benefit Scores** – Benefit scores were developed to quantify how well each of the four funding level alternatives addressed the community objectives. A two-step process was used to develop the funding level benefit scores. This process is explained in further detail in Section 3.2 below. Once the funding level benefit scores were calculated, the alternatives were optimized by selecting a combination of project categories from among the four funding levels that resulted in the highest overall benefit score. This analysis is explained in further detail in Section 3.3 below.

The final MCDA tool and resulting benefit scores developed for the IMP are included as Attachment A. More detailed information regarding the evaluation criteria, scoring process, and optimization analysis used to evaluate the IMP alternatives are described below.

3.1 Weighted Evaluation Criteria

A key element of EPA's Integrated Planning Framework is conducting community outreach to maintain open communication with community stakeholders and ensure that all potential needs and priorities are considered in the planning process. The City's community outreach program (see Technical Memorandum 8) was structured such that input and results from outreach activities could be used to directly identify objectives that would be targeted by the MCDA.

Community priorities were structured based upon a triple bottom line (social, economic, and environmental) approach through the stakeholder engagement process to identify five community objectives for the IMP (Figure 3). The objectives were then weighted on a 0 to 1 scale (with a sum of 1) based on all outreach activities as well as input provided by Columbia City Council members during individual meetings. These five objectives represent the primary decision criteria used in the MCDA.

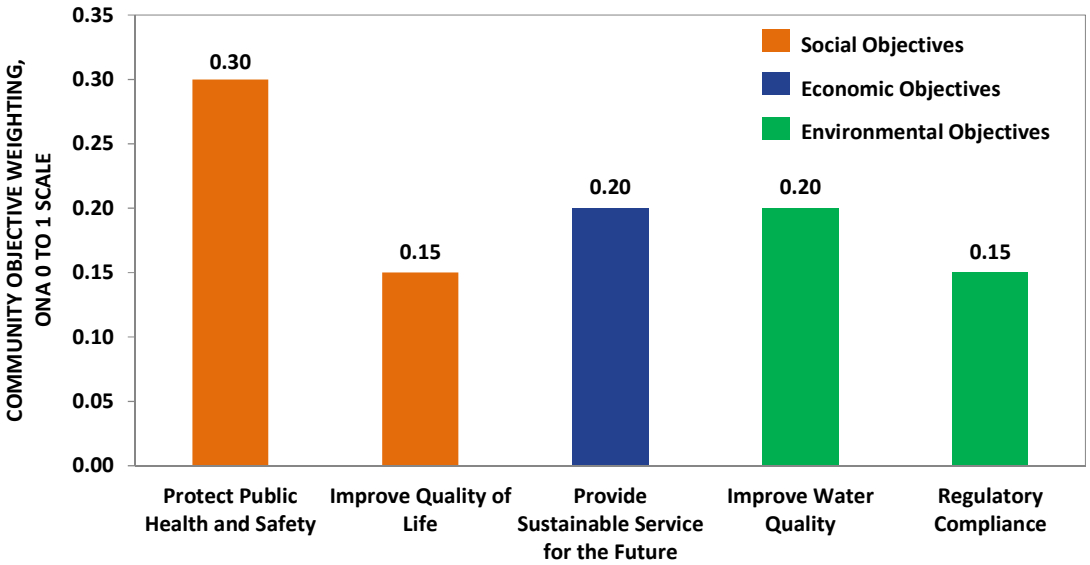

Figure 3. Final Triple Bottom Line Objectives and Prioritization Weightings Resulting from IMP Community Outreach Activities.

Once the primary objectives were defined and prioritized by the community, the project team worked collaboratively to review the remaining outreach results, and identify and weight 10 additional sub-objectives that more specifically characterized the five community objectives. Descriptions of each sub-objective identified for the MCDA are included in Attachment B. Objective and sub-objective weights were then multiplied together to develop a combined weight which reflects the relative importance of each sub-objective in the MCDA.

Table 2. Final Community Objectives, Sub-Objectives, and Priority Weightings using in the MCDA Evaluation. Note that community objective weights must total 1.0. Similarly, the sub-objective weights must total 1.0 for each corresponding community objective. The combined weight is the product of the objective and sub-objective weights.

Triple Bottom Line Criterion	Community Objective (Weight)	Sub-Objective (Weight)	Combined Weight
Social Objectives	Protect Public Health & Safety (0.30)	Reduce Pathogen Exposure (0.50)	0.15
		Reduce Safety Hazards from System Failures (0.50)	0.15
	Improve Quality of Life (0.15)	Provide Community-Wide Benefits (0.50)	0.075
		Reduce Potential for Property Damage (0.50)	0.075
Economic Objectives	Provide Sustainable Services for Future (0.20)	Renew Systems Beyond Effective Life (0.50)	0.1
		Improve Services to Underserved and Redeveloping Areas (0.30)	0.06
		Provide Adequate Services to Growing Areas (0.20)	0.04
Environmental Objectives	Improve Water Quality (0.20)	Protect or Improve Water Quality in City Streams (0.60)	0.12
		Protect Important Regional Waterbodies (0.40)	0.08
	Achieve Regulatory Compliance (0.15)	Proactively Address Clean Water Act Requirements (1.0)	0.15

3.2 Funding Level Benefit Score Development

Funding level benefit scores were developed based on a two-step analysis of the underlying project categories presented in Table 1. In the first step, the relative benefit of all wastewater collection, wastewater treatment, and stormwater management project categories were calculated for each sub-objective. Ratings were first assigned on a 0 to 5 scale to each project category to indicate how well it addressed an individual sub-objective relative to the other projects. Consensus- based ratings were assigned during a project team workshop. Ratings reflected a qualitative assessment of the anticipated benefits of each project on each sub-objective; a rating of 0 indicated that the project was not anticipated to benefit the sub-objective, whereas a rating of 5 indicated the highest benefit was expected.

For example, the project team determined that reducing building backups through improvements in the wastewater collection system would be more effective at reducing pathogen exposure to the public (sub-objective) than implementing chemical wastewater disinfection or stormwater runoff treatment. Therefore, reducing building backups was rated a "5" for that sub-objective and wastewater disinfection and stormwater runoff treatment were rated "3" and "1", respectively. The same analysis was conducted across all sub-objectives.

Relative benefits (weights) were then calculated for each project category by dividing the assigned rating by the sum of the ratings for each sub-objective.

In the second step, the benefit provided by each project category was calculated across the four potential funding levels for each sub-objective. Ratings (also on a 0 to 5 scale) were assigned to indicate the benefit expected from implementing each project category as funding levels increase. For example, the project team determined that the existing funding level for wastewater collection system private common collector elimination (PCCE) project category reduces some pathogen exposure to the public (sub-objective) but could be more effective. Therefore, the existing funding level for this project was rated a "1". As PCCE funding increased to Level 1, Level 2, and Level 3, PCCE project ratings increased to "3", "4", and "5", respectively. The same analysis was conducted for each project category across all sub-objectives. These ratings were then multiplied by the weighting value developed in the first step described above to calculate a project benefit score for each funding level and sub-objective.

Project benefit scores were summed to develop the final funding level benefit scores (Figure 4). The final scores are normalized to the same 0 to 5 scale used to develop ratings and are helpful for evaluating the overall value produced by each funding level relative to all community objectives. The MCDA results indicate that the existing funding level produces the least amount of benefit (0.8 points) to the community and Level 3 funding produces the most benefit (5.0 points). According to the analysis, the greatest incremental increase in benefit occurs when moving from the existing funding to Level 1 (2.1 points). However, to meet the MCDA goal, this incremental increase in benefit must be evaluated with respect to the incremental costs of each additional level of funding.

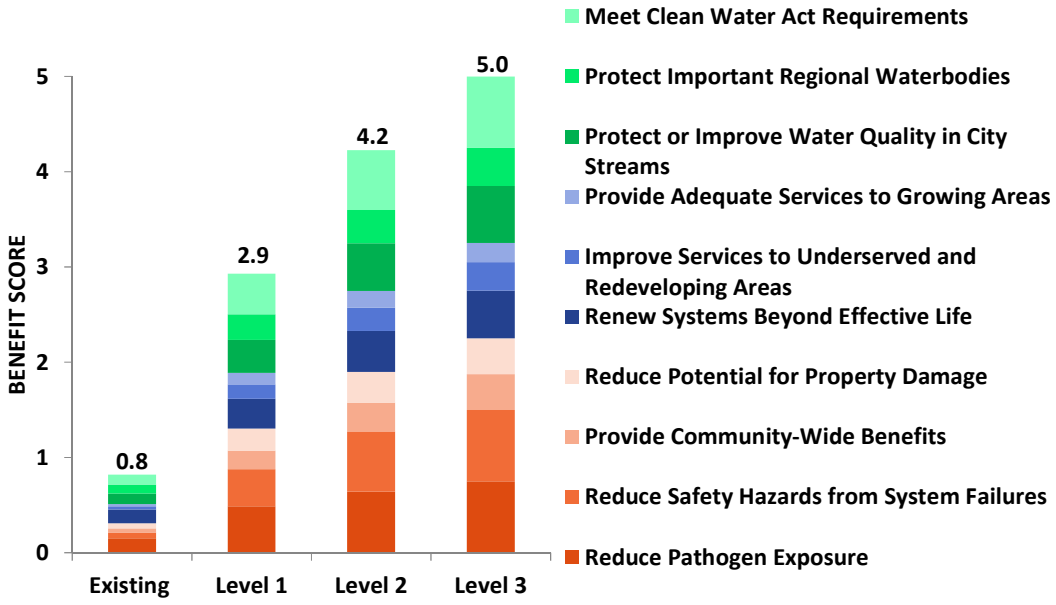

Figure 4. Final Funding Level Benefit Scores Calculated for the IMP. Benefit scores were normalized using a 0 to 5 scale. The orange, blue, and green colors presented in the figure correspond to the social, economic, and environmental sub-objectives, respectively.

The incremental increase in funding level benefit scores presented in Figure 4 were evaluated with respect to the total 20-year costs presented in Figure 1. Results of the evaluation show that Level 2 funding is the most cost-effective alternative because it produces the greatest benefit (0.79 points) for every $100 million dollars of total cost (Figure 5).

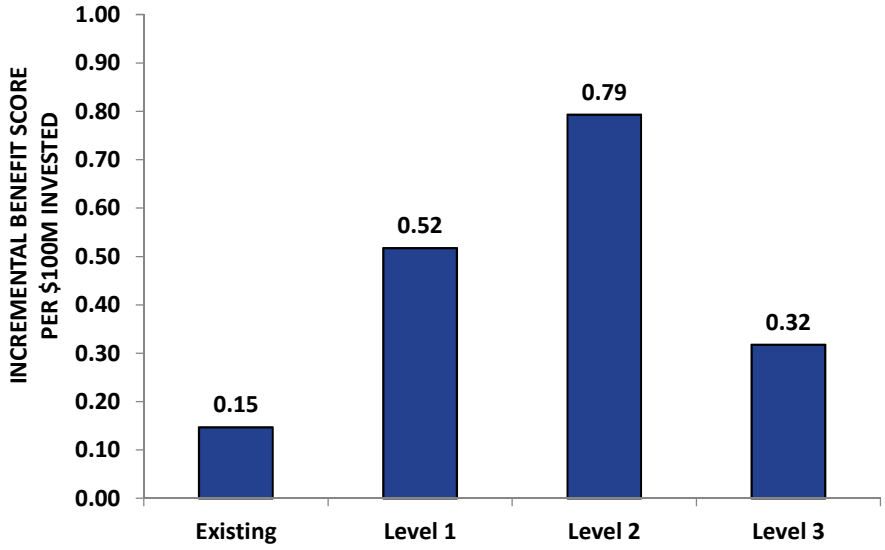

Figure 5. Incremental Benefit Produced by Each Funding Level Alternative per Additional $100 Million Invested.

3.3 Alternative Optimization

The project team recognized that although Level 2 funding represented the best value of the alternatives evaluated (Figure 5), an optimized funding level could be developed by combining the project categories that provided the best value from among the four funding levels. To develop the optimized suite of alternatives, the team divided the individual project category scores calculated in step two of the rating process described in Section 3.1 by their respective costs and selected the most cost-effective projects. The team found that Level 1 funding for most wastewater treatment and collection system project categories provided the best value. For the stormwater management system however, it was generally more beneficial to pursue Level 2 funding (Table 3). This conclusion is consistent with earlier IMP results (see Technical Memoranda 4 and 7) which highlighted the significance of the City's stormwater system needs relative to the funding currently available.

Table 3. Project Categories Selected to Form the Optimized Alternative.

System	Wastewater Treatment							Wastewater Collection									Stormwater Management						
Project Category	Wet Weather Imp.	Expanded Nitrification	Biological Nutrient Removal	Chemical Disinfection	Constructed Wetlands Impr.	Digester Rehabilitation	Digester Capacity Imp.	Wet Weather Program	Asset Management	System Renewal	System Capacity	Building Backups	Private Common Collectors	System Expansion	Cleaning Program	Pump Station Repair	Annual Improvements	SW Planning	System Assessment	System Renewal	Flood Control	Stream Erosion	Runoff Treatment	MS4 Program
Level 1		✓	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓				✓		✓
Level 2	✓				✓						✓								✓	✓	✓		✓	
Level 3																								

The analysis resulted in an optimized suite of alternatives with a total benefit score of 3.6 points and a total 20-year cost of $1.02 billion (in 2017 dollars). Results show that on a per dollar basis (Figure 6), the optimized alternative produces marginally greater benefit than the Level 2 funding alternative (0.81 points vs. 0.79 points per additional $100 million invested) while costing $114 million dollars less ($1.13 billion vs. $1.02 billion) over the 20-year planning period. The reduced cost of this best value suite of alternatives may be particularly important when considering overall program affordability. As a result, the optimized funding level is the preferred alternative for the IMP. Before implementing the optimized alternative, the City will evaluate its impact relative to community affordability and average residential monthly bills (see Technical Memorandum 10).

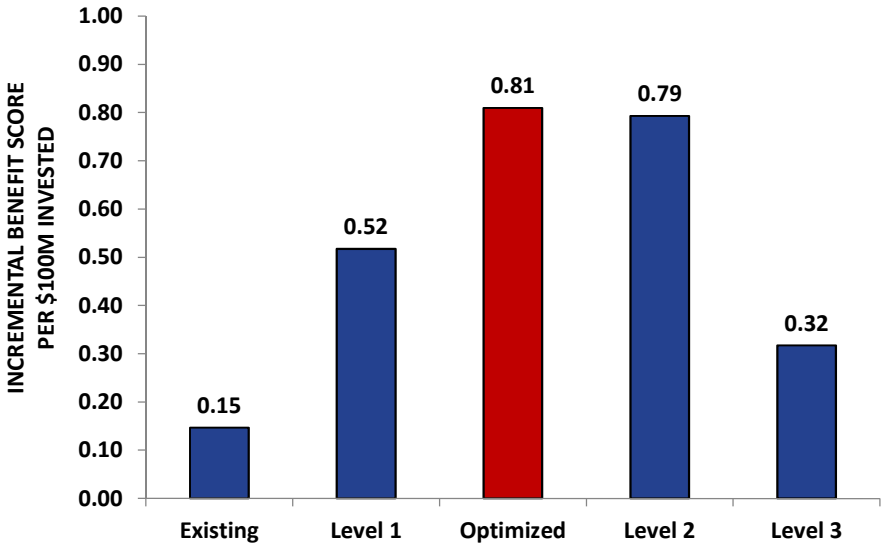

Figure 6. Comparison of the Incremental Benefit Produced by the Optimized and Original Funding Level Alternatives per Additional $100 Million Invested.

Section 4. Summary

During early phases of the IMP, the project team developed a series of wastewater treatment, wastewater collection, and stormwater management alternatives to address system needs, current and anticipated regulatory drivers, and City goals over the next 20 years (the IMP planning period). The alternatives included maintaining existing funding levels or increasing funding to three (Level 1, Level 2, and Level 3) potential higher levels designed to address system needs and goals in an increasingly proactively manner. Because the City is interested in implementing IMP wastewater and stormwater alternatives that cost-effectively provide the greatest benefit to the community over the 20-year planning period, the project team conducted an MCDA evaluation to identify the funding level that satisfied that goal.

MCDA is a structured, quantitative technique used to solve planning problems that involve multiple decision criteria or objectives. Decision criteria represent the important issues or objectives that the alternatives are intended to address. In this MCDA, the evaluation criteria reflect important community objectives that were identified during outreach activities conducted as part of the IMP process. Potential funding level alternatives were rated relative to the community objectives using a standardized rating system.

Initial results showed that the Level 2 funding alternative provided more benefit per dollar invested (Figure 5) than did the other funding levels evaluated. The project team then used the initial results and ratings to develop an optimized combination of Level 1 and Level 2 projects that produced the highest benefit (3.7 points) at the lowest 20-year cost ($1.02 billion, in 2017 dollars).

The optimized funding level is the preferred alternative for the IMP (Attachment C). Before implementing the optimized alternative, the City will evaluate its impact relative to community affordability and average residential monthly bills (see Technical Memorandum 10).

This Page Intentionally Left Blank