STRATUS CONSULTING

Guidelines for Assessing the Cost and Effectiveness of Efficiency, Reuse, and Recapture Projects for the Clean Water State Revolving Loan Fund

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Contents

Acronyms and Abbreviations

AF	acre-foot
AMR	automatic meter reading
ARRA	American Recovery and Reinvestment Act
AWE	Alliance for Water Efficiency
CHP	combined heat and power
CNT	Center for Neighborhood Technologies
CPI	Consumer Price Index
CSO	combined sewer overflow
CWA	Clean Water Act
CWSRF	Clean Water State Revolving Fund
EPA	U.S. Environmental Protection Agency
FWPCA	Federal Water Pollution Control Act
GPR	Green Project Reserve
HVAC	heating, ventilating, and air conditioning
I/I	Infiltration/Inflow
O&M	operations and maintenance
OMB	Office of Management and Budget
POTW	publicly owned treatment works
PV	present value
ROI	return-on-investment
RSL	remaining service life
WRRDA	Water Resources Reform and Development Act of 2014

1. Introduction

The Water Resources Reform and Development Act of 2014 (WRRDA, Public Law 113-121) made several changes to Titles I, II, IV, and VI of the Federal Water Pollution Control Act (FWPCA), the federal statute that governs the Clean Water State Revolving Fund (CWSRF). One of the major changes is the addition of Section 602(b)(13) under Title VI of the FWPCA, which requires all CWSRF project applicants to certify that they have:

- "…studied and evaluated the cost and effectiveness of the processes, materials, techniques, and technologies for carrying out the proposed project or activity for which assistance is sought under this title"; and

- "…selected, to the maximum extent practicable, a project or activity that maximizes the potential for efficient water use, reuse, recapture, and conservation, and energy conservation, taking into account the cost of constructing the project or activity; the cost of operating and maintaining the project or activity over the life of the project or activity; and the cost of replacing the project or activity" (U.S. EPA, 2015, p. 6).

In its interpretive guidance on WRRDA changes (U.S. EPA, 2015), the U.S. Environmental Protection Agency (EPA) recommended that each state CWSRF program develop criteria and/or guidance to help project applicants conduct cost and effectiveness analyses and demonstrate that they have maximized the use of efficiency, reuse, and recapture project elements. This report provides a general framework and methodology that states can easily adopt to meet this objective. Specifically, the following sections provide resources and guidance that project applicants can use to evaluate the benefits and costs associated with different project options, and that states can use to confirm the consideration of such options by all CWSRF applicants. The overall objective is to help applicants develop and analyze a range of project alternatives when evaluating potential CWSRF projects, including both traditional and non-traditional infrastructure alternatives (i.e., efficiency, reuse, and recapture project elements), and select the option or mix of options that best meets the needs of the utility and the community it serves.

This guidance is organized as follows:

- Section 2 briefly describes the CWSRF program

- Section 3 provides an overview of CWSRF water efficiency and reuse, stormwater recapture (i.e., green infrastructure), and energy-efficiency projects

- Section 4 outlines our general economic framework and guidance for evaluating CWSRF projects

- Section 5 provides step-by-step guidance for evaluating the costs, benefits, and effectiveness of CWSRF project alternatives
- Section 6 provides conclusions related to the overall guidance.

2. Background

The U.S. Congress established the CWSRF with the passage of the Amendments to the Clean Water Act (CWA) in 1987. Through the CWSRF program, each state and Puerto Rico maintains revolving loan funds that provide low-cost financing to communities for a wide range of water quality infrastructure projects. Since the program's inception, states have allocated approximately $101 billion of total CWSRF funds to municipal wastewater treatment projects (under Section 212 of the CWA),[1] and about $4.3 billion to projects that reduce nonpoint source pollution and/or protect local estuaries (under Sections 319 and 320 of the CWA, respectively. [2]

Municipal wastewater treatment projects that have traditionally been funded under CWSRF programs include secondary and advanced treatment facilities, collector sewers, sewer rehabilitation, and sanitary and combined sewer overflow (CSO) reduction projects. In the past, these projects have relied largely on traditional or "gray" infrastructure approaches to wastewater and stormwater management. However, in 2009 Congress developed the Green Project Reserve (GPR) Program as part of the American Recovery and Reinvestment Act (ARRA). The GPR required all CWSRF programs to direct a portion of their federal grant funding to projects that included green infrastructure (recapture), water efficiency and reuse, energy efficiency, or other environmentally innovative activities. Although these types of projects have always been eligible for CWSRF funding, the dedicated GPR funding stream increased the number of efficiency, reuse, and recapture projects implemented under the program.

In recent years the federal government has reduced its requirements related to the percentage of total funding that states must allocate to GPR projects. However, WRRDA 2014 serves to mainstream the implementation of GPR-type projects by requiring all CWSRF program applicants to evaluate and maximize the potential for efficient water use, reuse, recapture, and energy conservation when developing and submitting projects for funding.

1. The U.S. GAO (2006) reported that as of 2006, projects to build or improve wastewater treatment plants alone account for over 60% of this amount, with the remainder supporting the construction or rehabilitation of sewer and stormwater collection systems.

2. Through 2014, total CWSRF funding has amounted to $105 billion. This includes $37.7 billion in federal funds and $67.6 billion in state funding (Mark Mylin, Program Analyst, CWSRF, EPA, personal communication, December 8, 2014).

3. CWSRF Efficiency, Reuse, Recapture, and Energy-Efficiency Projects

As described above, the intent of this guidance is to help project applicants assess the costs, benefits, and effectiveness of incorporating water conservation, reuse, recapture, and energy-efficiency elements into their CWSRF projects. As a starting point, the following sections provide an overview of these different project types and offer additional resources that applicants can draw upon when following this recommended economic analysis framework. It is important to note that the different types of projects described below do not necessarily need to constitute whole projects, but rather can be incorporated or combined with more traditional project elements to meet clean water goals.

3.1 Water Efficiency

Definition: EPA's WaterSense Program defines water efficiency as "the use of improved technologies and practices to deliver equal or better services with less water. Water efficiency encompasses conservation and reuse efforts, as well as water loss reduction and prevention, to protect water resources for the future" (U.S. EPA, Undated, p. 7). For the purposes of this guidance, we address water reuse projects separately from water-efficiency and conservation projects because reuse projects often have different economic considerations.

Benefits: Water-efficiency and conservation projects provide a number of potential benefits. Within the context of the CWA and state CWSRF programs, primary benefits include:

- Eliminating, downsizing, or postponing the need for capital projects by reducing the amount of wastewater or stormwater entering the system
- Extending the life of existing facilities
- Lowering variable operating costs, including energy costs
- Protecting and preserving environmental resources by reducing runoff and associated pollutant loading
- Reducing sewer overflows by decreasing the volume of wastewater base flows in the sewer collection system.

In addition to benefits directly tied to the goals of the CWSRF, water-efficiency and conservation projects have a number of important co-benefits for drinking water utilities (or combined utilities), businesses, and households. For example, water conservation projects can help to avoid or postpone new water supply development costs, improve water supply reliability and drought preparedness, help farmers maintain and even improve crop yields and quality, and reduce water and energy costs for households (this can be particularly important when projects or programs are targeting low-income households).

Exhibit 1 provides additional information related to the economics of water-efficiency and reuse projects.

Exhibit 1. Resources for assessing the costs and benefits of water-efficiency and reuse projects.

The **California Urban Water Conservation Council** offers three tools to help guide decision-making on water conservation (https://www.cuwcc.org):

1. Cost-Effectiveness Analysis spreadsheets that use a return-on-investment (ROI) approach for long-term water-saving benefits compared to one-year investment options
2. A Decision Support System Model for long-term water conservation plans
3. Direct Utility Avoided Costs/Environmental Benefits Models to assist water utilities in quantifying environmental benefits and costs related to water-efficiency programs.

The Victorian Department of Treasury and Finance (Australia) performed a comprehensive **benefit-cost analysis of advanced metering infrastructure** that provides important insights (http://www.smartmeters.vic.gov.au/about-smart-meters/reports-and-consultations/advanced-metering-infrastructure-cost-benefit-analysis/executive-summary).

The Alliance for Water Efficiency (AWE) **Water Conservation Tracking Tool** helps water utilities evaluate water savings, costs, and benefits of conservation programs. The tool is available to AWE members (http://www.allianceforwaterefficiency.org/tracking-tool.aspx).

The WateReuse Foundation's **Economic Framework for Evaluating Benefits and Costs of Water Reuse** provides a tool to help water agencies and other water sector professionals conduct a benefit-cost analysis of water reuse investments (https://www.watereuse.org/product/03-006-2).

Project types: CWSRF programs can fund a wide variety of water-efficiency projects. Projects eligible for funding under Section 212 of the CWA (municipal wastewater treatment projects) must reduce demand for capacity at publicly owned treatment works (POTW),[3] while Section 319 and 320 projects must address non-point source pollution or protect/improve water quality in an estuary. Examples of water-efficiency projects include[4]:

3. Per U.S. EPA (2015): Only specified public entities are eligible for assistance for water-conservation projects; however, project activities may take place at publicly or privately owned properties, provided the project reduces demand for POTW capacity.

4. This section is not intended provide a comprehensive list of all efficiency, reuse, and recapture projects eligible for funding under CWSRF.

- Installing or retrofitting water-efficient devices, such as plumbing fixtures and appliances (e.g., shower heads, toilets, urinals, other plumbing devices)
- Incentive programs and policies (e.g., education programs, rebates, pricing/rate structures) that encourage households and businesses to conserve water
- Installing water meters in previously unmetered areas (enabling customer billing for water and wastewater service based on metered use)
- Replacing faulty water meters, rightsizing large meters that may be under-recording, or upgrading existing meters with automatic meter reading (AMR) technology
- System water audits, water conservation plans, and water-loss reduction measures
- Retrofitting or replacing existing landscape or agricultural irrigation systems with more efficient irrigation systems, including moisture and rain-sensing equipment.

Despite the many types of water-efficiency improvements that qualify for funding under CWSRF, states have traditionally funded leak detection, agricultural efficiency, and reuse projects (Blette, 2009). With recent changes to the CWSRF through WRRDA 2014, agencies may begin to apply for more funding to implement conservation programs and efficiency improvements at wastewater treatment plants, households, and businesses.

3.2 Water Reuse

Definition: Water reuse (or water reclamation) involves the advanced treatment and reuse of municipal (or onsite) wastewater or stormwater to offset the use of potable water supplies and/or meet environmental standards. Municipal water reuse programs have traditionally developed water supplies for non-potable purposes such as for industrial uses or agricultural and landscape irrigation. However, an increasing number of communities are considering and implementing indirect and direct potable reuse systems.

Benefits: Similar to water-efficiency projects, water-reuse projects typically produce a wide range of direct and indirect benefits. Although water reuse may be more expensive than traditional supply options, it can offer important environmental and social benefits, including:

- Avoided wastewater discharges
- Avoided costs associated with alternative water supplies and/or related infrastructure expansion

- Increased ability to meet critical instream flow conditions for fish and other aquatic species and ecosystem services of concern
- Reduced energy consumption and air pollution where more energy-intensive water supply options would be the alternative to reuse (e.g., desalination or importing water from long distances, which can require significant amounts of energy for pumping)
- Increased protection of groundwater systems – from subsidence, reduced storage capacity, and saltwater intrusion – by reducing pumping demands on aquifers
- Increased water supply reliability and drought preparedness
- Sustaining agricultural communities by reducing municipal demands on water currently used for irrigation.

Project types: CWSRF provides funding for construction of reuse facilities (including non-potable, indirect, and direct reuse), as well as for the extra treatment costs and distribution pipes associated with water reuse, relative to traditional supplies[5]. Options incorporated into CWSRF projects may also include onsite reuse, decentralized treatment and reuse systems, injection wells, and systems that allow for utilization of harvested rainwater (e.g., publicly-owned cisterns and distribution pipes).

3.3 Stormwater Recapture and Green Infrastructure

Definition: In the context of the CWSRF, recapture projects are often referred to as green infrastructure projects. Green infrastructure includes a wide array of practices that use vegetation, soils, and natural processes to manage wet weather flows by infiltrating, evapotranspiring, and harvesting and reusing stormwater. On a regional scale, green infrastructure includes the preservation and restoration of natural landscape features, such as forests, floodplains, and wetlands. On the local scale, green infrastructure consists of site- and neighborhood-specific practices, such as permeable pavement, bioretention, downspout disconnections, rain gardens, trees, and green roofs.

Benefits: Water resource managers implement green infrastructure solutions to reduce stormwater runoff, thereby reducing associated pollutant loading and sewer overflows. Green infrastructure also provides a number of important co-benefits, including enhanced groundwater

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[5] Per EPA (undated) Green Project Reserve Guidance for the CWSRF, GPR Crosswalk Table for projects eligible for CWRSF funding under 320 and 319 of the CWA. http://www.epa.gov/cwsrf/green-project-reserve-guidance-clean-water-state-revolving-fund-cwsrf.

supplies, energy savings (due to avoided stormwater treatment and pumping), cleaner air (and associated health benefits), reduced urban temperatures, increased climate resiliency, source-water protection, improved quality of life for local residents, and increased recreational opportunities (see Exhibit 2 for additional information on the benefits and costs of green infrastructure).

Project types: Specific green infrastructure projects that are eligible for CWSRF funding include:

- Installation of site-specific practices, such as permeable pavement, bioretention, downspout disconnections, rain gardens, trees, cisterns, and green roofs
- Implementation of green streets (combinations of green infrastructure practices in transportation rights-of-ways), for either new development, redevelopment, or retrofits
- Street tree or urban forest canopy programs
- Establishment or restoration of permanent riparian buffers, floodplains, wetlands, and other natural features, including vegetated buffers or soft bioengineered stream banks. This includes stream day lighting.
- Projects that involve the management of wetlands to improve water quality and/or support green infrastructure efforts (e.g., flood attenuation)
- Large-scale stormwater infiltration/recharge projects.

Exhibit 2. Resources on the economics of green infrastructure.

Center for Neighborhood Technologies (CNT), Green Values Stormwater Management Calculator – assesses cost-effectiveness and environmental benefits of green infrastructure options (http://greenvalues.cnt.org/).

The Value of Green Infrastructure: A Guide to Recognizing Its Economic, Environmental, and Social Benefits – this guide describes the steps necessary to quantify and value many of the environmental, social, and public health benefits of green infrastructure. The guide includes simple, illustrative examples to assist the reader in performing their own calculations (http://www.americanrivers.org/wp-content/uploads/2013/09/Value-of-Green-Infrastructure.pdf?506914).

Case Studies Analyzing the Economic Benefits of Low Impact Development and Green Infrastructure – this EPA report summarizes 13 economic benefit analyses conducted by public entities across the United States to assess the effectiveness of their green infrastructure programs. The case studies were selected to represent a range of methodologies, geographic contexts, and municipal program types (http://water.epa.gov/polwaste/green/upload/lid-gi-programs_report_8-6-13_combined.pdf).

3.4 Energy Efficiency

Definition: Energy-efficiency projects involve the use of improved technologies and practices to reduce the energy consumption of water quality projects, use energy in a more efficient way, and/or to produce or utilize renewable energy. Exhibit 3 highlights several EPA resources on energy efficiency for water and wastewater utilities.

Benefits: The benefits of energy-efficiency projects include reduced operating costs, decreased emissions and associated health effects, and a reduced carbon footprint.

Project types: Specific energy-efficiency projects include:

- Renewable energy projects such as wind, solar, geothermal, micro-hydroelectric, and biogas combined heat and power (CHP) systems that provide power to a POTW
- Micro-hydroelectric projects that involve capturing the energy from pipe flow
- Installation of energy-efficient lighting; heating, ventilating, and air conditioning (HVAC); process equipment (including pumps); and electronic equipment and systems at POTWs
- Installation of collection system Infiltration/Inflow (I/I) detection equipment
- Energy management planning for POTWs, including energy assessments, energy audits, optimization studies, and sub-metering of individual processes to determine high energy-use areas.

Exhibit 3. EPA resources on energy efficiency for water and wastewater utilities.

EPA's website provides a number of resources related to energy efficiency for water and wastewater utilities:

Ensuring a Sustainable Future: An Energy Management Guidebook for Wastewater and Water Utilities – provides a step-by-step process to help utilities assess their current energy usage, conduct energy audits, and identify actions to improve energy efficiency (http://water.epa.gov/infrastructure/sustain/upload/Final-Energy-Management-Guidebook.pdf).

Energy Use Assessment Tool – provides guidance for conducting a utility bill analysis to assess baseline energy use and costs prior to a full-scale energy audit (http://www.epa.gov/cleanenergy/).

Energy Star/Portfolio Manager for water and wastewater utilities – a tool designed to help utilities manage energy use and cost to compare performance against similar facilities (available from EPA by request – EnergyUseTool@epa.gov).

4. Overview of Economic Framework and Guidance

To ensure that each CWSRF project or activity maximizes the potential for efficiency, the framework includes the following steps[6]:

1. Identify the objective of the proposed project (i.e., What problem is the project intended to resolve?).

2. Establish the baseline alternative. The development of the baseline allows the project applicant to evaluate alternative options in a comparative framework.

3. Identify and screen potential efficiency, reuse, and recapture options applicable to the applicant's CWSRF project or activity, and evaluate the feasibility of potential project elements to help meet the stated objective.

4. For options brought forward for further analysis from the initial screening step, identify and, to the extent feasible, quantify the key benefit(s) and costs based on existing data and available information.

5. Develop a lifecycle analysis framework to assess costs and benefits (or levels of effectiveness) over time, as well as the overall ROI associated with different project elements.

6. Incorporate non-quantified/non-monetized benefits and costs of various alternatives into the decision framework. This includes the identification and characterization of financial, social, and environmental benefits associated with efficiency, reuse, and recapture projects.

7. Summarize and compare alternatives, and identify the optimal combination of project elements.

EPA's recommendation for developing an economic framework for assessing efficiency, reuse, and recapture projects seems to focus on cost-effectiveness analysis, rather than full benefit-cost analysis (U.S. EPA, 2015). In the traditional sense, cost-effectiveness analysis allows project applicants to compare the costs for different options that are designed to achieve a specific target. Benefit-cost analysis on the other hand compares total project benefits to total costs, with the objective of maximizing net benefits.

6. The framework presented here is not necessarily linear; findings from one step may result in the need to visit a previous step.

Although cost-effectiveness analysis can serve as a useful assessment tool, it is also important to consider the array of benefits that efficiency, reuse, and recapture projects provide when selecting project alternatives. We have therefore incorporated cost-effectiveness analysis into the guidelines (which includes quantifying key benefits), but also provide applicants with a process for identifying (but not necessarily quantifying or monetizing) the full suite of benefits associated with different project alternatives and including this information in their overall decision-making process. Thus, our approach represents somewhat of a hybrid of these two types of analyses.

In addition, although this recommended framework contains seven comprehensive steps, the level of analysis required for each step will vary based on the complexity of the project and the difference in the alternatives being evaluated. In the following sections we highlight instances in which applicants may be able to conduct a more limited analysis within this framework.

Further, there are some cases in which a state may choose to exempt project applicants from having to follow the framework. This likely includes planning projects, such as conducting an energy-efficiency analysis or developing a water conservation plan, as well as projects that have been developed as part of an approved energy or water-efficiency plan. Additional exemptions are noted in Step 3 of the economic framework.

5. Economic Framework for Evaluating CWSRF Project Alternatives

This section provides step-by-step guidance for assessing the effectiveness, costs, and benefits of CWSRF projects.

5.1 Step 1. Define the Project Objective

The first step in the framework is to clearly articulate the primary objective of the project by asking, "What is the problem to be solved?" This allows the project applicant to identify alternative project options, including green infrastructure, reuse, and water and energy-efficiency options, and compare how well these options will solve the problem.

In some cases, project applicants may have a specific project in mind before they begin to apply this framework. For example, they may want to expand a stormwater collection system by a specified length of pipes/tunnels, or replace a specific segment of pipe to accommodate larger wastewater flows. These do not represent project objectives, but rather alternatives for meeting broader objectives. The broader objectives associated with these project alternatives might respectively include "manage stormwater runoff from X impervious acres to reduce annual sewer overflows by Y in Z watershed" and "accommodate expected growth in X section of the sewer system."

Exhibit 4 shows examples of the broader objectives associated with common, traditional CWSRF projects. When defining the project objective, project applicants may need to be more specific than the examples shown here. For example, the problem to be solved may be related to a specific location within a service area or watershed; this should be included in the project objective. In addition, to evaluate projects within a cost-effectiveness framework, it is important to identify quantitative targets as part of the project objective, when feasible (e.g., reduce energy use associated with wastewater treatment by 20%, or reduce CSOs to 100,000 gallons per year at a specific outfall). In some cases, it may be more helpful to set threshold levels (e.g., reduce energy consumption by *at least* 20%) to allow for different outcomes associated with project alternatives. Clearly defining these parameters will allow the project applicant to identify and compare alternative project options in later stages of the framework.

5.2 Step 2. Establish the Baseline

The next step in the framework is to establish a baseline scenario against which changes resulting from project alternatives can be compared and measured. The baseline scenario not only establishes the problem-solving context within which the project is being considered, but also helps to identify avoided costs and/or forgone benefits associated with project alternatives.

For most project applicants, this step will be easy because the baseline scenario will likely include an already-planned project, or a traditional "gray infrastructure" project approach. This type of baseline applies when doing nothing is not an option – for example, the project is being undertaken to meet a specific regulatory requirement or to maintain a basic core service of unquestionably high value. ***This is almost always the case with CWSRF projects*.** In some rare cases, however, a "without project" baseline alternative may be appropriate. This may apply, for example, to an energy-efficiency project, where the baseline scenario is to maintain existing levels of energy consumption per unit of wastewater treatment.

An important aspect of defining the baseline scenario is that it must anticipate future conditions over the expected life of the project (which is typically 20 years or more). The baseline is not the same thing as the current situation. Defining the baseline means looking into the years ahead; making assumptions about future growth rates and associated water demands, wastewater flows, and/or stormwater runoff; and designing projects accordingly. This will allow the project applicant to fairly assess the effectiveness and feasibility of alternative project options (i.e., efficiency, reuse, and recapture options) in meeting the project objective.

Exhibit 4. Primary objectives associated with common CWSRF project types

CWSRF project objective	Common CWSRF projects
Maintain existing levels of wastewater or stormwater collection service and/or treatment	▸ Rehabilitate or replace portion of sewer or stormwater collection system, including pipes and/or pump stations (infrastructure may be at risk of failing due to age, I/I, etc.) ▸ Rehabilitate or replace infrastructure at POTW
Accommodate future growth that is expected to result in increased water demand, wastewater flows, and/or stormwater runoff	▸ Expand or construct reclaimed water system (to meet increased water demands) ▸ Expand, construct, or upgrade wastewater collection system and/or POTW to accommodate expected increase in wastewater and stormwater flows ▸ Expand, construct, or upgrade stormwater collection system and/or POTW to accommodate increase in stormwater runoff associated with expected growth
Improve water quality to protect beneficial uses or meet specific water quality standards, such as related to combined or sanitary sewer overflows (SSOs), total maximum daily loads, or other discharge requirements	▸ Expand or construct reclaimed water system (to avoid wastewater discharges) ▸ Upgrade POTW to meet water quality standards ▸ Expand gray infrastructure tunnel system to reduce CSOs or SSOs ▸ Separate combined sewer system to reduce CSOs ▸ Implement stream restoration project to reduce erosion and/or the downstream impacts of other discharges
Improve energy efficiency[a]	▸ Replace or upgrade wastewater or stormwater collection and treatment system with more energy-efficient equipment (e.g., energy-efficient pumps) ▸ Increase renewable energy use by installing solar panels or using biogas

a. For a small percentage of CWSRF projects, the primary objective is to improve energy efficiency. State CWSRF programs have funded many energy-efficiency projects as part of the GPR.

5.3 Step 3. Identify Alternative Project Options

Next, the applicant should identify and perform an initial screening analysis of project alternatives that meet the project objective, including alternatives that incorporate efficiency, reuse, and recapture. This step entails answering two key questions:

1. Are there efficiency, recapture, or reuse project options (or elements) that would fully (or partially) meet the project's objectives?

2. Are there alternative materials or equipment that can be used to maximize energy and water efficiency and/or stormwater recapture when the project is implemented?

Answering the first question may result in a completely different approach for meeting the project's objective relative to the baseline alternative, or an alternative that includes a combination of baseline and efficiency, reuse, and/or recapture project components. For example, instead of expanding capacity at an existing POTW to accommodate future growth within a service area, the applicant may be able to offset some (or all) of the increased treatment demand by implementing a water-conservation program to reduce the volume of wastewater base flows entering the sewer system. In addition, in combined sewer systems, applicants may also be able to use green infrastructure to reduce peak stormwater flows, thereby offsetting some of the demand for increased POTW capacity. At this stage, it is not necessary to define the exact combination or level of efficiency, reuse, and recapture elements, as these will be refined in later stages of the analysis. Exhibit 5 provides examples of how efficiency, reuse, and recapture options can help to meet common CWSRF project objectives.

The second question is a bit more focused and applies to all project options, including the baseline alternative and any other alternatives identified. To answer this question, project applicants should identify any opportunities where they may be able to use different materials or processes to maximize water and energy efficiency or recapture. For example, there may be opportunities to integrate higher-efficiency pumps into a planned water reuse project, or to install permeable pavement instead of traditional asphalt after replacing a sewer line.

Exhibit 6 provides an example of project alternatives (including the baseline) that meet different objectives often associated with CWSRF projects. Although this is a simplified example, it helps to demonstrate how project applicants can identify and compare alternatives that incorporated efficiency, reuse, and recapture based on the project's objective. This example also demonstrates that project applicants can use this framework to evaluate simple changes to the project baseline (e.g., incorporate energy-efficient pumps into pump station replacement projects) to more complex projects.

Exhibit 5. Efficiency, reuse, and recapture project elements as they relate to common CWSRF objectives.

Water-efficiency and conservation projects can offset demand for increased wastewater treatment capacity, reducing the need for, or size of, associated infrastructure.

Water reuse offsets potable water demand, reduces wastewater discharges, and can help POTWs meet discharge requirements.

Stormwater capture and green infrastructure projects can reduce urban stormwater runoff and associated pollution, and decrease CSOs and I/I.

Energy-efficiency projects can be integrated into many different types of wastewater and stormwater-related projects, and can help utilities meet broader energy management and sustainability goals.

Potential off-ramp: For projects that entail rehabilitating or replacing pipe(s) within a portion of an *existing* sewer/stormwater system, project applicants will likely be able to answer "no" to both of the questions posed above (if the existing pipe is being replaced with the same size pipe). If pipe repair and replacement needs are not addressed, this will result in significant service disruptions and potentially, adverse public health effects. Project applicants do not need to evaluate this specific type of project within this economic framework.

Other projects that do not necessarily need to be evaluated within this framework include stream restoration projects (which constitute a small percentage of CWSRF projects), projects that are being implemented as part of an approved water or energy-conservation plan (as noted in Section 4), and projects for which applicants can document that they have already maximized water and energy efficiency, reuse, or recapture as part of the design process. These projects include, for example, pump or pump station replacement projects for which the project applicant is already using certified high-efficiency pumps, or projects that involve expanding a gravity-based recycled water distribution system (or if pumping is required, includes certified high-efficiency pumps).

Exhibit 6. Example of traditional and non-traditional project alternatives that meet common CWSRF objectives

Project objective	Traditional project alternative (baseline)	Non-traditional project alternatives (i.e., projects that include efficiency, reuse, and recapture elements)	
		Non-traditional Alternative A	Non-traditional Alternative B
Accommodate expected future increase in demand for wastewater treatment capacity in service area	Expand or build new treatment plant to accommodate increased wastewater flows	Offset increased demand by 15–25% through meter replacement/AMR program Offset increased demand by 5–10% through installation of water-efficient devices in service area households Reduce expansion of existing wastewater treatment plant accordingly	Offset increased demand by 15–25% through meter replacement/AMR program Offset increased demand by 5–10% through installation of water-efficient devices in service area households Implement water reuse system to account for 50% of increased demand Install decentralized wastewater treatment facilities to meet remaining demand
Reduce CSOs to meet regulatory requirements	Construct "gray" tunnel project to capture and treat stormwater through combined sewer system	Evaluate options for capturing 30–60% of runoff from impervious area with green infrastructure Downsize tunnel project accordingly	Evaluate options for capturing 30–60% of runoff from impervious area with green infrastructure Implement satellite treatment facilities to reduce energy use associated with pumping Downsize (or eliminate) tunnel project accordingly
Reduce non-renewable energy use by at least 20% at POTW	No action – maintain current operations and equipment	Install solar technology to meet at least 20% of POTW power needs	Upgrade existing POTW with energy-efficient lighting, HVAC, process equipment (including pumps), and electronic equipment and systems
Maintain existing levels of service by replacing section of sewer system (including pipes and pumps) identified in capital improvement plan as in need of repair	Replace system with same size pipes and same model of pumps	Upgrade system with same size pipes and pumps with higher energy efficiency	Upgrade system with higher-efficiency pumps Install permeable pavement instead of traditional asphalt over pipe replacement area to reduce urban stormwater runoff
Expand water reuse system to provide non-potable water for irrigation purposes	Implement water reuse system as planned	Implement water reuse system as planned but with higher-efficiency pumps	Implement onsite systems to potentially reduce energy use and increase the total amount of reuse water available

Once potential project alternatives are identified, the next step is to assess the technical, economic, and regulatory feasibility of the different options, identify fatal flaws, and select a reasonable range of alternatives for further analysis. This assessment should include the baseline alternative developed in Step 2 if it represents a viable project alternative (i.e., rather than a "without project" scenario). Exhibit 7 provides examples of technical, economic, and regulatory/political criteria for project applicants to consider in the initial alternatives screening phase.

Exhibit 7. Criteria for assessing feasibility of alternative project options in initial screening phase.

Technical criteria. This entails a simple screening related to the technical capacity and effectiveness of each proposed option in relation to meeting specified targets. For example, when assessing the viability of a non-potable reuse project, a key technical component is whether there is enough customer demand to meet project goals. For projects that incorporate green infrastructure, technical feasibility may be based on the amount and location of public and private lands available for green infrastructure solutions, or whether a high water table in a given area may limit the ability to infiltrate runoff without causing flooding. Technical feasibility may also include criteria associated with uncertainty surrounding the implementation of new technologies and other potential risks (e.g., such as risks associated with climate variability and change).

Economic criteria. Assessing the economic feasibility of alternative project options involves comparing relative project costs, including capital, operations and maintenance (O&M), and overall lifecycle costs, as well as project benefits. At this stage of analysis, a qualitative characterization of costs is sufficient – options that advance beyond the screening stage will be subject to further economic analysis in later steps.

Regulatory/political and community support. When a project is being implemented to meet regulatory requirements, the project applicant must consider whether the project fully meet the requirements within the specified timeline for compliance. Any potential regulatory issues that may inhibit implementation should also be identified at this stage. For example, in many communities there are barriers associated with implementing green infrastructure on private land, or limitations on the use of stormwater recapture or onsite reuse systems.

Another factor in the inevitable success of any project is whether or not there is political and community support behind it. It is important to identify potential outreach/stakeholder issues upfront. Although the lack of political or community support does not necessarily mean that a project should not be implemented, it is important to identify the level of public outreach that will be necessary, which will directly influence project costs.

The next step is to compare the relative technical, economic, and regulatory/political feasibility of the project alternatives using a simple ranking system (e.g., applying a low, medium, or high ranking to the different criteria within each broad feasibility category). Based on this ranking, project applicants should identify two to four alternatives (including the baseline alternative) for further analysis. In some cases, this decision will be straightforward, as there may only be one or two feasible project options, or an applicant may simply be comparing two alternatives that utilize different materials (e.g., permeable pavement versus asphalt). In other cases, the project applicant may have to revisit the initial development of alternative project options (e.g., combining alternatives or adding (or reducing) certain components to find a feasible solution that incorporates efficiency, reuse, and/or recapture elements). In addition, the alternatives selected in this stage may continue to evolve, as the project applicant begins to assess costs and benefits in more detail.

5.4 Step 4. Identify and, to the Extent Feasible, Quantify Project Costs and Key Benefits

The next step in the process is to develop a thorough inventory of all likely costs and benefits associated with each of the project alternatives brought forth from Step 3. This includes financial (e.g., capital and operating costs), environmental (e.g., improved water and/or air quality), and social (e.g., improved public health, economic development, increased resiliency to climate change and variability) considerations. Temporary social costs, such as traffic delays and increased noise from construction, should also be taken into account.

Consistent with cost-effectiveness analysis, we recommend that the applicant focus on quantifying the costs (to the extent feasible) and key benefit(s) associated with a given project (e.g., water or energy savings, pollutant load reduction, acre-feet of reclaimed water production). As noted above, it is not necessary to perform a full benefit-cost analysis to meet EPA's objective for cost-effectiveness analysis. Thus, the project applicant does not need to translate key project benefits into monetary terms. However, it is important in this stage to identify the full suite of benefits associated with each alternative so that they can inform the decision-making process (at least) in a qualitative way (see Step 6).

The following sections describe the different considerations that should be taken into account when identifying and quantifying project costs and benefits.

Project costs

When assessing project costs, it is important to identify all significant direct and indirect costs associated with the design, construction, and O&M of a proposed project, regardless of who may incur the cost. Cost parameters associated with water quality projects typically include, but are not limited to:

- Engineering and design
- Environmental mitigation
- Right-of-way acquisition
- Construction
- O&M
- Replacement costs

- Salvage value
- Temporary and permanent public impacts (e.g., traffic, noise, dust, impacts to businesses)
- Public relations.

As described in more detail below (see Section 5), it is important to think about and quantify all costs over the expected life of the project. However, it may be difficult to assign a monetary value to some parameters (e.g., public relations and other social impacts such as potential for loss of business due to construction activities). These costs should be identified and, if significant, should be incorporated into the final project ranking process outlined in Step 6.

Project benefits

With cost-effectiveness analysis, it is important to estimate the physical quantity associated with the key project benefit(s) (e.g., reduction in overflows, energy savings). This allows for a direct comparison of alternatives on a cost-per-unit of benefit basis. In some cases, project alternatives may result in different levels of benefits. For example, one alternative may reduce CSOs by 100,000 gallons per year, while another reduces CSOs by 90,000 gallons per year. When this occurs, the benefit that each alternative will provide should be quantified and incorporated into the lifecycle analysis conducted in Step 5.

Another important type of benefit that we recommend project applicants attempt to quantify (when applicable) includes any costs that may be avoided if the project alternative is implemented. This typically applies when the baseline alternative is a “no action” or “without project” scenario, but can also apply when directly comparing alternatives. For example, this is the case when comparing a project that incorporates water-reuse or efficiency elements to one that relies on the expansion of wastewater infrastructure to accommodate higher flows – the reuse and/or efficiency project will result in avoided costs of securing additional water supplies. These costs would not necessarily be reflected in the alternative that relies on expanding wastewater infrastructure to accommodate future growth.

In addition to these key benefits, the project applicant should identify any other financial, environmental, and/or social benefits associated with the proposed project alternatives. In some cases, it may be easy to assign a quantitative or monetized value to these benefits; this may be helpful in later stages of the framework if the lifecycle analysis of two or more alternatives yields similar results. However, in most cases, we recommend incorporating these benefits in a qualitative way (see Step 6).

5.5 Step 5. Develop Lifecycle Analysis

The benefits and costs of CWSRF projects generally occur as a stream of values over time. For example, a project may have initial capital costs in the first year or two to construct associated infrastructure facilities, and then annual O&M costs that are incurred each year from facility completion over the rest of its lifetime. Values that occur in different time periods need to be adjusted to their "present value." The use of present values allows any series of costs or benefits over time to be correctly summed into a single value at a single point in time. This allows for a comparison of alternatives with different project timing (due to different start years or different project lifetimes).

For the purposes of this analysis, lifecycle costs and benefits represent the total discounted values associated with constructing, owning, operating, and maintaining an asset or program over a period of time. In addition to the present value dollars, with cost-effectiveness analysis, key physical benefits can also be discounted so that project applicants can compare present value costs per unit of benefit (e.g., $/gallon of stormwater captured, $/unit of water savings).

When conducting a lifecycle analysis for project alternatives, the following economic concepts must be considered:

- The period of **time** over which costs and benefits are incurred
- The use of **nominal versus real values**
- The **discount rate** applied to future costs (and benefits) to equate them with present-day costs (and present-value benefits)
- **Escalation rates** applied to specific project components.

The following sections provide further detail on these economic concepts and offer recommendations for conducting lifecycle analyses.

Appropriate project lifetimes

To evaluate the costs and benefits over a project's lifecycle, the analysis period is typically chosen based on the expected life of the asset or program being evaluated. However, a shorter evaluation period may be considered for projects that have an exceptionally long life expectancy. Project evaluation over an extended period (e.g., 50+ years) has the potential to increase uncertainties and magnify assumptions regarding risk costs, discount rates, inflation, and other project parameters. In general, we recommend a project life of no more than 50 years.

In addition, although project alternatives may have different expected lifetimes, it is important to assess operation, maintenance, and replacement costs and project benefits over the same number of years in order to fairly compare alternatives. To account for differences in expected project life, replacement costs and remaining service life (RSL) values should be incorporated into the total project cost.

Replacement costs can be applied when one project alternative has an expected life that is shorter than the analysis period. For example, if Alternative A has an expected life of 20 years and Alternative B has an expected life of 40 years, one could assume an analysis period of 20 or 40 years. With a 40-year analysis period, the analyst should assume that in year 20 of the analysis period, the utility (or other management agency) will incur costs associated with replacing Alternative A's infrastructure. Alternatively, the analyst could shorten the analysis period to 20 years, and include the RSL value for Alternative B as a project benefit.

Nominal versus real values

When project costs and benefits are inflated to reflect the values expected in each year of the project lifecycle, the values are said to be in "nominal" terms. "Real" values, on the other hand, remove the general expected rate of inflation, presenting values as if prices were constant in each year (i.e., no inflation). Differences in real values from year to year are then attributed to real changes in relative values beyond general inflation.

For economic analyses, benefits and costs are normally not entered in inflation-adjusted dollars. Instead, the use of real or constant dollars keeps inflation-related projections from clouding the analysis. The use of real values also allows for a more transparent application of escalation rates for specific project inputs, which is different from the general inflation rate. Exhibit 8 provides further information on understanding nominal versus real analysis.

Exhibit 8. Formula to discount future constant value costs to present value.

$$\text{Present value} = \text{Future value X } 1/(1 + r)^n$$

Where:

r = real discount rate
n = number of years in the future when the cost will be incurred.

The term $1/(1 + r)n$ is known as the discount factor and is always less than or equal to one. Using this formula, a $1,000 cost incurred in year 30, discounted to the present (year zero) at a 4% real discount rate, would have a present value of $308.

Source: U.S. DOT, 2002.

Discount rate

Lifecycle analysis needs to account for the time value of money, or the fact that most people prefer a dollar today more than an inflation-adjusted dollar in the future. The annual rate at which present values are preferred to future values is known as the discount rate. To compare the benefits and costs of different projects over time, all values must be "discounted" to present value using the discount rate. This allows for a direct comparison across project alternatives regardless of possible differences in the timing of benefits and costs for each project.

Exhibit 8 shows the formula used to discount future constant value costs (i.e., presented in real terms in the same dollar year) to present value.

It is important to evaluate a range of discount rates when conducting economic analysis. Various government entities have specified discount rates to be used in project evaluation analyses. The federal Office of Management and Budget (OMB) regularly updates discount rates in Appendix C to its Circular Number A-94, *Guidelines and Discount Rates for Cost Analyses of Federal Programs.*[7] OMB also mandates that federal agencies apply a 7% real rate of discount when evaluating the benefits and costs of federal regulatory actions, while EPA recommends a 3% real discount rate to reflect the social rate of time preference.[8] The *Federal Code of Regulations, Plan Formulation and Procedures* directs federal water resource agencies to use specific rates to evaluate water project alternatives. For fiscal year 2015, the general planning rate is 3.375% in real terms (USBR, 2014). We suggest using the upper and lower bound estimates from this range when conducting lifecycle analyses.

Finally, although the discount rate can be expressed in nominal or real terms, it is important to use a real discount rate when analyzing costs and benefit values in real terms (which we recommend above for lifecycle cost analysis). Exhibit 9 provides additional information related to inflation, discounting, and comparing values over time.

Escalation

Escalation is a means of building relative cost changes into the cost calculation. To account for cost escalation, a percentage rate is applied to particular project cost elements (e.g., construction materials, labor) to reflect the expected change in the cost of the item relative to other elements. This is different than a general price increase across the whole economy, which is accounted for by inflation [i.e., using the Consumer Price Index (CPI)]. When lifecycle cost analyses are conducted in real terms, escalation rates applied reflect a real change in the cost of a good or service.

7. OMB recommends using real interest rates on Treasury notes and bonds matched to the project time period for the real discount rate.

8. The social rate of time preference reflects the fact that most projects conducted for the public good should provide benefits for future generations. In these cases, the time value of money (and the discount rate) is lower because there is a preference to more equally allocate benefits and costs across time.

Exhibit 9. Understanding inflation and discounting.

An inherent problem in project evaluation or decision analysis is the difficulty of making value comparisons among projects that are not measured in equal units. Even when values are stated in monetary units such as dollars, the values still may not be comparable, for at least two reasons:

1. ***Inflation***. Expenditures typically occur at various points in the past or future and are therefore measured in different value units because of changes in price (e.g., a 1980 dollar would, in general, have purchased more real goods and services in 1980 than would a 2015 dollar in 2015). A general trend toward higher prices over time, as measured in dollars, is called inflation. A general trend toward lower prices is called deflation. Dollars that include the effects of inflation or deflation over time are known as nominal, current, or data year dollars. Dollars that do not include an inflation or deflation component (i.e., their purchasing power remains unchanged) are called real, constant, or base year dollars.
2. ***Discounting***. Costs or benefits (in constant, real dollars) occurring at different points in time – past, present, and future – cannot be compared without allowing for the opportunity value of time. The opportunity value of time as it applies to current versus future funds can be understood in terms of the economic return that could be earned on funds in their next best alternative use (e.g., the funds could be earning interest), or the compensation that must be paid to induce people to defer an additional amount of current-year consumption until a later year. Adjusting for the opportunity value of time is known as discounting.

Analytically, adjusting for inflation and discounting are entirely separate concerns, and they should not be confused by attempting to calculate both at once. Instead, future costs and benefits of a project should be expressed in real dollars and then discounted to the present at a discount rate that reflects only the opportunity value of time (known as a real discount rate). This is because public sector project benefits should be dependent only upon real gains (cost savings or expanded output), rather than real gains plus price effects, or inflation.

If future costs and benefits of a project are provided in nominal dollars, the conversion of these nominal dollars to real dollars can be accomplished through the use of applicable indexes as follows:

$$\textbf{Dollars}_{\textbf{(base year)}} = \textbf{Dollars}_{\textbf{(data year)}} * \textbf{Price Index}_{\textbf{(base year)}} / \textbf{Price Index}_{\textbf{(data year)}}$$

Inflation or price indexes are available for every possible product and service. The choice among indexes ranges from consumption indexes such as the CPI to a narrow sector or commodity (e.g., construction material costs).

Source: U.S. DOT, 2002.

Different escalation rates may be applied to various project inputs, including chemicals, materials, labor, and others. For example, escalation rates are often applied to construction pricing, which has experienced uncommon escalation in recent years with rates between 6% and 10% per annum (in nominal terms). Fuel and energy price escalation can also have a significant effect on overall project costs.

Putting lifecycle analysis components together

Exhibit 10 shows a simplified lifecycle cost comparison of two different approaches for CSO control: a gray infrastructure approach and a green infrastructure approach. For the purposes of this example, we assume the quantification of one key project benefit: gallons of CSO reduction. Key assumptions include a 3% discount rate and a 30-year analysis period. In Exhibit 10, the green infrastructure alternative costs more than the gray infrastructure alternative. In some cases, however, green infrastructure solutions may be less costly than a gray alternative. Similarly, projects that incorporate efficiency or reuse components may also cost less than the corresponding "gray" alternative.

In Exhibit 10, the total (non-discounted) upfront capital costs of the gray infrastructure alternative ($30 million) are greater than those associated with the green infrastructure alternative ($24 million). However, in this example the ongoing O&M costs associated with the green alternative are quite a bit higher than those associated with the gray alternative. Over a 30 year-operation period, the total cost of the green alternative, including present value capital and O&M, is about $11.5 million greater than the gray alternative. Both alternatives meet the same objective of achieving 10,000,000 gallons of capture per year, although on a somewhat different timeline. Thus, in a traditional cost-effectiveness analysis, the gray infrastructure alternative would be selected as the preferred alternative because it is less expensive on a cost-per-unit basis. However, as noted in Step 6 of this guidance, the green infrastructure alternative provides a number of co-benefits that the gray infrastructure alternative does not provide. When these benefits can be easily monetized, they should also be included in the lifecycle analysis.

In addition, the example shown in Exhibit 10 compares two alternatives that achieve the same benefit – 10 million gallons of stormwater capture per year. However, in some cases, the alternatives that the project applicant is considering will result in different levels of benefits. When this occurs, it is important to compare the cost-effectiveness of the two alternatives (i.e., cost per unit of benefit achieved), as well as the total benefits that each alternative will achieve over time. This includes the primary water quality benefits (e.g., gallons of stormwater capture), as well as any other financial, social, and environmental benefits that the project applicant evaluates qualitatively in Step 6.

Within this same framework, project applicants can also identify "break-even points" or the ROI associated with different improvements. For example, Exhibit 11 shows the payback period for a hypothetical energy-efficiency project. This example assumes a $4.5 million (non-discounted) capital investment to improve energy efficiency over 3 years. As shown, compared to a baseline without these improvements, the project would result in an annual energy savings of $300,000 per year, resulting in a cumulative present value savings of more than $5.6 million over 30 years. This compares to total present-value costs of the improvements of approximately $4.37 million. As shown, total energy savings begin to exceed total investment costs in year 24 of the project.

Year	Gray infrastructure solution					Green infrastructure solution				
	Key project benefit (gallons of capture)	PV benefit (gallons of capture)	Capital costs	O&M costs	PV total	Key project benefit (gallons of capture)	PV benefit (gallons of capture)	Capital costs	O&M costs	PV total
2015			$10,000,000		$10,000,000			$4,000,000		$4,000,000
2016			$10,000,000		$9,708,738	1,666,667	1,618,123	$4,000,000	$283,333	$4,158,576
2017			$10,000,000		$9,425,959	3,333,333	3,141,986	$4,000,000	$566,667	$4,304,521
2018	10,000,000	9,151,417		$1,000,000	$915,142	5,000,000	4,575,708	$4,000,000	$850,000	$4,438,437
2019	10,000,000	8,884,870		$1,000,000	$888,487	6,666,667	5,923,247	$4,000,000	$1,133,333	$4,560,900
2020	10,000,000	8,626,088		$1,000,000	$862,609	8,333,333	7,188,407	$4,000,000	$1,416,667	$4,672,464
2021	10,000,000	8,374,843		$1,000,000	$837,484	10,000,000	8,374,843		$1,700,000	$1,423,723
2022	10,000,000	8,130,915		$1,000,000	$813,092	10,000,000	8,130,915		$1,700,000	$1,382,256
2023	10,000,000	7,894,092		$1,000,000	$789,409	10,000,000	7,894,092		$1,700,000	$1,341,996
2024	10,000,000	7,664,167		$1,000,000	$766,417	10,000,000	7,664,167		$1,700,000	$1,302,908
2025	10,000,000	7,440,939		$1,000,000	$744,094	10,000,000	7,440,939		$1,700,000	$1,264,960
	.	.	.	.		.	.		.	.
	.	.	.	.		.	.		.	.
2045	10,000,000	4,119,868		$1,000,000	$411,987	10,000,000	4,119,868		$1,700,000	$700,377
2046	10,000,000	3,999,871		$1,000,000	$399,987	10,000,000	3,999,871		$1,500,000	$599,981
2047	10,000,000	3,883,370		$1,000,000	$388,337	10,000,000	3,883,370		$1,200,000	$466,004
2048			($5,000,000)		($1,885,131)	10,000,000	3,770,262		$900,000	$339,324
2049						10,000,000	3,660,449		$600,000	$219,627
2050						10,000,000[a]	3,553,834		$300,000	$106,615
2051								($6,000,000)		($2,070,195)
Totals:					$45,724,862					$53,058,051
Cost effectiveness (PV $/PV gal)					$0.25/gal					$0.28/gal

Stormwater capture benefits realized as soon as first green infrastructure project comes online

Stormwater capture benefit begins after project is constructed

30 years of operation

30 years of operation after last project is implemented

Salvage value included as a benefit at the end of the asset's life (negative cost)

RSL included here as benefit because the green infrastructure alternative has a longer expected life

O&M costs begin to decline in 2046 because GI projects implemented in 2016 begin to reach the end of their useful life and are therefore no longer maintained.

PV: present value.

a. Because the green infrastructure alternative has a longer project life, stormwater capture benefits are not phased out the same way they are phased in as projects come online. This helps to offset the difference in costs because the green infrastructure alternatives will continue to result in additional capture after the analysis period.

Exhibit 10. Example lifecycle analyses for hypothetical green and gray infrastructure project alternatives.

Energy efficiency project – ROI						
Project year	**Calendar year**	**Capital costs**	**Present value costs**	**Energy savings (relative to baseline or "do nothing")**	**Present value energy savings**	**Cumulative present value savings**
1	2015	$1,500,000	$1,500,000			
2	2016	$1,500,000	$1,456,311			
3	2017	$1,500,000	$1,413,894			
4	2018			$300,000	$274,542	
5	2019			$300,000	$266,546	$541,089
6	2020			$300,000	$258,783	$799,871
7	2021			$300,000	$251,245	$1,051,117
8	2022			$300,000	$243,927	$1,295,044
9	2023			$300,000	$236,823	$1,531,867
10	2024			$300,000	$229,925	$1,761,792
.	.			.	.	.
.	.			.	.	.
.	.			.	.	.
21	2035			$300,000	$166,103	$3,889,202
22	2036			$300,000	$161,265	$4,050,466
23	2037			$300,000	$156,568	$4,207,034
24	2038			$300,000	$152,008	**$4,359,042**
25	2039			$300,000	$147,580	**$4,506,622**
26	2040			$300,000	$143,282	**$4,649,903**
27	2041			$300,000	$139,108	**$4,789,012**
28	2042			$300,000	$135,057	**$4,924,069**
29	2043			$300,000	$131,123	**$5,055,192**
30	2044			$300,000	$127,304	**$5,182,495**
31	2045			$300,000	$123,596	**$5,306,091**
32	2046			$300,000	$119,996	**$5,426,088**
33	2047			$300,000	$116,501	**$5,542,589**
34	2048			$300,000	$113,108	**$5,655,697**
	Totals	$4,500,000	$4,370,205	$9,300,000	$5,655,697	

Point at which cumulative savings exceed total costs.

Exhibit 11. Example lifecycle analysis of hypothetical energy efficiency project.

Note: Cumulative present value savings begin to exceed total present value costs between years 24 and 25 of the project.

Again, this is a simplified example; it does not take into account any potential losses in energy savings over time, and assumes that O&M costs (aside from energy costs) are the same under the baseline as they are under the project alternative that includes energy-efficient measures. When calculating savings over time, these considerations should be taken into account.

The information developed in lifecycle cost analyses can also be used to calculate total ROI. Exhibit 12 presents the ROI calculation associated with the energy-efficiency example presented above.

Exhibit 12. Calculating ROI.

The formula for calculating ROI is simple:

(Return – Investment) / Investment

In the hypothetical energy-efficiency project presented above, the total initial investment is $4.37 million (in present value terms), while total energy savings over 30 years amount to $5.66 million. Thus, the ROI is:

($5,655,697 – $4,370,205) ÷ $4,370,205 = 29%.

5.6 Step 6. Incorporate Non-Monetary Benefits and Costs

As noted above, it is not always feasible to incorporate all costs or benefits into cost-effectiveness or benefit-cost analyses in quantitative or monetary terms due to time and resource constraints. However, when evaluating project alternatives, it is important to describe these non-quantified benefits and costs in a meaningful, qualitative manner.

One way to do this is by using a simple scale to indicate the likely impact on overall project costs or net project benefits. Impacts can be qualitatively ranked to reflect relative outcomes that span from very negative to very positive. This simple ranking can provide a starting point for considering the effect of non-quantified benefits or costs across project alternatives. The suggested rating scale ranges from -5 to 5, where 1 and 2 are considered low impact, a rating of 3 is considered moderate, and a rating of 4 or 5 would be considered a high public impact. Negative ratings indicate costs, while positive ratings indicate benefits.

Exhibit 13 provides a simple example, again using a simplified green versus gray infrastructure project comparison. Because within this framework, the project applicant would have already quantified water quality improvements associated with these two alternatives (the key benefit), it is not included here. This simple ranking of benefits and costs can serve as a useful tool in evaluating project alternatives, particularly where the optimal project may not be the least-cost option. This ranking is incorporated into Step 7 in the final ranking of alternatives.

Exhibit 13. Comparison of non-monetary benefits and costs for green and gray infrastructure alternatives for increasing stormwater capture

	Green infrastructure alternative	Gray infrastructure alternative
Increased recreational opportunities	5	3
Increased local employment	3	2
Community aesthetics/livability	5	1
Reduced urban heat island affect	2	0
Improved habitat[a]	3	0
Energy savings	3	0
Reduced carbon footprint	3	0
Improved air quality	4	0
Climate resiliency	5	1
Construction/traffic disruption	-3	-1
Flexibility[b]	4	-4
Total	34	2

a. This does not include habitat improvements due to improved water quality. Improved water quality is included separately in the effectiveness criteria.
b. Due to its decentralized nature, the green infrastructure alternative offers much more flexibility in responding to evolving conditions and/or information. For example, if changing climate conditions indicate additional stormwater management controls are necessary, green infrastructure practices can be installed, on an incremental basis, in targeted areas of the city. Further, existing green infrastructure installations can be modified to increase effectiveness if conditions on-the-ground indicate the need for an alternative approach. By contrast, once gray infrastructure has been integrated into the city's stormwater management system, it is much more difficult to adapt to changing conditions. "Overbuilding" the infrastructure system upfront to accommodate the potential additional flows can be very costly.

5.7 Step 7. Summarize and Compare Alternatives, and Determine the "Optimal" Combination of Project Elements

The last step in the framework is to synthesize the information developed in the previous steps, and select the preferred project alternative. In some cases, this may mean combining certain elements of various alternatives to maximize ROI or community benefits, or to reduce risk.

One of the first steps within this framework is to determine the lifecycle costs and key benefits associated with the project alternatives that have passed through an initial feasibility screening. This allows the applicant to assess overall cost-effectiveness (on a unit-cost basis), and identify the least-cost alternative. When selecting and developing a final ranking of alternatives, it is important to assess whether the least-cost alternative is also the preferred option, or whether a higher-cost alternative (or a combination of alternatives) should be implemented. For example:

- Do any of the higher-cost alternatives provide important co-benefits that the least-cost alternative does not provide? This situation is exemplified in our simple comparison of green versus gray project alternatives in Steps 5 and 6.

- Does the higher-cost alternative become more expensive after a certain level of implementation (i.e., Do marginal costs increase?). If so, would reducing the level of implementation and combining it with different project elements result in a more effective alternative that maximizes benefits to the community? For example, the average cost of a proposed 1,000 acre-foot (AF) water reuse project may be $100/AF. However, providing the first 500 acre-feet may cost $50/AF on average, while the second 500 acre-feet may cost $150/AF due to the location of the recycled water customers. In this case, it may make sense to develop the first 500 acre-feet, and implement more cost-effective water-efficiency or gray infrastructure measures in order to meet the original project objective.

- Is there a high level of uncertainty surrounding the ability of the project to meet water quality goals? To some extent, this should be examined when developing project alternatives. In some cases there may be a need for additional redundancy in order to reduce overall project risk. For example, the results ofprograms to reduce total wastewater flows through household water conservation measures can be variable because they are dependent on actions by the customer. In this case, it may make sense to pair water conservation measures with alternative options (e.g., gray infrastructure), allowing for some redundancy to ensure that the project will meet water quality goals. Alternatively, fixed gray infrastructure projects may not allow for flexibility in dealing with uncertainty or variability in precipitation and runoff caused by climate change. Green infrastructure projects can supplement gray projects for additional flexibility, and can be implemented on an incremental basis.

In the final comparison of alternatives, these types of considerations can be formalized to some extent using multi-criteria decision analysis or a simple ranking/decision matrix. This will allow project applicants to develop an overall ranking of project alternatives based on costs, benefits, and other considerations (e.g., risk, uncertainty). First, the applicant scores (e.g., based on a scale of 1 to 10) each alternative across different cost, benefit, and feasibility categories. Project alternatives can then be directly compared. Through this process, project applicants may also identify the need to re-evaluate the structure or combination of project elements for alternatives that score relatively well.

Exhibit 14 shows an example of a decision framework based on a tool developed as part of a WateReuse Research Foundation project, which was designed to help utilities assess the benefits and costs of non-potable and indirect water-reuse project alternatives. This framework is developed within a triple bottom line framework, which provides an effective communication tool. This framework can easily be adapted to accommodate other project types.

	Alternative 1 (baseline)	Alternative 2	Alternative 3
Financial			
Capital cost			
Periodic replacement costs			
O&M costs			
Avoided costs of baseline projects			
Social			
Increased water supply reliability			
Local/neighborhood impact – visibility, noise, etc.			
Change in perceived public health impact			
Organization and business integration issues			
Agricultural benefits			
Environmental			
Meet discharge requirements			
Energy use/greenhouse gas emissions			
Environmental amenities associated with the project			
Downstream water quality impacts			
Groundwater impacts			
Constraints			
Regulatory			
Additional funding availability/financing			
Water rights			
Public opinion/acceptance			
Political leadership			
Total project score			

Exhibit 14. Example decision framework for water reuse project alternatives.

6. Conclusions

This document provides a comprehensive framework that project applicants can use to assess the costs and benefits of alternative options for meeting their CWSRF-related goals. States can also use this guidance as a way to certify that project applicants have incorporated efficiency, reuse, and recapture elements into their proposed projects, to the maximum extent practicable.

Although this framework contains seven comprehensive steps, project applicants can use the framework to assess both simple and complex projects. It can also be used to assess the many different types of projects that can be implemented with CWSRF funding. With this guidance, project applicants can go beyond traditional cost comparisons and identify the projects that maximize benefits and cost-effectiveness for their community over time.

To help project applicants implement this framework, we suggest that states develop a checklist or spreadsheet tool that corresponds to each step outlined above. This will help to ensure that project applicants apply the framework in a consistent way, and that they have considered and evaluated all feasible options for incorporating efficiency, reuse, and recapture elements.

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