Making the Right Choices for Your Utility:

Using Sustainability Criteria for Water Infrastructure Decision Making

February 2015

EPA United States Environmental Protection Agency

Table of Contents

Contributors

Jim Horne
U.S. EPA (Lead)

Bonnie Gitlin
U.S. EPA

Kellie Kubena
U.S. EPA

Deborah Nagle
U.S. EPA

Matt King
U.S. EPA

Cheryl Welch
Tualatin Valley Water District

Mike Beezhold
CDM Smith

This product was developed with assistance from Rob Greenwood, Morgan Hoenig, and Louis Sweeny at Ross Strategic (www.rossstrategic.com) under Contract EP-C-11-009 with the Office of Wastewater Management at the U.S. Environmental Protection Agency.

Introduction and Purpose of This Guide

Having the capacity to compare a range of infrastructure alternatives objectively is critical to a water or wastewater utility's long-term sustainability and its ability to serve the needs of its community. **This guide is designed to help water and wastewater utilities undertake these critical comparisons, in the context of meeting their existing regulatory requirements and improving the sustainability of utility operations.**

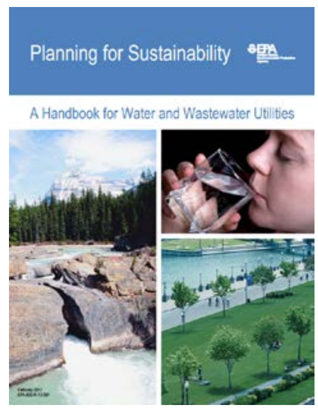
This document is designed to supplement the United States Environmental Protection Agency's (EPA) *Planning for Sustainability: A Handbook for Water and Wastewater Utilities* ("the Handbook"), issued in February 2012. The Handbook identifies a number of steps utilities can take to incorporate sustainability considerations into their existing planning processes, organized around four core elements of planning commonly used by utilities:

- **PLANNING ELEMENT 1: Goal Setting** – Establish sustainability goals that reflect utility and community priorities.
- **PLANNING ELEMENT 2: Objectives and Strategies** – Establish objectives and strategies for each sustainability goal.
- **PLANNING ELEMENT 3*:* Alternatives Analysis** – Analyze a range of alternatives based on consistent criteria.
- **PLANNING ELEMENT 4: Financial Strategy** – Ensure that investments are sufficiently funded, operated, maintained, and replaced over time.

One of most important of these elements is Alternatives Analysis. Alternatives Analysis involves objectively evaluating a range of infrastructure and/or operational alternatives in order to make informed choices about utility investments to ensure the long-term sustainability of the utility and the community it serves.

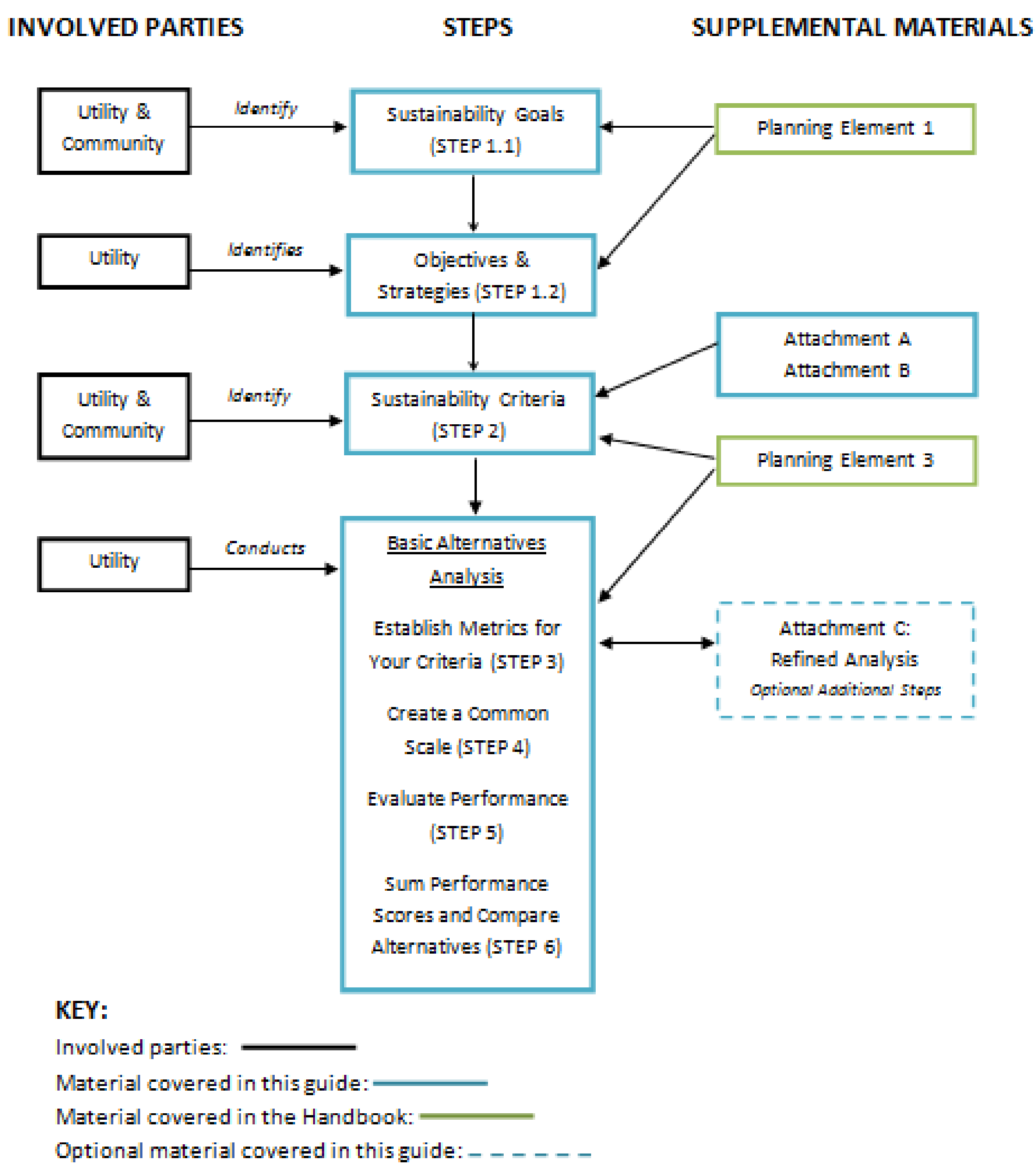
Planning Element 3 in the Handbook provides basic information and steps that utilities can take to incorporate sustainability criteria into their alternatives analysis activities. The Handbook also provides examples of how utilities of different sizes have approached this planning element; they cover a range from general, qualitative approaches, to full monetization of both costs and benefits.

This document supplements Element 3 in the Handbook (Alternatives Analysis) to provide more detailed guidance on alternatives analysis methods that utilities can use to



TIP: This document assumes a basic level of familiarity with the concepts presented in *Planning for Sustainability: A Handbook for Water and Wastewater Utilities.* EPA strongly encourages you to become familiar with the *Handbook* as you use the supplemental information in this guide. The Handbook can be found online: http://water.epa.gov/infrastructure/sustain/upload/EPA-s-Planning-for-Sustainability-Handbook.pdf incorporate sustainability criteria when evaluating infrastructure or operational alternatives and making decisions related to major infrastructure investments. It enables utilities of varying degrees of size and capacity, working with local officials and community members, to undertake a decision-making process that gives balanced consideration to a full range of alternatives – including green and decentralized technologies – to best meet the overall short and long-term needs of the community.

The diagram below provides a visual process for conducting an alternatives analysis. It also shows what information is available in this guide, what information is available in the Handbook, and what roles the utility and the community can play at each step.



What Are 'Sustainability Criteria'?

In conventional alternatives analysis, utilities typically focus on criteria based on technical performance (e.g., whether the alternative support meeting a regulatory endpoint such as a technology or water quality discharge standard) and the cost of doing so (i.e., the present value of the full life-cycle costs of the alternative), along with other important technical and operational criteria such as reliability, maintainability, and accessibility.

This guide acknowledges the importance of these conventional criteria, while providing guidance on how utilities can supplement these with a range of additional criteria and related methods to help your utility evaluate infrastructure and other operational alternatives more broadly, and in a consistent and transparent manner. In particular, this guide brings a focus to criteria that enable utilities to make decisions that reflect other community and utility sustainability goals and objectives related to economic, social, and environmental performance. **Some potential examples of sustainability criteria include greater use of green or decentralized approaches, ecological impacts such as habitat restoration, and reduced greenhouse gas emissions through greater energy efficiency.**

How This Document Can Help Your Utility

Infrastructure investments are often some of the largest and longest term financial commitments a community will make. They can represent a once-in-a-generation opportunity to influence the short- and long-term economic, social, and environmental sustainability and resiliency of your community. Let's not miss this opportunity. EPA believes that this guide will help to leverage these opportunities and equip utility managers, local officials and community members to:

1. Define your sustainability goals and objectives;
2. Better understand the options for the type of sustainability criteria you can use;
3. More efficiently define, scale, and measure these criteria; and
4. Better integrate these criteria into alternatives analysis methods to make sound and transparent decisions, leading to greater overall utility and community sustainability.

How Alternatives Analysis Methods Support the Criteria

There is a wide range of methods and approaches to incorporating "non-conventional criteria" into alternatives analysis. *Planning for Sustainability: A Handbook for Water and Wastewater Utilities*, under Planning Element 3, provides an overview and examples of the range of approaches available to utility managers from strictly qualitative to highly quantitative, including full monetization of the criteria being considered.

This supplemental guide does not seek to explore and explain this full range of methods available to utility managers. Rather, the purpose of this guide is to distill the experience utilities have had with incorporating sustainability criteria into alternatives analysis and provide you with a ***basic, sound, and easily explainable (and transparent)*** way to conduct the analysis in the context of working with community officials and citizens. The guide is also intended to be useful for utilities with either limited time or limited resources to devote to such analyses. The approach touches on all the elements of much more sophisticated methods, should the utility wish to employ these methods, while deliberately avoiding some of their more conceptually and methodologically challenging aspects. The guide indicates where "POSSIBLE REFINEMENTS" might be useful. Appendix C provides descriptions of some of these refinements, which are more complex analytical approaches for those interested in diving more deeply.

How to Get Started

This guide provides a step-by-step approach to take your utility from setting sustainability-oriented goals and objectives to establishing evaluation criteria and performance metrics for the purpose of making decisions through the calculation of "benefits scores" for each alternative, and finally to making a comparative ranking of all alternatives. In all, there are six steps:

- **Step 1 –** Determine the Sustainability Goals and Objectives Used to Make Decisions on Alternatives
- **Step 2 –** Determine the Criteria You Will Use to Support Analysis of Your Objectives
- **Step 3 –** Establish the Metrics for Your Selected Criteria
- **Step 4 –** Create a Common Scale for Your Criteria
- **Step 5 –** Evaluate the Performance of Each Alternative
- **Step 6 –** Sum Performance Scores for Each Alternative and Compare Alternatives

EXAMPLE: SMITHTOWN UTILITY DISTRICT

Throughout this guide, we will the "Smithtown Utility District" as an example to illustrate how a utility can work through and implement each of the six steps to incorporating sustainability criteria into alternatives analysis.

The Smithtown Utility District (SUD), a municipal wastewater treatment system with a single treatment facility, needs to comply with new regulations and has under consideration two alternatives. To keep the example simple, both alternatives deliver identical regulatory, reliability, and maintainability performance. Alternative 1 has a full life-cycle, net present value cost of $12 million; Alternative 2 has a $6 million cost.

- **Alternative 1: Provides a treatment upgrade that addresses the new regulatory requirements and includes leveraging the new investments to enhance biogas to energy production at the treatment plant. This alternative does require plant expansion with substantial encroachment on an existing residential neighborhood, as well as the conversion of what is currently open space to facility property.**
- **Alternative 2: Provides a treatment upgrade that addresses the new regulatory requirements, but does not alter the current energy production capability of the plant. This alternative maintains the existing footprint of the plant, but it uses the construction activities as an opportunity to reduce permeable surface wherever possible.**

Let's Get Started…

STEP 1: Determine the Sustainability Goals and Objectives Used to Make Decisions on Alternatives

KEY TERMS

Goals: Broad, qualitative statements of what the utility hopes to achieve.

Objectives: Specific, measurable statements of what will be done to achieve goals within a particular time frame.

Strategies: General approaches or methods for achieving objectives and resolving specific issues. Strategies help to answer the question "How will we accomplish our objectives?"

The first step in building sustainability criteria into alternatives analysis is to **set sustainability goals** and **identify objectives and strategies** for reaching these goals.

[STEP 1.1] GOAL SETTING: Establish sustainability goals that reflect utility and community priorities.

To provide a foundation as a way to incorporate sustainability throughout your planning processes, your utility should set sustainability goals. The goals should be broad, high-level statements that define the utility's aspirations for improving its sustainability.

In the context of goal setting, sustainability can be broadly defined using the following elements, commonly known as the triple bottom line:

(1) Environmental sustainability.
(2) Social sustainability.
(3) Economic sustainability.

Whenever practicable, your utility should consult with community members, customers, decision makers, and other key stakeholders when defining sustainability goals. This process could be incorporated into other existing planning processes – either community planning processes or utility long-term planning. Another source of insight for goal setting could be talking to neighboring utilities about the priorities that they have deemed important. Down the road, these utilities could also become partners in pursuing your sustainability-related initiatives, helping you to accomplish your goals.

TIP: Discuss your utility's sustainability goal setting as part of a broader planning process, such as an update to the community development plan.

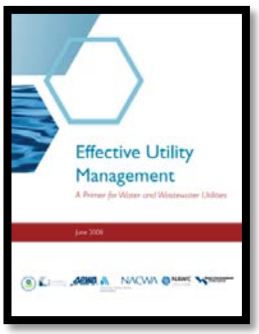
Key Questions to consider when setting sustainability goals include:

- Questions for your utility:
    - What opportunities do our infrastructure and operations provide for increased sustainability and improved performance?
    - Has an assessment helped to identify gaps in technical, managerial, or financial capacity that could be addressed to improve system performance or resilience?

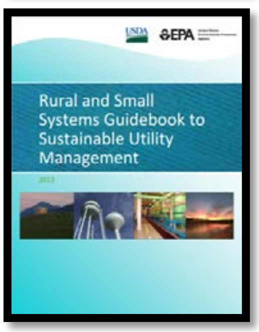
- How can strategies for meeting regulatory requirements complement our utility's sustainability goals?

- Questions for the community:
  - Are there existing community plan or "vision" documents that include sustainability priorities? Examples of such priorities might include greater access to public transportation, increased amounts of open space, or reductions in greenhouse gas (GHG) emissions
  - Are there other important resources in the community that stakeholders want to see created, preserved or enhanced (e.g., wetlands, open space, or parks)?
  - Are other community departments (e.g., transportation) pursuing sustainability goals?

Key Resources that utilities might want to look at when setting sustainability goals include:



Effective Utility Management: A Primer for Water and Wastewater Utilities
The *Primer* presents a framework for water and wastewater utility managers to use when assessing the effectiveness of their utilities. The framework is based on a series of 10 Attributes of Effectively Managed Utilities and Keys to Management Success.
Available online:
http://water.epa.gov/infrastructure/sustain/upload/2009_05_26_waterinfrastructures_tools_si_watereum_primerforeffectiveutilities.pdf



Rural and Small Systems Guidebook to Sustainable Utility Management
The *Guidebook* uses the same Effective Utility Management framework as the *Primer*, but is tailored to the needs of rural and small systems.
Available online:
http://water.epa.gov/infrastructure/sustain/upload/Rural-and-Small-Systems-Guidebook_1-20-15_508.pdf

Moving Toward Sustainability: Sustainable and Effective Practices for Creating Your Water Utility Roadmap
Using the same Effective Utility Management framework as the two previous documents, this document identifies a series of proven and effective managerial practices to improve utility operations over time and move toward sustainability, at a pace consistent with utility needs and the needs of its community.
Available online:
http://water.epa.gov/infrastructure/sustain/upload/Sustainable-Utilities-Roadmap-12-10-14_508.pdf

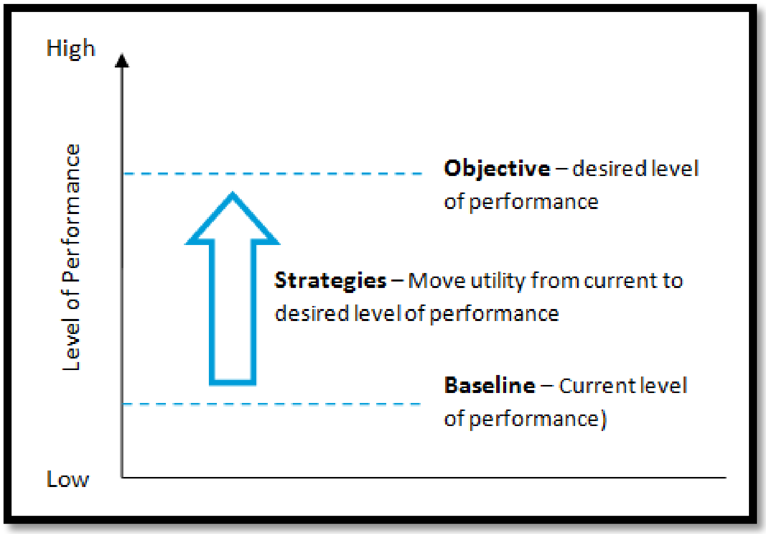
Once you have set your sustainability goals, **don't forget to...**

- ✓ Document your goals and communicate them, both internally and externally.
- ✓ Make plans for how often the goals should be assessed for progress or updated.

For additional information about goal setting, refer to PLANNING ELEMENT 1 in ***Planning for Sustainability: A Handbook for Water and Wastewater Utilities***.

[STEP 1.2] OBJECTIVES AND STRATEGIES: Establish objectives and strategies for each sustainability goal

Once you have defined your sustainability goals, you should set explicit objectives and strategies for each goal. Each objective will represent a specific outcome that your utility will work toward; strategies will describe approaches for reaching these outcomes. When setting objectives and strategies, it is also useful to determine the baseline for performance, which represents your utility's current level of performance and is needed to measure progress towards the objective.



When setting objectives, take current resources, conditions, and constraints into account. The most effective objectives and strategies follow the SMART principles:

- **S**pecific – utilities specify exactly what will be achieved
- **M**easurable – utilities have the ability to measure whether they are meeting the objectives
- **A**ttainable – utilities can realistically achieve the objective in the time period specified
- **R**ealistic – utilities can achieve the objective with the capacity, funding, and other resources available
- **T**ime-based – utilities set a timeframe for achieving the objective

When developing strategies to achieve each objective, it is typically best to start by brainstorming. When brainstorming, there is no limit on the number of strategies allowed, and no strategy is off the table. After a complete brainstorm has taken place, then strategies can be evaluated and narrowed down based on which can realistically be implemented, and which will give your utility the best returns with regard to its sustainability goals.

After setting objectives and strategies, you should determine baseline information for each objective. They can either be a specific quantitative measurement (e.g., kilowatt hours of energy used per month for an objective related to energy savings) or a qualitative description of current conditions.

TIP: Some objectives might not be quantifiable. In assessing some elements of sustainability (especially those related to social sustainability), it might be difficult to come up with an objective that includes a specific numerical goal. In these cases, work to set concise objectives and describe baseline performance qualitatively. For example, if a utility is seeking to enhance livability in its community, an objective could be "enhance public space." Step 4 in this guide includes additional information on how these types of objectives can be assessed.

Key Questions to consider when identifying objectives and strategies include:

- Are there strategies that will result in dual benefits (i.e., will they help advance more than one sustainability goal or objective)?
- How many objectives and strategies can our utility realistically take on related to each sustainability goal?
- When setting timelines, how many sustainability objectives can realistically be addressed at one time? What are the priorities for which to address first?

TIP: When first starting with alternatives analysis, focus on a limited number of objectives to help simplify the process.

EXAMPLES OF SUSTAINABILITY GOALS WITH RELATED OBJECTIVES AND STRATEGIES

Goal	Objectives and Strategies
Utility seeks to engage in climate change mitigation efforts.	OBJECTIVE: Reduce net GHG emissions by 20 percent over three years. STRATEGIES: (1) Conduct an initial audit to establish a baseline level of annual GHG emissions (2) Identify major sources of direct (e.g., methane output) and indirect (e.g., energy consumption) GHG emissions associated with utility operations (3) Identify methods for reducing or eliminating emission sources
Utility seeks to enhance community livability.	OBJECTIVES: (1) Improve community aesthetics (2) Enhance public space STRATEGIES: (1) Place utility infrastructure in locations least visible to community members (e.g., not near residential or commercial developments) (2) Seek project options that provide opportunities to add to existing or new park or recreational areas

EXAMPLE: SMITHTOWN UTILITY DISTRICT

In addition to conventional goals such as regulatory compliance and effectiveness and reliability of treatment performance, SUD, through consultation within its community, has identifies three sustainability goals:

(1) Improve community livability
(2) Improve energy performance
(3) Enhance ecosystem functions

As captured in the Table below, SUD also works with its community to create a single objective for each goal. (Note that it would often be the case that each sustainability goal would have more than one

objective associated with it.) These objectives will form the basis for comparing the performance of any project alternatives SUD will need to evaluate in the future.

Goal	Objective
Improve community livability	Create greater compatibility of utility infrastructure with community conditions.
Improve energy performance	Decrease million gallon (mg) energy requirements by 20 percent over five years.
Enhance ecosystem function	Increase community stormwater infiltration by 10 percent over three years.

For additional information about **objectives an**d strategies, refer to PLANNING ELEMENT 1 in ***Planning for Sustainability: A Handbook for Water and Wastewater Utilities***.

STEP 2: Determine the Criteria You Will Use to Support Analysis of Project Alternatives

KEY TERMS

Alternatives: Within a strategy, specific infrastructure investments or operational changes for achieving objectives.

Criteria: Measures or conditions used to evaluate alternatives.

Once you have determined your goals and objectives, you will need to determine the criteria that you will use to evaluate alternatives for future projects, programs, and investments. Historically, utilities have tended to focus on conventional criteria (e.g., cost effectiveness, payback period, or return on investment). This guide, however, will focus on **sustainability** criteria – specifically criteria related to community environmental, social, and economic performance.

Attachment A includes examples of potential evaluation criteria that you can consider. The list is not meant to be exhaustive, but can provide a starting point for criteria development. The criteria in this list are drawn from the following sources, which can also be good resources for utilities looking for additional information.

Key Resources that your utility might want to look at when selecting sustainability criteria include:

- ISI Envision Infrastructure Rating System http://www.sustainableinfrastructure.org/rating/
- UN Commission on Sustainable Development Indicators http://www.un.org/esa/sustdev/natlinfo/indicators/guidelines.pdf
- Environmental Sustainability Index (Yale Center for Environmental Law and Policy) http://envirocenter.yale.edu/programs/environmental-performance-management/environmental-sustainability-index
- Global City Indicators Facility http://www.cityindicators.org/
- Minneapolis Sustainability Indicators http://www.ci.minneapolis.mn.us/sustainability/indicators/sustainability_indicators
- Sydney 2030 - http://www.sydney2030.com.au/

POSSIBLE REFINEMENTS – ACCOMMODATING THE DIFFERING RELATIVE IMPORTANCE OF YOUR SUSTAINABILITY GOALS

When establishing the criteria that you will use to assess different alternatives, you may find that your community values certain sustainability goals more or less than others. If this is the case, you have the option of weighting the goals (and associated objectives and criteria) differently in your analysis. Refinement 1 in **Attachment C** provides a description of how you can adjust criteria weighting in this manner.

Once selected, criteria should be clearly defined and communicated so that there is no question about the scope of each. Definitions should be clear about the relationship of each criterion to alternatives. Below are examples of definitions of ten different criteria for the three different pillars of triple bottom line sustainability.

Environmental Criteria – *Example Definitions*

Ecosystem Impacts: Utility operations and infrastructure choices can influence or impact surrounding ecosystems by affecting ecological structure, or key ecological functions, or changing the makeup of the ecosystem as a result of land use, construction, or discharge practices. This criterion supports evaluating project alternative performance relative to ecosystem effects addressing such areas as impermeable surface changes, habitat extent or alteration, and species diversity. *[Examples for this criterion are included in Attachment B]*

Energy Impacts: Water and wastewater utilities are highly energy-intensive, and project alternatives will exhibit differences in their energy requirements and their potential for ongoing contribution to energy optimization for the utility system. This criterion supports evaluating the comparative energy performance (use or production) of project alternatives. Some wastewater treatment plants are now being called Resource Recovery facilities (WEF 2013). *[Examples for this criterion are included in Attachment B]*

Greenhouse Gas Impacts: Water sector utilities, as large energy users, contribute to GHG emissions through fossil fuel and electricity-based energy use, as well as through methane and nitrous oxide emissions from operations like digesters. This criterion supports evaluation of project alternatives from the standpoint of their impact on such areas as increased energy efficiency (a leading way utilities can reduce GHG emissions), better optimized operations to reduce methane or nitrous oxide emissions, utilization of biogas for energy production (e.g., combined heat and power), and handling and disposition of biosolids. *[Examples for this criterion are included in Attachment B]*

Water Impacts: This criterion supports the evaluation of project alternatives from the perspective of the potential for affecting different aspects of the water cycle. Utilities reside at a critical nexus in the overall water cycle within their communities, operating across the water withdrawal, use, and replenishment continuum. Project alternatives hold the potential to reflect differences in their impacts on the place, timing, and amount of water withdrawals, the ratio of consumptive to non-consumptive use, the degree of water use efficiency (e.g., revenue versus non-revenue water) and conservation, and the place, timing, and amount of water replenishment.

Social Criteria – *Example Definitions*

Aesthetic Impacts: Utility investments can affect the community's aesthetic composition, for example, by enhancing or degrading the character of a neighborhood, blocking or enhancing views, or adding industrial structures that either fit with the character of, or are out of place in, a neighborhood. This criterion supports evaluating the inherent aesthetic impacts of a project alternative separate from any consideration of mitigation measures that could be used to reduce undesirable effects. For example, the community could construct an aesthetic compatibility index to rate alternatives.

Educational Opportunities: Utility project alternatives might or might not be inherently conducive to informing and educating the public about the value of water and the essential service water and wastewater systems provide to their communities. This criterion supports evaluating how conducive a project alternative will be to conveying these and related messages through ready access to and interactivity with the location, posting of educational signage, tour opportunities, or other messaging opportunities. *[Examples for this criterion are included in Attachment B]*

Public Space Enhancement: Utility operations can impact public spaces through the type and location of facilities or infrastructure (e.g., gray, green, and decentralized). This criterion supports the evaluation of (1) direct impacts on public spaces such as waterfront areas, green spaces, parks, or other public gathering places by increasing/decreasing access, quality, or availability, and (2) opportunities created when the project alternative is conducive to creating or enhancing existing public spaces through creative utilization of land resources (e.g., the multi-purpose benefit of creating a park when covering a finished water reservoir). *[Examples for this criterion are included in Attachment B]*

Economic Criteria – *Example Definitions*

Economic Base Impacts: The decisions that utilities make relative to location and capacity of infrastructure and facilities can affect property values, commercial, industrial, and retail activity, and residential patterns in neighborhoods. This criterion seeks to account for these external economic impacts for each project alternative under consideration.

Enhanced Resiliency: Project alternatives can, in and of themselves, be more or less resilient – have the inherent ability to recover from or adjust easily to unforeseen events or change – or they can contribute differently to overall utility or community resiliency. This criterion supports evaluating project alternatives from the perspective of how well they help the utility/community to strengthen its ability to prepare for, respond or adapt to, and/or recover from significant man-made or natural disasters through vulnerability or consequence reduction.

Community Design Consistency: Many communities have established sustainability or other long-range plans that seek to influence the livability and quality of life within their jurisdictions, including density, access to transportation service, and land use pattern objectives. This criterion supports evaluating project alternatives for their degree of support or enhancement to these types of urban design considerations.

When developing sustainability criteria, **don't forget that…**

- ✓ Sustainability criteria are not meant to supplement regulatory (e.g., biologic oxygen demand) or conventional technical performance (e.g., maintainability).
- ✓ Sustainability Criteria should address at least one of the three triple bottom line pillars of sustainability – environmental, social, and economic.
- ✓ Each criterion should be screened for potential relationships to the impacts that a water or wastewater system project design, construction, or operation could have.
- ✓ Each utility objective with direct relevance to the alternatives under consideration should have at least one criterion set for it.

EXAMPLE: SMITHTOWN UTILITY DISTRICT

SUD now moves to apply its community sustainability goals and related objectives in the context of considering alternatives to meet a new regulatory requirement. It must examine the nature of possible impacts of the alternatives to select evaluation criteria with direct relevance to the alternatives under consideration. To support the three objectives it has set in support of its sustainability goals, SUD works with the community to identify criteria to evaluate alternatives relative to these objectives. The table below provides the criteria that they select. These criteria are far from exhaustive relative to the identified objectives and the alternatives under consideration. Under an actual alternatives analysis a utility can anticipate having additional criteria for each objective.

Goal	Objective	Criteria
Improve community livability	Create greater compatibility of utility infrastructure with community conditions.	Neighborhood aesthetic impact
Improve energy performance	Decrease million gallon (mg) energy requirements by 20 percent over five years.	Net electricity consumption
Enhance ecosystem function	Increase community stormwater infiltration by 10 percent over three years.	Permeable surface impact

For additional information about determining criteria, refer to PLANNING ELEMENT 3 in ***Planning for Sustainability: A Handbook for Water and Wastewater Utilities***.

STEP 3: Establishing the Metrics for Your Selected Criteria

Under Step 2, your utility identified criteria associated with the goals and objectives established during Step 1. In Step 3, you will "build out" the criteria by creating a performance basis for evaluating performance through criteria and means of measurement using metrics for each criterion.

Each sustainability objective (Step 1) will be supported by one or more evaluation criterion (Step 2), and each criterion will be supported by a performance scale, which is used to evaluate (score) each alternative under consideration. Performance scales represent the different levels of performance (outcomes or impacts) that can result from an alternative. The performance scale constructed for each criterion needs to apply across the full range of alternatives under consideration (we will address this as part of Step 4). You will likely use two basic means to measure performance: direct measurement (when an obvious quantitative means is available); and a constructed metric for inherently qualitative criteria.

POSSIBLE REFINEMENTS:

CONVERTING NATURAL SCALES TO CONSTRUCTED SCALES

When working with readily quantified and measurable criteria such as those measured in acres or kWh, you have the option of making specific performance estimates for each alternative and then converting those estimates into a more precise constructed benefits scale. This approach is referred to as "normalizing" a direct measurement metric to a common constructed benefits scale score. It is covered in Refinement 2 in **Attachment C**.

Direct Measurement

Direct measurement is undertaken with criteria that can be readily quantified and measured. For example, electricity consumption can be readily measured as kilowatt hours (kWh) per month, and permeable surface impact can be readily measured in acres. In these cases, kWh and acres would be the metrics for each criterion, respectively. When creating the performance scale, you will first select a desired, specific performance metric, (e.g., acres, time, kWh, etc.), and then set a range that incorporates the anticipated performance endpoints across all of the alternatives to be examined.

Constructed Measurement

Constructed measurement supports criteria that are qualitative in nature (e.g., aesthetic impacts) or criteria for which your ability to provide precise quantitative performance estimates is constrained. Constructed measurement can come in a variety of forms, but it can typically be well handled with a simple 0 to 5 or 0 to 10 scale. Essentially, constructed measurement is used to express qualitative criteria in a quantitative manner to establish the ability to compare otherwise unlike performance characteristics of an alternative (e.g., comparing an aesthetic impact to an ecosystem impact). Many criteria likely to be used by water sector utilities have the potential for either positive or negative outcomes (for example, community aesthetics might decrease or increase depending on the alternative selected). As a result, a minus five (-5) to plus five (+5) constructed measurement approach can often serve your analysis well. Attributes of a good constructed measurement include the following:

- The measurement matches how precisely the criterion can be characterized.
- The measurement corresponds to natural clusters or thresholds in the criteria that will make it easier to rate an alternative.
- The incremental benefit provided by moving up each level of the scale is the same (or very similar).
- The range of the scale corresponds to the widest performance range possible of the alternatives under consideration.

EXAMPLE: SMITHTOWN UTILITY DISTRICT

After establishing criteria related to each of its goals, SUD derives the following performance basis and means of measurement for each of the identified criteria:

Goal	Objective	Criteria	Metric (Means of Measurement)
Improve community livability	Create greater compatibility of utility infrastructure with community conditions.	Neighborhood aesthetic impact	Aesthetic compatibility index
Improve energy performance	Decrease million gallon (mg) energy requirements by 20 percent over five years.	Net electricity consumption	Kilowatt hours (kWh) per month
Enhance ecosystem function	Increase community stormwater infiltration by 10 percent over three years.	Permeable surface impact	Acres of permeable surface

SUD is now ready to move to Step 4 and establish a common benefits scale for comparing its two alternatives across these three criteria.

STEP 4: Create a Common Scale for Your Criteria

Under Step 4, your utility will establish a consistent basis for comparing the criteria to ensure the validity of the aggregated benefit score for each alternative. Establishing a standard benefits scale to compare criteria becomes critical to achieving this outcome. Under Step 3, SUD established three separate bases of measuring alternative performance relative to the selected criteria: an aesthetic compatibility index, kWh, and acres. These are not directly comparable in their current form: they represent trying to compare apples to oranges to bananas.

There are two key considerations when establishing the comparable basis depending on the scales (direct or constructed measures) developed for each criterion. First, constructed measures used across all criteria are most easily utilized if established on a consistent basis from the outset. Second, when you have criteria using direct, quantitative metrics to capture performance (e.g., net kWh consumption), all of the metrics, along with any constructed metrics, must be placed on a comparable basis. The simplest, and most straight forward means to provide this comparable basis, is to depict your direct metrics on a consistent constructed metric basis from the outset.

POSSIBLE REFINEMENTS – ADJUSTING FOR DIFFERENCES IN BENEFITS

Performance outcomes along the performance continuum associated with any criteria might not reflect a linear, stepwise increase in the benefits provided. For example, you might continue to derive enjoyment when moving from one to two scoops of ice cream, but by the time you've eaten ten scoops, an eleventh probably will not be that desirable. The same situation might be in play with certain of your evaluation criteria. If this is the case, the different levels of the performance scale will require an adjustment to calculate a truly accurate representation of benefit. See Refinement 3 in **Attachment C** for a review of a method for addressing such benefit situations.

For most utilities, a minus 5 (-5) to plus five (+5) constructed benefit scale will accommodate the full range of criteria. By including a negative and positive range, it reflects that a utility can experience both negative and positive performance outcomes.

In this step, you simply establish the full range of anticipated performance of your full suite of alternatives relative to each of your performance criteria. You will then assign the ranges of performance to the constructed benefit scale. In the SUD example provided here, the performance metrics for each criterion have a common minus five (-5) to plus five (+5) constructed benefits scale established and the anticipated performance range for each criteria is divided into equal increments along the constructed scale.

EXAMPLE: SMITHTOWN UTILITY DISTRICT

In Step 3, SUD established the following performance basis for each of the three sustainability criteria to be used for evaluating its alternatives:

- **Neighborhood aesthetic compatibility index for aesthetic impacts;**
- **kWh per month for measuring net electricity impacts; and**
- **Acres for measuring net permeable surface impacts.**

Under Step 4, SUD decides to use a minus five (-5) to plus five (+5) constructed benefits scale to form a comparable performance evaluation basis. SUD's next step is to decide the likely range of performance for each of the alternatives (to establish the end points for each criterion), and assign interim ranges of performance to the increments of the minus five (-5) to plus five (+5) constructed scale. The constructed benefit scales for each of the criteria appear in Attachment B; they are repeated here for easy reference.

- **For Aesthetics, SUD has creates a basic, and fairly subjective, qualitative index that ranges from "substantial aesthetic incompatibility" through "no impact" and out to "substantial contribution to improved aesthetics," and assigns the endpoints at -5 and +5. By doing this, SUD translates a qualitative performance basis into a quantitative index that will allow for comparability to other sustainability criteria. [Note that when addressing inherently qualitative and subjective criteria, it is important to try to define or describe, through examples or other means, the basis for the judgments that will be made. In this case, the example of an industrial facility placed in a residential neighborhood is used for this purpose.]**

- **For Net Electricity Consumption, SUD has estimates that the likely end points of performance for the two alternatives is somewhere around plus or minus 275,000 kWh per month; these become the end points of its -5 to +5 constructed benefits scale. SUD then assigns approximately equal increments of net electricity consumption performance to each of the scale increments between -5 and +5. By doing this, SUD has translates an easily measured, quite objective, direct performance basis (kWh) into a constructed benefit scale format allowing for direct comparability to the aesthetics performance of alternatives.**

- **For Permeable Surface Impact, SUD estimates the likely end points of performance for the two alternatives as somewhere around plus or minus 40 acres of net permeable surface impact. These plus or minus 40 acres become the end points for the -5 to +5 performance scale. And, as with net electricity consumption, SUD assigns equal increments of net permeable surface impact to each of the constructed benefit scale increments of -5 to +5. At this point, all three performance criteria have been placed on a fully comparable basis, and SUD is prepared to move to Step 5, where it will evaluate each of the alternatives against these criteria.**

SMITHFIELD UTILITY DISTRICT SCORING CRITERIA

Scoring:	-5	-4	-3	-2	-1	0	1	2	3	4	5
CRITERION: Neighborhood Aesthetic Impact (METRIC: Aesthetic compatibility index)	Alternative has no compatibility with existing location (e.g., industrial above ground structure placed in residential neighborhood)					Alternative does not alter neighborhood character (e.g., facilities located underground or have a low profile creating no visual or other aesthetic impacts)					Alternative enhances neighborhood character by contributing improved visual conditions (e.g., green infrastructure alternative that has tree plantings)
CRITERION: Net electricity consumption (METRIC: kWh)	Alternative increases plant's energy consumption by 226,000 to 275,000 kWh per month	Alternative increases plant's energy consumption by 176,000 to 225,000 kWh per month	Alternative increases plant's energy consumption by 126,000 to 175,000 kWh per month	Alternative increases plant's energy consumption by 76,000 to 125,000 kWh per month	Alternative increases plant's energy consumption by 26,000 to 75,000 kWh per month	Alternative impacts plant energy consumption by an increase of up to 25,000 kWh or produces up to 25,000 kWh per month .	Alternative produces energy of 26,000 to 75,000 kWh per month	Alternative produces energy of 76,000 to 125,000 kWh per month	Alternative produces energy of 126,000 to 175,000 kWh per month	Alternative produces energy of 176,000 to 225,000 kWh per month	Alternative produces energy of 226,000 to 275,000 kWh per month
CRITERION: Permeable surface impact (METRIC: Acres)	Substantial addition to existing impermeable surfaces in the community (more than 50 acres of impermeable surface added)	Addition to existing impermeable surfaces in the community (36-50 acres of impermeable surface added)	Addition to existing impermeable surfaces in the community (21-35 acres of impermeable surface added)	Addition to existing impermeable surfaces in the community (11-20 acres of impermeable surface added)	Addition to existing impermeable surfaces in the community (1-10 acres of impermeable surface added)	No change to existing impermeable surface area	Decrease of impermeable surfaces from existing baseline (1-10 acres of permeable surface added)	Decrease of impermeable surfaces from existing baseline (11-20 acres of permeable surface added)	Decrease of impermeable surfaces from existing baseline (21-35) acres of permeable surface added)	Decrease of impermeable surfaces from existing baseline (36-50 acres of permeable surface added)	Substantial decrease of impermeable surfaces from existing baseline (more than 50 acres of new permeable surface)

STEP 5: Evaluate the Performance of Each Alternative

In Step 4, you created a common performance scale for all of your evaluation criteria. In this step, you will assess each alternative relative to its performance against each of the criteria. This step should be familiar to any utility that has conducted comparative analysis of alternatives using conventional performance criteria such as reliability, maintainability, and technical performance. Essentially, you will be looking at the design and performance parameters of the alternatives to estimate the nature of the impacts that can be expected relative to the evaluation criteria.

EXAMPLE: SMITHTOWN UTILITY DISTRICT

By completing the previous steps, SUD has prepared design parameters for its two alternatives and now moves to characterize performance for each of the evaluation criteria.

POSSIBLE REFINEMENTS:

PERFORMANCE UNCERTAINTY

Some uncertainly about the precise performance an alternative can deliver is not uncommon, and in the case where there is substantial (material) uncertainly, an adjustment to the process for deriving a benefit score is needed. Typically, the same experts/stakeholders best positioned to rate or establish performance for a given alternative are also best positioned to estimate the uncertainly of performance. Though many methods for addressing uncertainly exist, a relatively straightforward and common approach is to derive an “expected value” (probability-weighted outcome) for an alternative’s performance. This approach is covered in Refinement 4 of **Attachment C.**

Alternative 1:

- **<u>Livability as Evaluated through Aesthetic Impacts:</u> Alternative 1 involves an expansion of the exiting SUD treatment plant, which will bring the facility’s fence line and new above-ground industrial structures within site distance of an existing neighborhood. In discussions with its stakeholders, SUD concludes this represents a minor, negative aesthetic impact and assigns a minus one (-1) aesthetics score to this alternative.**
- **<u>Energy Performance as Evaluated through Net Electricity Generation</u>: Alternative 1 allows the facility to introduce enhanced biogas to energy operations in conjunction with infrastructure upgrades needed to meet new regulatory requirements. SUD expects this enhancement to support 325,000 kWh per month in electricity production, and the overall project “nets out” at 250,000 kWh per month in additional electricity available to the plant (operation of the new equipment requires 75,000 kWh per month in new electricity demand, thus the net figure of 325,000 kWh). This produces a scaled score of plus 5 (+5), because the “5” value covers a range of net electricity production from 226,000 to 275,000 kWh.**

- **<u>Ecosystem Function as Evaluated through Net Permeable Surface</u>: Alternative 1 requires expanding the current treatment plant beyond its current footprint and into adjacent, open space grassland. The design specifications for the new plant indicated a need for 9 additional acres of space, essentially all of which will now become impermeable surface (paved surfaces, and building/tank roofs). This impact produces a scaled score of minus 1 (-1), as the loss of 9 acres falls in the 1 to 10 acres of added impermeable surface range.**

Alternative 2:

- **<u>Livability as Evaluated through Aesthetic Impacts</u>: Alternative 2 involves no expansion of the exiting SUD treatment plant, and leaves all facilities well away from the existing neighborhood. The plant has never received complaints about the appearance of its structures, and in presenting this information to its stakeholders, SUD concludes that its existing structures do not have an aesthetic impact on the existing neighborhood. As a result, SUD assigns a zero (0) as the aesthetics score for this alternative.**
- **<u>Energy Performance as Evaluated through Net Electricity Generation</u>: Alternative 2 seeks to make the minimum necessary infrastructure upgrade investments to meet the new regulations. It does not add any enhancements for purposes of generating electricity. The new treatment process will require 70,000 kWh per month to operate (in addition to current plant monthly electricity requirements). This additional electricity demand produces a scaled benefit score of minus 1 (-1), as this alternative would increase the plant's monthly electricity requirements by between 26,000 and 75,000 kWh per month.**
- **<u>Ecosystem Function as Evaluated through Net Permeable Surface</u>: Alternative 2 maintains the treatment plant's existing footprint, but provides an opportunity to create green space within the plant fence lines as old structures are replaced by structures with smaller footprints. The net result of this conversion will be the addition of 11 acres of permeable surface, which produces a benefits score of plus 2 (+2) for this alternative.**

Criteria	Aesthetic Impact	Net Electricity Consumption	Permeable Surface Impact
Alternative 1	-1	5	-1
Alternative 2	0	-1	2

STEP 6: Sum Performance Scores for Each Alternative and Compare Alternatives

In Step 6, your utility will compare alternatives based on their performance, leading to a final decision on the preferred alternative. If care has been taken in the previous steps to establish a consistent basis for performance evaluation of each alternative across all selected criteria, this step becomes very straight forward. The "total benefit score" of each alternative is merely the sum of each of the individual criterion benefit scores.

We have not yet addressed the incorporation of costs into the alternatives analysis process. This is the point at which you can decide to maintain the benefits scores as separate evaluation factors, or to combine the benefit scores with the cost of the alternatives to derive a cost/non-monetized benefit calculation.

EXAMPLE: SMITHTOWN UTILITY DISTRICT

SUM PERFORMANCE SCORES

Under Step 5, SUD evaluated the performance of each alternative relative to the three criteria, and assigned specific performance (benefits) scores to each. The aggregate benefit scores for the two alternatives can now be calculated.

- **Alternative 1: Total Benefit Score = aesthetics (-1) + net electricity (+5) + net permeable surface (-1) = +3**
- **Alternative 2: Total Benefit Score = aesthetics (0) + net electricity (-1) + net permeable surface (+2) = +1**

Criteria	Aesthetic Impact	Net Electricity Consumption	Permeable Surface Impact	Total Score
Alternative 1	-1	5	-1	3
Alternative 2	0	-1	2	1

COMPARE ALTERNATIVES

Treating all the criteria as equally weighted, Alternative 1 achieves the higher benefit score, and this score is dependent on its very high performance relative to the net electricity performance basis. If cost was not a factor (which is unlikely), SUD would select Alternative 1. However, cost, (as usual) is a key evaluative aspect of SUD's analysis. The cost of Alternative 1 is $12 million, while the cost of Alternative 2 is $6 million, and both projects produce identical performance relative to the needed compliance with the new regulations. With cost considered, Alternative 1 remains the preferred option. Alternative 1 has a benefit/cost ratio of 3:12 (= 0.25); Alternative 2 has a benefit/cost ratio of 1:6 (= 0.17). Overall, the

alternative with the highest benefit/cost ratio is preferred. One way to think about this result is that Alternative 1 requires an expenditure of $4 million for each benefit point, while Alternative 2 requires an expenditure of $6 million for each benefit point.

Conclusion

Having the capacity to compare a range of infrastructure alternatives objectively is critical to a water or wastewater utility's long-term sustainability and its ability to serve the needs of its community. EPA recognizes that conducting an alternatives analysis that incorporates nonconventional sustainability criteria presents a challenge for many systems. Coupled with *Planning for Sustainability: A Handbook for Water and Wastewater Utilities,* this document provides a strong starting point for a utility to take the sustainability priorities of its community into account when doing long-term planning and making decisions about infrastructure updates.

For additional resources and information on sustainable utility management for water and wastewater utilities, please visit EPA's website: http://water.epa.gov/infrastructure/sustain/watereum.cfm.

Attachment A: Potential Evaluation Criteria

Economic Criteria

Affordability

All-Hazards Resilience (e.g., flood or drought tolerance)

Disaster Recovery Prospects

Economic Development Opportunity

Green Business Development (e.g., creating green jobs, utilization of sustainable companies/materials)

Grayfield or Brownfield Impacts (e.g., potential to repurpose degraded or unused lands)

Local Economic Development

- Local Employment Impact
  - Community Workforce Skills and Capabilities
  - Local Workforce Competitiveness
  - Local Labor Use
- Local Material Use
- Local Supplier Use

Environmental Criteria

Air Quality

Ecosystem:

- Biodiversity (e.g., preservation of biodiversity, restoration of biodiversity)
- Ecosystem Functions and Services (e.g., preservation or restoration of ecosystem functions and services)
- Floodplain Functions
- Green Space Preservation (e.g., preservation of habitat, riparian/aquatic areas, farmland, open space)
- Habitat Fragmentation/Integration (e.g., preservation of habitat connectivity or habitat restoration)
- High Ecological Value Land
- High Ecological Value Species
- Impermeable Surface
- Invasive Species (e.g., presence of exotic species, potential to introduce exotic species)
- Land Disturbance

- Prime Farmlands
- Riparian and Aquatic Habitat
- Sensitive Areas
- Threatened/Endangered Species
- Wetlands

Energy:

- Energy Consumption
- Energy Intensity (unit of energy per unit of gross domestic product, GPD, produced)
- Energy Type (e.g., renewable)
- Net Embodied Energy (sum of energy required to produce goods or services)

Greenhouse Gas Emissions

Material:

- Avoidance of Waste (requires the use of less overall material)
- Reuse or Recycling of Materials
    - Deconstruction (ability to recycle or reuse)
    - Existing Structure and Materials Reuse
    - Recycled Materials or Structure
    - Sustainable materials sourcing

Solar Reflectance Index (SRI) (heat island effect)

Water:

- Net Positive Water Generation (e.g., surface and groundwater replenishment or hydrologic connection)
- Potable Water Need Reduction
- Stormwater Management (e.g., use of natural systems to capture, treat, or evapotranspire stormwater runoff)
- Water Loss
- Water Quality (e.g., pollution reduction benefits)
- Water Recycling Potential
- Water Up-Cycling Potential (e.g., improve quality of water to expand the economic or ecosystem value of the water)

Social Criteria

Community Impacts

- Aesthetics (e.g., viewscapes, obtrusive lighting, glare)

- Business/Residential Access During Construction
- Historic and Cultural Resources
- Livability/Desirability
- Noise
- Odor
- Traffic Congestion
- Vibration
- Working Lands (e.g., addition or preservation of working lands, such as farms or managed forests)

Community Design Consistency

Community Infrastructure Integration Potential

Educational Opportunities

Non-motorized and Public Transit Mobility and Access

Public Art

Public Awareness (e.g., of the value of water and wastewater services)

Public Engagement Potential

Public Space (e.g., waterfront access)

Safety Risks

Urban Sprawl (e.g., use of smart growth principles, potential to promote or discourage sprawl)

Attachment B: Key Considerations for Selected Sample Analysis Criteria

Attachment B includes examples of how criteria can be built out to include scoring on a -5 to +5 scale. Each example also includes impact areas, performance metrics, resources, evaluative questions, and example assessments. This section includes example build-outs of the following criteria:

The elements of each example include:

POTENTIAL IMPACT AREAS: Illustrate what types of environmental, social, or economic impacts the criteria could affect. Identifying impact areas for each criterion will help the utility to understand why the criterion is important, and to think through what could be measured to determine a score for the criterion.

EXAMPLE PERFORMANCE METRICS: Examples of what could be measured for each criterion. Performance metrics would be used in establishing performance baselines, objectives, and alternative scoring.

RESOURCES: Short list of resources to help think through evaluating each criterion.

EVALUATIVE QUESTIONS: Example questions for each criterion to help the utility think about what could be measured, how it could be scored, and other assessments to consider.

EXAMPLE ASSESSMENTS: Show how the criterion can be used to score an alternative on a -5 to +5 scale related to a given sustainability goal. Some criteria do not include explanations or defined performance ranges for each score; this is an acceptable method, and is called an "arrayed" scale. Other criteria do not include negative values; this is also acceptable if an alternative cannot produce a negative result.

Aesthetic Impacts

Utility investments can have an impact on the community's aesthetic composition, including enhancing or degrading the character of a neighborhood, blocking or enhancing views, or adding industrial structures that are either fitting with the character of, or are out of place in, a neighborhood. This criterion supports evaluating the inherent aesthetic impacts of a project alternative separate from any consideration of mitigation measures that could be used to reduce undesirable effects. For example, the community could construct an aesthetic compatibility index to rate alternatives.

Potential Impact Areas:

- Partially or completely blocked views.
- Addition of unattractive fencing or other barriers.
- Inconsistency between infrastructure aesthetics and neighborhood character.
- Contrast between natural features and infrastructure.

Example Performance Metrics:

- Sight distance (linear yards or feet) from alternative to homes, commercial buildings, or main streets
- Exposure (number of people per day expected to be exposed to view of alternative)
- Degree of neighborhood character compatibility (e.g., high, medium, low)

Resources:

- **U.S. Environmental Protection Agency. *Aesthetics of Low Impact Development.*** Describes how low impact development technologies can benefit a community's visual environment. http://water.epa.gov/polwaste/green/upload/bbfs4aesthetics.pdf
- **Florida Department of Transportation. *Aesthetic Effects Evaluation.*** Evaluation sheet to assess a project's compatibility with the existing physical character and aesthetic values of the affected community. http://www.dot.state.fl.us/emo/pubs/sce/AestheticEffectsEvalSheet-2012-1206.pdf

Evaluative Questions to Consider

What aesthetic resources exist within the community? (e.g., natural areas, architectural highlights)

What is the general character of the neighborhood or viewshed where the infrastructure will be added or modified?

Are the visual characteristics of the proposed infrastructure obviously different from the characteristics of the surrounding area?

Will the project be clearly visible, partially visible, or hidden when it is complete?

Will the project open new access to or create new scenic views or vistas?

Adapted from USF CUTR: http://cutr.usf.edu

- **University of South Florida Center for Urban Transportation Research. *Aesthetics and Livability***. Provides an overview of how to assess the visual impacts of construction projects within a community. http://www.cutr.usf.edu/pubs/CIA/Chapter_8.pdf

Example Assessments:

Goal: Improve aesthetics
Criterion: Neighborhood compatibility
Metric: Index of compatibility

Scoring	-5	-4	-3	-2	-1	0	1	2	3	4	5
	Alternative has no compatibility with existing location (e.g., industrial above ground structure placed in residential neighborhood)					Alternative does not alter neighborhood character (e.g., facilities located underground or have a low profile creating no visual or other aesthetic impacts)					Alternative enhances neighborhood character by contributing improved visual conditions (e.g., green infrastructure alternative that has tree plantings)

Goal: Improve aesthetics
Criterion: Sight distance
Metric: Distance from residential or commercial developments

Scoring	0	1	2	3	4	5
	Alternative clearly visible from commercial or residential developments (located within 20 yards)	Alternative is located 21-100 yards away from commercial or residential developments	Alternative is located 101-200 yards away from commercial or residential developments	Alternative is located 201-350 yards away from commercial or residential developments	Alternative is located 350-500 yards away from commercial or residential developments	Alternative is located 500-600 yards away from commercial or residential developments

Ecosystem Impacts

Utility operations and infrastructure choices can influence or impact surrounding ecosystems by affecting ecological structure, key ecological features, or changing the makeup of the ecosystem as a result of land use, construction, or discharge practices. This criterion supports evaluating project alternative performance relative to ecosystem effects addressing such areas as impermeable surface changes, habitat extent or alteration, and species diversity.

Potential Impact Areas:

- Ecosystem structure (e.g., key habitats, habitat pattern, habitat connectivity, impermeable surfaces, complexity of ecosystem).
- Ecosystem functions (e.g., hydrologic processes/water cycle, flood plain functions, sediment processes, nutrient cycling, water purification).
- Species and food webs (e.g., diversity and extent of key species; population dynamics of key species; and biotic interactions that form and maintain communities of native species).

Example Units of Measure:

- Area (e.g., acres):
    - Habitat protected or eliminated.
    - Food production land protected or eliminated.
    - Impermeable surfaces added or eliminated.
    - Native plant communities protected, added, or eliminated.
- Length (e.g., linear feet, yards, or miles):
    - Length of affected streambed.
    - Length of continuous wildlife corridor created or eliminated.

Resources:

- **U.S. Geological Survey. *Effects of Urban Development on Stream Ecosystems in Nine Metropolitan Study Areas Across the United States***. Discusses the challenges of urban development and the impact of such development on stream ecosystems. http://pubs.usgs.gov/circ/1373/pdf/Circular1373.pdf

Evaluative Questions to Consider

What is the baseline (starting) condition for the ecosystem impact being evaluated? (Baseline can be measured against starting point immediately before implementation of alternative, or against historical averages)

What are the direct and indirect impacts of each alternative (e.g., a point source of pollution could have direct impacts at the discharge point and indirect impacts downstream)

Is this ecosystem service or habitat type already in short supply relative to demand?

Where do critical habitat and other sensitive ecosystem areas exist within the community?

Adapted from WRI: www.wri.org

- **World Resources Institute.** ***Weaving Ecosystem Services into Impact Assessment.*** Outlines a methodology for integrating ecosystem services into impact assessments to analyze a project's immediate and long-term impacts (free download). http://www.wri.org/sites/default/files/weaving_ecosystem_services_into_impact_assessment.pdf
- **U.S. Environmental Protection Agency.** ***Considering Ecological Processes in Environmental Impact Assessments.*** Guidance for the incorporation of ecological considerations into the preparation and review of environmental impact assessments. http://www.epa.gov/compliance/resources/policies/nepa/ecological-processes-eia-pg.pdf

Example Assessments:

Goal: Improve ecosystems
Criterion: Permeable surface impact
Metric: Acres

Scoring	-5	-4	-3	-2	-1	0	1	2	3	4	5
	Substantial addition to existing impermeable surfaces in the community (more than 50 acres of impermeable surface added)	Addition to existing impermeable surfaces in the community (36-50 acres of impermeable surface added)	Addition to existing impermeable surfaces in the community (21-35 acres of impermeable surface added)	Addition to existing impermeable surfaces in the community (11-20 acres of impermeable surface added)	Addition to existing impermeable surfaces in the community (1-10 acres of impermeable surface added)	No change to existing impermeable surface area	Decrease of impermeable surfaces from existing baseline (1-10 acres of permeable surface added)	Decrease of impermeable surfaces from existing baseline (11-20 acres of permeable surface added)	Decrease of impermeable surfaces from existing baseline (21-35) acres of permeable surface added)	Decrease of impermeable surfaces from existing baseline (36-50 acres of permeable surface added)	Substantial decrease of impermeable surfaces from existing baseline (more than 50 acres of new permeable surface)

Goal: Improve ecosystems
Criterion: Habitat connectivity
Metric: Acres

Scoring	-5	-4	-3	-2	-1	0	1	2	3	4	5
	Substantial impact to habitat connectivity (more than 500 yards of connective corridor eliminated)	Decrease in habitat connectivity from existing baseline (351-500 yards of connective corridor eliminated)	Decrease in habitat connectivity from existing baseline (201-250 yards of connective corridor eliminated)	Decrease in habitat connectivity from existing baseline (101-200 yards of connective corridor eliminated)	Decrease in habitat connectivity from existing baseline (50-100 yards of connective corridor eliminated)	No change to existing habitat connectivity	Increase in habitat connectivity from existing baseline (50-100 yards of connective corridor added)	Increase in habitat connectivity from existing baseline (101-200 yards of connective corridor added)	Increase in habitat connectivity from existing baseline (201-350 yards of connective corridor added)	Increase in habitat connectivity from existing baseline (351-500 yards of connective corridor added)	Substantial increase in habitat connectivity (more than 500 yards of connective corridor added)

Educational Opportunities

Utility project alternatives might or might not be inherently conducive to informing and educating the public about the value of water and the essential service water and wastewater systems provide to their communities. This criterion supports evaluating how conducive a project alternative will be to conveying these and related messages through ready access to and interactivity with the location, posting of educational signage, tour opportunities, or other messaging opportunities.

Potential Impact Areas:

- Ready visual access for posted signs or other forms of visual media (explicit messaging opportunities).
- Ready access to experiential or service learning opportunities (implicit messaging opportunities).

Example Units of Measure:

- Accessibility (scale from open to closed, by days or hours).
- Traffic/exposure (measure in number of people per day exposed to alternative).
- Means of communication (scale from multiple opportunities to communicate, such as interactive tours, to static communication opportunities, such as signs, to no new communication opportunities).
- Level of interactivity (scale from passive observation to fully interactive).

Resources:

- **U.S. Environmental Protection Agency. *Service Learning: Learning by Doing*.** Describes the concept of service learning and how students can be engaged in environmental education through service learning. http://www.epa.gov/osw/education/pdfs/svclearn.pdf
- **Water Research Center. *Moorhead Environmental Complex Educational Signage.*** Includes copies of the educational signs placed around the Moorhead Environmental Complex. http://water.epa.gov/polwaste/green/upload/bbfs4aesthetics.pdf

Evaluative Questions to Consider

Does the alternative present an inherent public education message? (e.g., publicly visible green infrastructure can send an implied sustainability message)

Is there existing educational signage or material that can be updated or more clearly displayed at utility facilities?

Is educational signage easily visible and located in high traffic areas?

Does the utility share infrastructure or other assets with another municipal department, presenting a joint education opportunity?

Can public access (e.g., public walkways or tour viewpoints) be included in the plans for the alternative?

- **Ryerson University. *Best Practices in Experiential Learning.*** Provides an overview of best practices in experiential learning, including types of experiential learning and how to incorporate experiential learning activities. http://www.ryerson.ca/content/dam/lt/resources/handouts/ExperientialLearningReport.pdf

Example Assessments:

Goal: Enhance or create educational opportunities
Criterion: Accessibility
Metric: Closed vs. open to public

Scoring	0	1	2	3	4	5
	Alternative is not accessible to public	Alternative is open to public for tours by appointment one day per week during limited hours	Alternative is open to public for tours by appointment two days per week during limited hours	Alternative is open to public for tours by appointment three days per week during limited hours	Alternative is open to public for tours by appointment four days per week during limited hours	Alternative is open to public for tours by appointment five days per week during limited hours

Goal: Enhance or Create educational Opportunities
Criterion: Accessibility
Metric: Number of viewers per day

Scoring	0	1	2	3	4	5
	Alternative is not visible to the public	Alternative is expected to be viewed by no more than 10 members of the public per week	Alternative is expected to be viewed by 11-20 members of the public per week	Alternative is expected to be viewed by 21-30 members of the public per week	Alternative is expected to be viewed by 31-40 members of the public per week	Alternative is expected to be viewed by 41-50 members of the public per week

Energy Impacts

Water and wastewater utilities are highly energy-intensive, and project alternatives will exhibit differences in their energy requirements and their potential for ongoing contribution to energy optimization for the utility system. This criterion supports evaluating the comparative energy performance (use or production) of project alternatives.

Potential Impact Areas:

- Energy consumed.
- Energy produced.
- Energy efficiency.

Example Performance Metrics:

- Energy in kilowatt hours (kWh).
- Energy in thermal megawatts (MWt or MWth).
- Energy in megawatts (MW) or megawatt hours (MWh).
- Energy in therms.
- Percentage of overall energy requirements (e.g., reduced utility's energy requirements by 20 percent, or, generated 30 percent of all energy consumed by utility)

Resources:

- **Focus on Energy. *Water & Wastewater Industry Energy Best Practice Guidebook.*** Provides guidance for energy use evaluation and energy management best practices in the utility setting. https://focusonenergy.com/sites/default/files/waterandwastewater_guidebook.pdf

- **U.S. Department of Energy. *Energy Efficiency Program Impact Evaluation Guide.*** Provides guidance for evaluating and measuring impact for energy efficiency programs. http://www1.eere.energy.gov/seeaction/pdfs/emv_ee_program_impact_guide.pdf

Evaluative Questions to Consider

Does the alternative offer opportunities for energy improvements such as biogas utilization equipment, effluent heat recovery, low-energy dewatering, or deammonification for side stream treatment?

Do local landscape features or climate conditions present opportunities for energy capture or generation?

Does the alternative present an opportunity to optimize the energy consumption of an existing process or piece of equipment (i.e., increase energy efficiency)?

- **U.S. Environmental Protection Agency. *Energy Efficiency in Water and Wastewater Facilities: A Guide to Developing and Implementing Greenhouse Gas Reduction Programs*.** Describes the benefits of energy efficiency in water and wastewater facilities, as well as methods for achieving those benefits. http://www.epa.gov/statelocalclimate/documents/pdf/wastewater-guide.pdf
- **Water Environment Federation. *Energy Roadmap: Driving Water and Wastewater Utilities to More Sustainable Energy Management.*** A series of steps to help wastewater utilities plan and implement a wastewater energy program. http://www.werf.org/c/KnowledgeAreas/Energy/Latest_News/2012/10152012_WEF_Energy_Roadmap.aspx

Example Assessments:

Goal: Reduce net energy impact
Criterion: Energy consumption/production
Metric: Percentage of plant energy requirements

Scoring	-5	-4	-3	-2	-1	0	1	2	3	4	5
	Alternative increases plant's electricity requirements by more than 50%	Alternative increases plant's electricity requirements by 31-50%	Alternative increases plant's electricity requirements by 16-30%	Alternative increases plant's electricity requirements by 6-15%	Alternative increases plant's electricity requirements by 1-5%	Alternative has no impact on plant energy consumption or production	Alternative produces electricity to cover 1-5% of plant's energy requirements	Alternative produces electricity to cover 6-15% of plant's energy requirements	Alternative produces electricity to cover 16-30% of plant's energy requirements	Alternative produces electricity to cover 31-50% of plant's energy requirements	Alternative produces electricity to cover more than 50% of plant's energy requirements

Goal: Reduce net energy consumption
Criterion: Energy consumption/production
Metric: Kilowatt hours (kWh)

Scoring	-5	-4	-3	-2	-1	0	1	2	3	4	5
	Alternative increases plant's energy consumption by 226,000 to 275,000 kWh per month	Alternative increases plant's energy consumption by 176,000 to 225,000 kWh per month	Alternative increases plant's energy consumption by 126,000 to 175,000 kWh per month	Alternative increases plant's energy consumption by 76,000 to 125,000 kWh per month	Alternative increases plant's energy consumption by 26,000 to 75,000 kWh per month	Alternative impacts plant energy consumption by an increase of up to 25,000 kWh or produces up to 25,000 kWh per month .	Alternative produces energy of 26,000 to 75,000 kWh per month	Alternative produces energy of 76,000 to 125,000 kWh per month	Alternative produces energy of 126,000 to 175,000 kWh per month	Alternative produces energy of 176,000 to 225,000 kWh per month	Alternative produces energy of 226,000 to 275,000 kWh per month

Greenhouse Gas Impacts

Water sector utilities, as large energy users, contribute to GHG emissions through fossil fuel and electricity-based energy use, as well as through methane and nitrous oxide emissions from operations like digesters. This criterion supports the evaluation of project alternatives from the standpoint of their impact on such areas as increased energy efficiency (a leading way utilities can reduce GHG emissions), better-optimized operations to reduce methane or nitrous oxide emissions, use of biogas for energy production (e.g., combined heat and power), and handling and disposition of biosolids.

Potential Impact Areas:

- Direct emissions (onsite):
    - Reduce or avoid methane (CH_4) emissions through treatment in aerobic, rather than anaerobic, conditions.
    - Capture of CH4 produced during treatment under anaerobic conditions.
- Indirect emissions (offsite):
    - Emissions resulting from consumption of energy produced offsite.
- Offset by providing renewable energy credits.

Example Performance Metrics:

- Tons of CO_2.
- Tons of CH_4.
- Tons of N_2O.
- Tons of CO_2 equivalent (CO_2e).
- Million metric tons of carbon dioxide equivalent ($MMTCO_2e$).

Evaluative Questions to Consider

Where does the utility's power come from? Produced on-site or off-site? How much CO2 is emitted at this power source as a result of each kilowatt hour of energy consumed?

Does the proposed alternative offer an opportunity for the reduction of energy consumption, which would reduce the plant's greenhouse gas emissions?

Does the proposed alternative offer an opportunity to capture methane or another greenhouse gas for reuse (e.g., in offsite energy generation)?

Resources:

- **Global Methane Initiative. *Municipal Wastewater Methane: Reducing Emissions, Advancing Recovery and Use Opportunities*.** Describes the role of wastewater in methane emissions, benefits of methane capture, abatement, recovery, and use opportunities. https://www.globalmethane.org/documents/ww_fs_eng.pdf
- **U.S. Environmental Protection Agency. *Energy Efficiency in Water and Wastewater Facilities: A Guide to Developing and Implementing Greenhouse Gas Reduction Programs*.** Describes the benefits of energy efficiency in water and wastewater facilities

(including GHG emission reductions), and provides methods for achieving those benefits.
http://www.epa.gov/statelocalclimate/documents/pdf/wastewater-guide.pdf

- **U.S. Department of Energy. *ENERGY STAR Portfolio Manager: Methodology for Greenhouse Gas Inventory and Tracking Calculations.*** Methodology for measuring the direct (on-site) and indirect (off-site) greenhouse gas emissions of a building.
https://portfoliomanager.energystar.gov/pdf/reference/Emissions.pdf

Example Assessments:

Goal: Reduce net greenhouse gas impact
Criterion: Direct emissions – methane (CH_4)
Metric: Tons of CH_4

Scoring	0	1	2	3	4	5	6	7	8	9	10
	Alternative increases treatment plant's methane emissions by more than 50 tons per month	Alternative increases treatment plant's methane emissions by 25-50 tons per month	Alternative increases treatment plant's methane emissions by 10-25 tons per month	Alternative increases treatment plant's methane emissions by 3-10 tons per month	Alternative increases treatment plant's methane emissions by 1-3 tons per month	Alternative has no impact on methane emissions	Alternative reduces treatment plant's methane emissions by 1-3 tons per month	Alternative reduces treatment plant's methane emissions by 3-10 tons per month	Alternative reduces treatment plant's methane emissions by 10-25 tons per month	Alternative reduces treatment plant's methane emissions by 25-50 tons per month	Alternative reduces treatment plant's methane emissions by more than 50 tons per month

Goal: Reduce net greenhouse gas impact
Criterion: Indirect emissions – carbon dioxide (CO_2)
Metric: CO_2 emissions resulting from energy consumption

Scoring	0	1	2	3	4	5	6	7	8	9	10
	Alternative increases energy consumption by more than 40% over previous option, increasing indirect CO_2 emissions	Alternative increases energy consumption by 26-40% over previous option, increasing indirect CO_2 emissions	Alternative increases energy consumption by 16-25% over previous option, increasing indirect CO_2 emissions	Alternative increases energy consumption by 6-15% over previous option, increasing indirect CO_2 emissions	Alternative increases energy consumption by 1-5% over previous option, increasing indirect CO_2 emissions	Alternative has no impact on energy consumption	Alternative reduces energy consumption by 1-5% over previous option, reducing indirect CO_2 emissions	Alternative reduces energy consumption by 6-15% over previous option, reducing indirect CO_2 emissions	Alternative reduces energy consumption by 16-25% over previous option, reducing indirect CO_2 emissions	Alternative reduces energy consumption by 26-40% over previous option, reducing indirect CO_2 emissions	Alternative reduces energy consumption by more than 40% over previous option, reducing indirect CO_2 emissions

Public Space Impact

Utility operations can affect public spaces through the type and location of facilities or (gray or green) infrastructure. This criterion supports evaluation of: 1) direct impacts on public spaces such as waterfront areas, green spaces, parks, or other public gathering places by increasing or decreasing access, quality, or availability, and 2) opportunities created when the project alternative is conducive to creating or enhancing existing public spaces through creative utilization of land resources (e.g., creating a park when covering a finished water reservoir).

Potential Impact Areas:

- Parks.
- Green spaces.
- Open spaces.
- Waterfront access.
- Recreational facilities.
- Brownfield repurposing.
- Other community spaces (e.g., community centers).

Example Units of Measure:

- Acres (e.g., park space, green space, open space).
- Square footage (e.g., recreational facilities or community space).
- Linear feet or yards (e.g., waterfront access).
- Person-days or person-hours (e.g., number of people per day using recreational space).

Resources:

- **American Planning Association. *Great Places***. Discusses how the decisions made by planners influence the quality of neighborhoods, streets, and public spaces. https://www.planning.org/greatplaces/

Evaluative Questions to Consider

Does the space accommodate multiple activities? What purpose does it serve for the surrounding community?

Where is the space located, and what is the setting (e.g., downtown, city center, waterfront, neighborhood)?

What activities make the space attractive to people and encourage community interaction (e.g., special events, commerce, entertainment, recreation)?

Is there a sense of cultural or historical significance about the space?

Does the alternative's location fall within or complement a comprehensive regional development plan that accounts for future growth?

Adapted from the American Planning Association: www.planning.org

- **Project for Public Spaces. *What Makes a Successful Place*?** A nonprofit planning, design, and educational organization dedicated to helping create and sustain public spaces that build stronger communities. Resources include an evaluation of what makes a successful public place. http://www.pps.org/reference/grplacefeat/

Example Assessments:

Goal: Enhance public space
Criterion: Park space relative to baseline of park space acreage
Performance Scale: Area of park space in acreage

Scoring	-5	-4	-3	-2	-1	0	1	2	3	4	5
	Alternative impacts or eliminates more than 50 acres of park space within the community.	Alternative impacts or eliminates 25-50 acres of park space within the community.	Alternative impacts or eliminates 10-25 acres of park space within the community.	Alternative impacts or eliminates 5-10 acres of park space within the community.	Alternative impacts or eliminates up to 5 acres of park space within the community.	Alternative does not change the number of acres of park space available to the community.	Alternative adds up to 5 acres of park space within the community.	Alternative adds 5-10 acres of park space within the community.	Alternative adds 10-25 acres of park space within the community.	Alternative adds 25-50 acres of park space within the community.	Alternative adds more than 50 acres of park space within the community.

Goal: Enhance public space
Criterion: Public use of community recreational space
Metric: Person hours (time spent using recreational space)

Scoring	-5	-4	-3	-2	-1	0	1	2	3	4	5
	Alternative causes a significant decrease in the amount of time spent by community members using recreational facilities		Alternative causes a marginal decrease in the amount of time spent by community members using recreational facilities			Alternative does not change the amount of time spent by community members using recreational facilities		Alternative causes a marginal increase in the amount of time spent by community members using recreational facilities			Alternative causes a significant increase in the amount of time spent by community members using recreational facilities

Attachment C: Refining Your Analysis – Optional Additional Steps

The refinements in this section represent opportunities for more in depth analytical methods for those who are interested in going beyond the basic analysis described in the main body of this guide. The refinements are linked to specific steps in the analysis and are independent of each other: You can choose to incorporate one of them, a few of them or all of them, depending on the needs of your specific conditions.

REFINEMENT 1: Accommodating the Difference in the Relative Importance of Sustainability Goals (Related to STEP 2)

As your utility, potentially engaging with your community, considers and identifies sustainability goals, you might find that certain goals should carry more "weight." Essentially, there might be a stronger preference for delivering performance on some goals relative to others. For example, if your utility and community identify energy performance, ecosystem function improvements, and livability improvements as its sustainability goals, interest in improved ecosystem function performance might be stronger relative to energy performance and livability improvements. Such situations are not at all unusual.

Under such circumstances, your analysis can use a basic weighting scheme to reflect these preferences. The process of weighting determines the relative contribution of each goal (and ultimately the criteria selected for evaluating alternatives) to the aggregate benefit score for each alternative. These weights can have a substantial impact on the results of the alternatives analysis. In addition, establishing these weights can prove to be among the most challenging aspects of working with a community during alternatives analysis, because the preferences (and therefore the weights) are often very dependent on the perspectives of individual stakeholders.

You can use many methods to establish relative weights, ranging from simple to highly complex. The more complex methods break the ranking process into smaller and smaller steps with the participants establishing the weights asked very specific questions about their preferences. Here we provide one of the more straightforward methods, direct estimation.

Direct estimation requires a single step and asks stakeholder participants to consider all the identified goals and compare them to each other by providing a rank. Although you can use a variety of scales, an easily comprehended approach is the use of a ten point ranking system, with each goal assigned a value of between 1 and 10. It is important to maintain, to the greatest extent possible, a 1:1 relationship between the sense of relative importance of the goal and its ranking. For example, if the livability goal is considered twice as important as the ecosystem function goal, and the livability goal is considered, overall, to be most important, then a ranking of 10 for livability and of 5 for ecosystem function would be appropriate.

The primary benefit of this technique is its simplicity and understandability. Major drawbacks are that it can be less reliable than more complex methods and it might provide less transparency into the specific reasoning behind the ranking. Once the ranking of each goal has been established, that weight (for example, 5 for ecosystem function) is applied mathematically as part of deriving the overall benefit score for each alternative.

EXAMPLE:

During Step 2 in the main guide, Smithtown Utility District selected in consultation with its community three sustainability goals and established an individual performance criterion for each: aesthetic impacts (for community livability); net electricity consumption (for energy performance); and permeable surface impact (for ecosystem function). SUD's two alternatives will be evaluated, in part, based on performance against these criteria. The table below provides an un-weighted and a weighted approached to scoring. Table 1(a) treats all three evaluation criteria as equivalent; the raw constructed scale scores for each alternative for each criterion are merely summed to produce the Total Benefit Score for each. Table 1(b) reflects the use of different weights, using a 1 to 10 basis, for the individual criteria. In this case, aesthetic impact is considered the most important (receiving a weight of 10), and net electricity consumption and permeable surface impact are each weighed equivalently (receiving weights of 5) and as half as important as aesthetic impacts. The benefits calculation incorporates the weights by multiplying the raw scale score by the assigned weight.

TABLE 1(a)

Criteria	**Aesthetic Impact**	**Net Electricity Consumption**	**Permeable Surface Impact**	**Total Score**
Alternative 1	-1	5	-1	3
Alternative 2	0	-1	2	1

TABLE 1(b)

Criteria	**Aesthetic Impact**	**Net Electricity Consumption**	**Permeable Surface Impact**	**Total Score**
Weight	**10**	**5**	**5**	
Alternative 1	*Raw Score x Weight* *-1 x 10 =* **-10**	*5 x 5 =* **25**	*-1 x 5 =* **-5**	10
Alternative 2	*Raw Score x Weight* *0 x 10 =* **0**	*-1 x 5 =* **-5**	*2 x 5 =* **10**	5

REFINEMENT 2: Placing Direct Measures on a Comparable Basis (Related to Step 3)

To compare any individual direct measure (quantitative) performance scale, you must "normalize" it to a common scale, and if the analysis is using a constructed scale of -5 to +5 for all constructed scale criteria, this scale would be used as the basis for normalizing. Under Step 4 in the main body of the text, net electricity generation (in kWh) and net permeable surface (in acres) were placed on a common -5 to +5 scale for comparability with each other, and for comparability with aesthetic impacts. This refinement supports two types of adjustments:

- A more precise conversion of direct, quantified performance to a constructed scale,
  and/or
- The basis for placing two or more quantified criteria with different performance metrics onto a common benefits scale.

Note that the normalization formula provided below can be used to create a comparable basis for any benefits scale selected. For example, performance measured in kWh and acres of permeable surface can be placed on a 0 to 10, or 0 to 100, scale using the method provided here. However, because the main body of the guide suggests using a -5 to +5 scale, that scale is used in the example below.

To create a common basis among different performance metrics, a basic normalization formula is used:

$$Scaled\ Value = \left(\frac{Alternative's\ Performance\ Value - Lowest\ Actual\ Raw\ Performance\ Value}{Highest\ Actual\ Raw\ Performance\ Value - Lowest\ Actual\ Raw\ Performance\ Value} \right) \times Highest\ Value\ for\ the\ Constructed\ Scale$$

This formula works by calculating a scaled value from 0 to 1 and then normalizing this value to the same range as that used for the constructed scale(s). The use of a constructed scale that has both a negative and positive range (in this case -5 to +5), as in the main body of this guide, creates one wrinkle in the use of this formula. When normalizing in such a context, the Lowest Actual Raw Performance Value used in the formula will be zero (0), and any calculations for Actual Raw Performance Values that carry a negative sign, will incorporate those values into the formula using a positive sign. Once the result is obtained (e.g., a positive 1), a negative sign will be assigned to it. (See example below)

EXAMPLE:

For Alternatives 1 and 2, conversion from specific kWh performance data to the -5 to +5 constructed scale being used across all criteria would involve the following.

- Alternative 1 produces a net, positive energy outcome of +250,000 kWh per month. This is Alternative 1's actual raw performance score. Between the two alternatives, it is the highest actual raw performance score.

- Alternative 2 produces a net, negative energy outcome of -70,000 kWh per month. This is Alternative 2's actual raw performance score, while the raw performance score used for converting to the constructed scale will be +70,000 kWh.
- The calculation for Alternative 1 is: (250,000 kWh – 0 kWh/250,000 kWh – 0 kWh) X 5 = 5, where:
  - 250,000 kWh in the numerator is Alternative 1's actual raw performance score;
  - 0 kWh (zero) in the numerator is the lowest actual performance value;
  - 250,000 kWh in the denominator is the highest actual raw value;
  - 0 kWh (zero) in the denominator is the lowest actual performance value; and
  - 5 is the highest constructed scale value.
- The calculation for Alternative 2 is: (70,000 kWh – 0 kWh/250,000 kWh – 0 kWh) X 5 = 1.4 (with this constructed scale result acquiring a negative sign (-1.4) to reflect the fact that the original raw value score (-70,000 kWh) was negative) , where:
  - 70,000 kWh in the numerator is Alternative 2's actual raw performance score (but given a positive sign);
  - 0 kWh (zero) in the numerator is the lowest actual performance value;
  - 250,000 kWh in the denominator is the highest actual raw value;
  - 0 kWh (zero) in the denominator is the lowest actual performance value; and
  - 5 is the highest constructed scale value.

REFINEMENT 3: Adjusting for Differences in Benefits (Related to Step 4)

Performance outcomes along the continuum of any measurement scale might not reflect a linear, stepwise increase (or decrease) in the benefits provided. The "Law of Diminishing Returns" is one reflection of such a situation. Diminishing returns refers to the outcome where an additional unit of performance beyond a certain level no longer provides the same rate or benefit (marginal utility) as previous performance improvement increments. For example, you might continue to derive enjoyment when moving from one to two scoops of ice cream, but by the time you've eaten ten, an eleventh probably will not be so desirable. The same outcome may be in play with certain of your evaluation criteria. If this is the case, the different levels of the performance scale will require an adjustment to calculate a truly accurate representation of benefit. There are sophisticated mathematical methods for deriving marginal utility; however, non-linear benefits adjustments can also be made by simply translating the linear raw score scale into a Benefits Adjusted Scale reflective of the interests and perspectives provided by community members or technical experts.

EXAMPLE:

The table on the next page provides the raw score scaling for the permeable surface impacts of alternatives as presented in Step 4 of the main text. The initial constructed scale is essentially linear, with the constructed scale score reflecting equal increments of change in the amount of permeable surface affected by an alternative with a corresponding 1 benefit point increase or decrease. The benefits adjusted scale indicates, however, that the community and/or utility wishes to reflect three distinct aspects of the loss or gain of permeable surface:

(1) Even low levels of permeable surface losses raise substantial concern for members of the community, and they wish to substantially penalize alternatives that lead to any amount of permeable surface loss. This is reflected by, for example, converting the -2 raw score associated with the loss of between 11 and 20 acres of permeable surface to a -3.5 benefits adjusted score. This creates additional -1.5 benefits score "penalty" for this level of permeable surface loss.

(2) Initial gains of permeable surface are valued more highly than later gains. This is reflected, for example, when converting the +2 raw score associated with the gain of between 11 and 20 acres to a +3 benefits adjusted score. This change reflects an incremental benefits adjusted score increase of 1.0 (from 2.0 to 3.0). This preference is further reflected in the incremental benefit between the raw scores of 4 and 5, while the benefits adjusted scores are 4.5 and 5.0, respectively (a 0.5 point increase in benefit).

(3) A loss of low levels of permeable surface is of greater concern than the desirability of adding low levels of additional permeable surface. This is reflected in the -2 benefits points assigned to the first increment of permeable surface loss (loss between 1 and 10 acres), and the 1.5 benefits points assigned to the first increment of permeable surface gain (gain between 1 and 10 acres).

CRITERION: Permeable Surface Impact (Metric: Acres)	Substantial addition to existing impermeable surfaces in the community (more than 50 acres of impermeable surface added)	Addition to existing impermeable surfaces in the community (36-50 acres of impermeable surface added)	Addition to existing impermeable surfaces in the community (21-35 acres of impermeable surface added)	Addition to existing impermeable surfaces in the community (11-20 acres of impermeable surface added)	Addition to existing impermeable surfaces in the community (1-10 acres of impermeable surface added)	No change to existing impermeable surface area	Decrease of impermeable surfaces from existing baseline (1-10 acres of permeable surface added)	Decrease of impermeable surfaces from existing baseline (11-20 acres of permeable surface added)	Decrease of impermeable surfaces from existing baseline (21-35) acres of permeable surface added)	Decrease of impermeable surfaces from existing baseline (36-50 acres of permeable surface added)	Substantial decrease of impermeable surfaces from existing baseline (more than 50 acres of new permeable surface)
Raw Score	-5	-4	-3	-2	-1	0	1	2	3	4	5
Benefits Adjusted Score	-5	-4.75	-4.5	-3.5	-2	0	1.5	3	4	4.5	5

Once the conversion from raw scores to benefits adjusted scores has been made, the benefits adjusted score is used in the overall calculation of benefits for alternatives.

REFINEMENT 4: Performance Uncertainty (Related to Step 5)

Uncertainly about the precise performance an alternative can deliver is not uncommon, and in the case where there is substantial uncertainly, an adjustment to the process of deriving a benefit score is needed. Typically, the same experts/stakeholders best positioned to rate a given criterion for a given alternative are also best positioned to estimate the uncertainly of performance. Though many methods for addressing uncertainly exist, many of which are quite sophisticated and require specialized software support, a relatively straightforward and common approach is to derive an "expected value" (probability-weighted outcome) for an alternative's performance.

EXAMPLE:
Alternative 1 has three different levels of possible net kWh production levels:

1. 150,000 kWh/month on the low end, with a 10 percent likelihood of this outcome.
2. 200,000 kWh/month in the mid-range, with an 80 percent likelihood of this outcome.
3. 250,000 kWh/month at the high end, with a 10 percent likelihood of this outcome.

Expected Value = .1(150,000) + .8(200,000) + .1(250,000) = 200,000 kWh per month. The 200,000 kWh value would be used for all net electricity production benefits calculations. Note that when assigning probabilities to each potential performance outcome, the sum across all assigned probabilities must equal 1 (or 100 percent).

Bringing It All Together: An Example of Benefits Score Derivation with all Four Considerations in Play

Addressing Uncertainty of Net Electricity Performance
The example in Refinement #4 addressed uncertainty in the net electricity performance of Alternative 1 and produced an expected net electricity performance of 200,000 kWh per month. In the absence of having made this adjustment for uncertainty, SUD had been using a 250,000 kWh per month figure, and that level of performance produced a constructed scale benefit score of +5. The uncertainty adjusted value of 200,000 kWh per month, however, produces a constructed scale benefit score of +4. This is the revised benefit score for Alternative 1.

Creating a Common Basis for Comparing Different Performance Metrics
The example in Refinement #3 addressed converting direct, quantitative performance (net electricity performance in kWh per month was used) to constructed scale performance for purposes of establishing comparability across different criteria. The new uncertainty adjusted performance for Alternative 1, however, is 200,000 kWh (a change from the performance of 250,000 kWh used previously). This change results in the need to re-run the normalization conversion.

- The calculation for Alternative 1 is: (200,000 kWh – 0 kWh/250,000 kWh – 0 kWh) X 5 = 4, where:

  - 200,000 kWh in the numerator is Alternative 1's actual (uncertainty adjusted) raw performance score;
  - 0 kWh (zero) in the numerator is the lowest actual performance value;
  - 250,000 kWh in the denominator is the highest actual raw value;
  - 0 kWh (zero) in the denominator is the lowest actual performance value; and
  - 5 is the highest constructed scale value.
- The calculation for Alternative 2 is: (70,000 kWh – 0 kWh/250,000 kWh – 0 kWh) X 5 = 1.4 (with this constructed scale result acquiring a negative sign (-1.4) to reflect the fact that the original raw value score (-70,000 kWh) was negative) , where:
  - 70,000 kWh in the numerator is Alternative 2's actual raw performance score (but given a positive sign);
  - 0 kWh (zero) in the numerator is the lowest actual performance value;
  - 250,000 kWh in the denominator is the highest actual raw value;
  - 0 kWh (zero) in the denominator is the lowest actual performance value; and
  - 5 is the highest constructed scale value.

SUD now has uncertainty adjusted performance of constructed scale score for Alternative 1 equal to +4, and it has a constructed scale score of -1.4 (based on the conversion from kWh performance to the -5 to +5 constructed scale).

Benefits Adjusted Scores

The Example in Refinement #2 used permeable surface performance as a means to demonstrate how non-linear relationships between increments of benefits levels can be addressed. Applying the information in the adjusted benefits table from Refinement #2 to Alternatives 1 and 2 results in the following changes to their scoring relative to permeable surface:

- Alternative 1 (which results in a loss of permeable surface between 1 and 10 acres) originally received a benefit score of -1. However, based on the table in Refinement #2, Alternative 1 will now receive a benefits adjusted score of -2.
- Alternative 2 (which results in a gain of permeable surface of between 11 and 20 acres) originally received a benefit score of +2. However, based on the table in Refinement #2, Alternative 2 will now receive a benefit score of +3.

Accommodating Differences in Relative Importance of Sustainability Goals and Final Benefits Scoring

The Example in Refinement #1 addressed assigning weights to each of SUD's three sustainability goals to reflect differences in their relative importance to the community Table 2(a) below replicates the summary benefits table provided in Step 6 in the main body of the text. The results in this table did not reflect any refinements to the benefits analysis. Table 2(b) below captures the weighted benefits scoring table from Refinement #1, but it now also includes the revised benefits scores for Alternatives 1 and 2 based on uncertainty, conversion to a common benefits scale, and benefits adjustment changes. The incorporation of these changes has substantially altered the results of the analysis. Alternative 2 has become a clear winner. Several factors have contributed to this result:

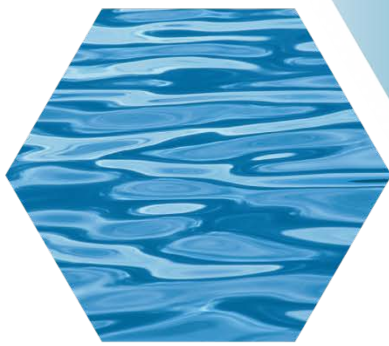
1. The uncertainty of the electricity generation performance of Alternative 1 lowered its benefit score relative to the net electricity performance criterion (from 5 to 4).
2. Alternative 1's negative impact on permeable surface was accentuated by the benefits adjusted score (moving from a -1 to -2).
3. Alternative 2's positive impact on permeable surface was accentuated by the benefits adjusted score (moving from +2 to +3).

TABLE 2(a): Original (with no refinements) Benefits Scoring

Criteria	**Aesthetic Impact**	**Net Electricity Consumption**	**Permeable Surface Impact**	**Total Score**
Alternative 1	-1	5	-1	3
Alternative 2	0	-1	2	1

TABLE 2(b): Refined Benefits Scoring

Criteria	**Aesthetic Impact**	**Net Electricity Consumption**	**Permeable Surface Impact**	**Total Score**
Weight	**10**	**5**	**5**	
Alternative 1	*Raw Score x Weight* *-1 x 10 =* **-10**	*4 x 5 =* **20**	*-2 x 5 =* **-10**	0
Alternative 2	*Raw Score x Weight* *0 x 10 =* **0**	*-1.4 x 5 =* **-7**	*3 x 5 =* **15**	8



Making the Right Choices for Your Utility:

Using Sustainability Criteria for Water Infrastructure Decision Making