Includes CD-ROM

WATEREUSE FOUNDATION

An Economic Framework for Evaluating the Benefits and Costs of Water Reuse

Final Project Report and User Guidance

WateReuse Foundation

An Economic Framework for Evaluating the Benefits and Costs of Water Reuse

About the WateReuse Foundation

The mission of the WateReuse Foundation is to conduct and promote applied research on the reclamation, recycling, reuse, and desalination of water. The Foundation’s research advances the science of water reuse and supports communities across the United States and abroad in their efforts to create new sources of high quality water through reclamation, recycling, reuse, and desalination while protecting public health and the environment.

The Foundation sponsors research on all aspects of water reuse, including emerging chemical contaminants, microbiological agents, treatment technologies, salinity management and desalination, public perception and acceptance, economics, and marketing. The Foundation’s research informs the public of the safety of reclaimed water and provides water professionals with the tools and knowledge to meet their commitment of increasing reliability and quality.

The Foundation’s funding partners include the U.S. Bureau of Reclamation, the California State Water Resources Control Board, the Southwest Florida Water Management District, and the California Department of Water Resources. Funding is also provided by the Foundation’s Subscribers, water and wastewater agencies, and other interested organizations. The Foundation also conducts research in cooperation with two water research coalitions – the Global Water Research Coalition and the Joint Water Reuse & Desalination Task Force.

An Economic Framework for Evaluating the Benefits and Costs of Water Reuse

Final Project Report and User Guidance

Principal Investigator
Robert S. Raucher, Ph.D.
Stratus Consulting Inc.

Cosponsors
Southwest Florida Water Management District
California State Water Resources Control Board
United States Bureau of Reclamation
Inland Empire Utilities Agency (CA)
Las Vegas Valley Water District (NV)
Santa Clara Valley Water District (CA)

Participating Agencies
Dublin San Ramon Services District (CA)
El Paso Water Utilities (TX)
Inland Empire Utilities Agency (CA)
Las Vegas Valley Water District (NV)
Orange County Water District (CA)
Phoenix Water Services Department (AZ)
Pinellas County Utilities (FL)
San Diego County Water Authority (CA)
Santa Clara Valley Water District (CA)
West and Central Basin Municipal Water Districts (CA)

WATEREUSE FOUNDATION

Published by the WateReuse Foundation
Alexandria, VA

Disclaimer

This report was sponsored by the WateReuse Foundation. The Foundation and its Board Members assume no responsibility for the content reported in this publication or for the opinions or statements of facts expressed in the report. The mention of trade names of commercial products does not represent or imply the approval or endorsement of the WateReuse Foundation. This report is published solely for informational purposes.

For more information, contact:
WateReuse Foundation
1199 North Fairfax Street, Suite 410
Alexandria, VA 22314
703-548-0880
703-548-5085 (fax)
www.WateReuse.org/Foundation

WateReuse Foundation Project Number: WRF-03-006
WateReuse Foundation Product Number: 03-006-02

ISBN: 0-9747586-9-8
Library of Congress Control Number: 2006931650

Printed in the United States of America

CONTENTS

FIGURES

TABLES

FOREWORD

The WateReuse Foundation, a nonprofit corporation, sponsors research that advances the science of water reclamation, recycling, reuse, and desalination. The Foundation funds projects that meet the water reuse and desalination research needs of water and wastewater agencies and the public. The goal of the Foundation's research is to ensure that water reuse and desalination projects provide high-quality water, protect public health, and improve the environment.

A Research Plan guides the Foundation's research program. Under the plan, a research agenda of high-priority topics is maintained. The agenda is developed in cooperation with the water reuse and desalination communities, including water professionals, academics, and Foundation Subscribers. The Foundation's research focuses on a broad range of water reuse research topics including the following:

- Defining and addressing emerging contaminants;
- Public perceptions of the benefits and risks of water reuse;
- Management practices related to indirect potable reuse;
- Groundwater recharge and aquifer storage and recovery;
- Evaluating methods for managing salinity and desalination; and
- Economics and marketing of water reuse.

The Research Plan outlines the role of the Foundation's Research Advisory Committee (RAC), Project Advisory Committees (PACs), and Foundation staff. The RAC sets priorities, recommends projects for funding, and provides advice and recommendations on the Foundation's research agenda and other related efforts. PACs are convened for each project and provide technical review and oversight. The Foundation's RAC and PACs consists of experts in their fields and provide the Foundation with an independent review, which ensures the credibility of the Foundation's research results. The Foundation's Project Managers facilitate the efforts of the RAC and PACs and provide overall management of projects.

The Foundation's funding partners are the U.S. Bureau of Reclamation, the California State Water Resources Control Board, the Southwest Florida Water Management District, the California Department of Water Resources, Foundation Subscribers, water and wastewater agencies, and other interested organizations. The Foundation leverages its financial and intellectual capital through these partnerships and funding relationships. The Foundation is also a member of two water research coalitions: the Global Water Research Coalition and the Joint Water Reuse & Desalination Task Force.

The objective of this report is to provide a practical, user-friendly, yet robust tool that wastewater agencies can use to identify and assess the benefits and costs of their water reuse options. The key is to provide an objective and comprehensive basis for considering all the benefits and costs so that utility managers, governing officials, customers, and other stakeholders can better understand the implications of applicable reuse options.

Ronald E. Young
President
WateReuse Foundation

G. Wade Miller
Executive Director
WateReuse Foundation

ACKNOWLEDGMENTS

This project was funded by the WateReuse Foundation in cooperation with the Southwest Florida Water Management District, the California State Water Resources Control Board, the United States Bureau of Reclamation, Inland Empire Utilities Agency (CA), Las Vegas Valley Water District (NV), and Santa Clara Valley Water District (CA).

This study would not have been possible without the insights, efforts, and dedication of many individuals and organizations. These include the members of the research team and PAC members (as identified blow); the WateReuse Foundation's project manager, Josh Dickinson; many key individuals at the participating utilities and related organizations; and the outstanding editorial and production staff at Stratus Consulting (including Diane Callow, Laura Cross, and Erin Miles).

The research team would like to thank the WateReuse Foundation for funding this applied research project, as well as the following organizations for their in-kind contributions: Dublin San Ramon Services District (CA), El Paso Water Utilities (TX), Inland Empire Utilities Agency (CA), Las Vegas Valley Water District (NV), Orange County Water District (CA), Phoenix Water Services Department (AZ), Pinellas County Utilities (FL), San Diego County Water Authority (CA), Santa Clara Valley Water District (CA), and West and Central Basin Municipal Water Districts (CA).

Principal Investigator and Project Manager

Robert S. Raucher, Ph.D., *Stratus Consulting Inc.*

Research Project Team

Kristin Darr, *Kristin Darr and Associates*
James Henderson, *Stratus Consulting Inc.*
Ron Linsky and colleagues, *National Water Research Institute*
John Rice, *Stratus Consulting Inc.*
Bahman Sheikh, *Water Resources and Reuse Specialist*
Carolyn Wagner, *Stratus Consulting Inc.*

Project Advisory Committee

Richard Belzer, *Regulatory Checkbook*
John Boland, *Johns Hopkins University*
Malcolm Castor, *Southwest Florida Water Management District*
Rich Mills, *State Water Resources Control Board*
Steve Piper, *United States Bureau of Reclamation*
Eric Rosenblum, *City of San Jose Environmental Services Department*

EXECUTIVE SUMMARY

PROJECT BACKGROUND AND OBJECTIVES

This research report develops an economic framework that is a tool to help water agencies and other water sector professionals conduct a benefit–cost analysis (BCA) of reuse or desalination investments. The economic framework is designed to help water managers (1) identify, (2) estimate (to the degree feasible and meaningful), and (3) effectively communicate the full range of benefits associated with water reuse projects or related activities.

Having a reasonably complete recognition and accounting of the full range of benefits of a reuse or desalination project is extremely important. This is because the financial costs of building and operating a reuse or desalination facility are often relatively high (compared to the cost of using more traditional sources of water). Given the high relative costs, water agencies and water resource planning bodies may wonder whether the expense is justified—i.e., whether the benefits may outweigh the costs. They may also face difficulties obtaining support from local governing officials or customers, or need economic justification for seeking funding support (e.g., cost sharing with neighboring entities in the region, or state and federal grants or loans).

One of the key challenges in assessing whether or where the benefits of reuse outweigh the costs is that the benefits are often hard to estimate in full. Among the key reasons that benefits are hard to identify or estimate are:

1. Benefits often are very diverse in type (i.e., many types of benefits may be generated, and several may not be immediately obvious to some parties);
2. Many of the benefit types are hard to explain, and/or difficult to estimate in monetary terms (e.g., many benefits involve "nonmarket" values for ecological or recreational services); and
3. Those who receive or enjoy the benefits (i.e., the beneficiaries) often are dispersed across water agency and political jurisdictional boundaries (meaning that there often are large externalities, and these are often positive externalities rather than negative ones).

These factors can make it very difficult to justify or build public/political support for reuse or desalination projects that, in reality, often have many important net social benefits to offer. This report is intended to help agencies overcome these challenges.

DIFFERENCES BETWEEN FINANCIAL AND ECONOMIC ANALYSIS

While technological advances and increased demands for water have combined to make water reuse increasingly feasible and more cost-effective, there are still several economic roadblocks to broader implementation of water reuse. One of the key challenges for reuse applications is that the financial assessment of such projects may often appear unfavorable, even though there may be total project benefits that outweigh the project's costs. Therefore, at the outset, it is important to make a clear distinction between:

1. A financial analysis of reuse (which is based solely on the cash flows of expenses and revenues in and out of the utility); and
2. An economic analysis that provides a broader perspective of the value of the reuse-generated waters (i.e., provides a suitable benefit–cost perspective for considering if a reuse investment is worth the expense to the broader region and community as a whole).

In brief, water reuse often is considered relatively expensive in terms of the direct financial cost of installing and operating the required treatment processes and related infrastructure. At the same time, the anticipated revenue stream may appear relative low. Thus, on a cash flow basis, reuse may appear to be a financial loser.

While financial analyses are very important and useful in many ways, they typically provide too limited a context with which to evaluate the real social worth of a reuse project. This is because a financial analysis focuses strictly on revenue and cost streams internal to the water agency, and these cash flows are not the same as the true worth or value of most water reuse projects to the community and society as a whole. For example, a financial analysis does not include benefits such as the environmental and social costs avoided when reuse enables a community to forgo developing alternative water supply options (e.g., when reuse avoids the need to extract more raw water from flow-limited streams). This WateReuse Foundation economic framework report and associated tools provide a suitable economic framework within which the benefits ("value") of water reuse projects can be more fully identified and evaluated, and then properly compared to the full costs of reuse.

KEY ISSUES AND APPROACHES FOR BENEFIT–COST ANALYSIS

How does an agency demonstrate that a reuse project is "economically and environmentally appropriate," or that a project provides "the greatest public benefits?" To address these questions, this report provides an analytical tool for conducting a "full social cost accounting" of the benefits and costs of reuse projects. Benefit–cost analysis is a technique that enables program evaluators to undertake structured comparative analyses of alternative approaches to achieve the same general outcome. It is widely used, and in some cases federally mandated, in evaluating complex projects that have substantial environmental and social impacts.

The term "full social cost accounting" refers to the economics perspective of trying to identify and account for *all* the benefits and costs of a potential action or policy, regardless of who bears the impact, or whether the impact can be valued using observed market prices. In other words, our framework is intended to help utilities include benefits, costs, and risks borne "internally" by the wastewater (and/or water supply) agency *as well as* those impacts borne "externally" by other parties (e.g., households, businesses, special interest groups). The approach is also intended to help utilities include, to the greatest degree feasible, "nonmarket" goods and services—meaning impacts that are not typically traded in markets and therefore do not have market-observable values (instead, these values need to be estimated using nonmarket valuation techniques—revealed or stated preference methods such as hedonic pricing or conjoint survey analysis, respectively, and/or using results of studies applied elsewhere, an approach referred to as "benefits transfer").

ENGAGING CUSTOMERS, GOVERNING OFFICIALS, AND OTHER STAKEHOLDERS

In addition to developing a tool to encompass the environmental and economic implications of reuse projects, another key function of the economic framework project is to provide a basis that agencies can use to help communicate their key assumptions, inputs, and findings with impacted communities and stakeholders. The tool developed can (and should) be used to facilitate a process wherein input is invited from relevant individuals and organizations, and through which utilities systematically reveal the key assumptions, input values, sensitivities, and other factors embodied in the analysis.

The framework tools are *not* intended to be used as a “black box” that develops fixed empirical outputs (e.g., dollar values) for all benefits and costs. Instead, the materials provided here are intended as a tool to help organize, document, and communicate benefit–cost information in a transparent manner, so that it can help guide public discourse and policy making.

There are several important reasons for engaging stakeholders throughout the application and interpretation of the economic framework. First, it is important to ensure that the key benefits of a potential reuse project are well recognized. Water reuse can generate many important types of benefits, but often the full range of benefits are not well recognized.

In addition, it is important that analysts applying the framework avoid technical jargon, and instead try to find and apply lay terms (especially to describe the types of benefits to be derived) that communicate with (i.e., can be understood by) the key stakeholders. This can be a challenge, because many reuse benefits are hard to describe in ways that resonate with stakeholders and public officials.

Also, it is important to consider stakeholders within the context of equity—what is often referred to as environmental justice. The economic framework encourages utility analysts to identify the key beneficiaries of reuse projects. This is intended to help all parties recognize (and consider the implications of) who will realize benefits, and who will bear the costs of a reuse project.

There are several additional important advantages from applying the broad BCA of the water reuse economic framework. Identifying and describing the full range of benefits, including those that accrue beyond the utility and its customers, will help the water agency:

- Recognize the full range of benefits of each reuse option, and portray all these benefits to governing/oversight bodies;
- Facilitate buy-in and support from utility customers, and help diffuse or offset possible opposition (e.g., by describing green values attributable to reuse, such as instream flow enhancement, and highlighting the local control benefits of reliance on a local water source);
- Identify beneficiaries beyond the agency’s customer base, thereby providing a basis for pursuing broader cost-recovery (i.e., by showing who benefits and how they benefit, there is a more logical and equitable basis for cost allocations that better reflect the distribution of benefits); and
- Provide a basis for seeking external funding support, by recognizing and systematically characterizing the external benefits (e.g., for seeking state or federal

grants to recognize how the water district reuse choices generate benefits to downstream users and/or for the environment in general).

Therefore, the economic framework provided here is designed to help utility analysts think about the distribution of all lifecycle benefits and costs, and also to provide a forum around which stakeholder interactions can be structured.

KEY ENVIRONMENTAL AND ECONOMIC BENEFITS AND COSTS TO INCLUDE IN THE ASSESSMENT

For some, a major concern regarding the development of reuse projects is the potential for adverse environmental or public health impacts, or both. These issues and concerns need to be given due consideration.

At the same time, comparatively little attention has focused on reuse as a mechanism for reducing adverse environmental impacts. The environmental and other benefits of reuse may include:

1. Increased ability to meet critical instream flow conditions for fish and other aquatic species and ecosystem services of concern, by reducing demands on existing freshwater surface and/or groundwater supplies.
2. Reduced energy consumption and air pollution where imported waters would be the alternative to reuse, by reducing the need for pumping large volumes of source water across great distances and gradients.
3. Increased protection of groundwater systems—from subsidence, reduced storage capacity, and salt water intrusion, by reducing pumping demands on aquifers.
4. Increased reliability and drought relief (i.e., reducing the variability and uncertainty about the volume of water available to the community, in the event of droughts or other source water-impacting events).
5. Increased local control (i.e., reuse water can be viewed as a local resource, in contrast to waters imported to a community from regions and/or by agencies beyond the jurisdiction and control of the local community).
6. Sustained agricultural communities, by reducing municipal demands on waters currently applied to irrigation.
7. Any cost savings associated with using reuse relative to other water supply and wastewater management options (e.g., costs avoided because new waters and/or related infrastructure expansion will not need to be incurred by the community or because wastewater treatment and discharges may be reduced or postponed).

A COMPARATIVE CONTEXT, WITH CAREFUL ATTENTION TO DEFINING THE BASELINE

One important key to conducting a proper economic evaluation is to place reuse in a comparative context, evaluating these options in terms of both a default scenario of no new water supplies, as well as comparing reuse to other water supply alternatives (e.g., additional surface water extractions, agricultural-urban water transfers, water conservation) specific to given regions. The key is to set up the economic analysis in a “with versus without” reuse context.

A challenge to defining the baseline is that the “with” and “without” context can become a place where stakeholder and utility hidden agendas or disagreement over core assumptions often arise. For example, setting the baseline may set off a debate between the utility and stakeholders over future demand projections (e.g., where some members of the community hold alternative views about the size and pace of future population growth, or about the effectiveness of additional conservation opportunities). Therefore, it is important to carefully define the baseline, be transparent about underlying assumptions, and engage relevant stakeholders at this critical stage of the economic analysis.

WHAT THE ECONOMIC FRAMEWORK TOOL AND GUIDANCE OFFER

The framework and its associated tools have been developed with the objective of providing water agency professions with a way to:

- Provide a technically sound, objective basis for identifying, quantifying, and monetizing benefits and costs (and net benefits)
    - Include and describe all the relevant benefits and costs of reuse
    - Adhere to principles of economics for professional integrity and rigor
    - Reveal how to address benefits that cannot be readily quantified or valued
- Work with stakeholders and public officials—and water agency professionals—to develop a “common parlance” for benefits (and costs)
    - Ensure that technicians (economists and engineers) do not talk past public officials, customers, constituencies, and stakeholders
    - Embrace and integrate stakeholder perceptions and value systems
    - Ensure broader recognition of all applicable benefits (and costs) of reuse.

The economic framework is intended to be generic, since each water reuse project and location has its unique properties. Thus, the framework tool should not be seen as a “plug and play” or “one size fits all” model. Rather, it is a practical framework or tool to organize, develop, and communicate credible analyses of benefits and costs.

CHAPTER 1

INTRODUCTION

PROJECT OBJECTIVE

Water reuse is broadly recognized as safe, technically feasible, and increasingly cost effective. However, there are still obstacles to its broader implementation. Many of these barriers arise because it has been difficult to clearly identify and articulate the full range of water reuse project benefits and even more challenging to estimate the value of these benefits.

This report is intended to help water districts and other interested parties overcome many of these obstacles. This report and its associated spreadsheet tool provide an objective, credible, and relatively simple way to:

- Distinguish between a *financial* analysis and an *economic* analysis, where the latter enables a more complete view of all reuse benefits and provides a suitable construct for comparing benefits to costs.
- *Identify* the full range of potential benefits associated with a reuse project and *quantify* and *monetize* these benefits (to the extent feasible) in ways that should be objective and credible.
- Assess the *distribution* (or *incidence*) of benefits and costs so that the beneficiaries of reuse projects can be identified (as can those who bear the costs) and thereby facilitate equitable cost recovery, provide justification for grants and other external financial assistance, and enable more extensive stakeholder identification and involvement.
- Develop a sound economic analysis of reuse projects, in a transparent, credible, replicable, and helpful manner, by providing an *organizational framework* (including a process, templates, and spreadsheet tool) to systematically conduct, organize, and portray key inputs, assumptions, findings, and sensitivities.
- Document, articulate, and *communicate* water reuse cost–benefit analyses to customers, managers, governing officials, and other important stakeholders.

WHY IT IS IMPORTANT TO DEVELOP AN ECONOMIC FRAMEWORK FOR WATER REUSE

There are fundamental issues about how liquid (and solid) by-products of wastewater treatment are perceived and used, either as wastes requiring prudent disposal or as resources that provide beneficial use values and promote sustainability. While intuition might point to the inherent superiority of the beneficial reuse options, the issue is complicated by several real and perceived concerns. Each wastewater management option, regardless of whether it reflects discharge and disposal or a beneficial water reuse approach, imposes financial costs on the wastewater agency, and beneficial reuse options in many instances are relatively expensive and potentially controversial. Each water reuse option may also generate benefits, costs, and potential risks that may accrue to people and entities other than the utility. These "external" costs, risks, and benefits typically are difficult to measure and not often systematically included within the internal cost-accounting decision-making framework of wastewater agencies.

Therefore, utilities need a systematic and objective manner to evaluate the full range of costs, benefits, and potential risks associated with their array of wastewater management and water reuse options. They also need to consider who might bear those costs, risks, and benefits, because the distribution (incidence) of the impacts raises the matter of fairness (environmental justice) and provides a practical basis for mission-critical dialogue with stakeholders and governing officials (e.g., to constructively engage winners and losers in the deliberations and to provide an economic basis for cost sharing, rate setting, or risk mitigation efforts).

The objective of the research developed here is to provide a practical, user-friendly, yet robust tool that wastewater agencies can use to identify and assess the benefits and costs of their water reuse options. The key is to provide an objective and comprehensive basis for considering all the benefits and costs, both internal and external to the agency, so that utility managers, governing officials, customers, and other stakeholders can better understand the implications of the applicable reuse options. The benefit–cost framework we provide should be useful as both (1) a tool for project evaluation (i.e., to help guide and conduct the analysis of Master Plan options), as well as (2) a process for information dissemination and stakeholder communication (i.e., to help document and portray key assumptions, findings, and associated sensitivity analyses).

ROADMAP TO THIS REPORT

There are several key parts to this report. Following this introductory chapter, the following materials are provided:

- Chapter 2 contains an overview of issues related to the economics of water reuse, describing the motivation for this project and providing an overview of the types of benefits that may be relevant for a water reuse project.

- Chapter 3 provides guidance on how to conduct an economic analysis of a reuse project, structured in a question-and-answer format, to help users understand the basis for (and how to implement) the economic framework embodied in the spreadsheet tool and associated templates.

- Chapter 4 provides hard-copy templates of the various tables and forms to guide users through the various steps we define for an economic analysis. These paper version templates also parallel what is provided in the spreadsheet tool to help users gain a visual overview of the steps in the software tool (although the software version differs in some ways, to enhance the value of functions enabled by a computerized approach). The templates also provide a means through which users can implement the economic framework offline (i.e., without relying on the electronic spreadsheet version).

- Chapter 5 provides some useful illustrations, tips, and lessons learned based on case study applications of the framework to water agencies that have participated in this research project.

- Chapter 6 offers conclusions and identifies an agenda for future research.

- A series of detailed appendices offer technical insights and resource guides to help water agency personnel understand how to develop estimates for several key benefit (and cost) categories, including values associated with water supply reliability and enhanced instream flows (such as recreation and ecosystem services).

CHAPTER 2

OVERVIEW OF WATER REUSE ECONOMIC ISSUES

BACKGROUND AND MOTIVATION

Given recent advances in membrane technologies, reclamation of wastewaters not only is technically feasible but also is becoming more economically competitive. This is due in part to technological advances that are lowering the cost of reuse-enabling technologies (e.g., membranes). Concurrently, increased demands on limited freshwaters have driven up the financial and environmental price of traditional source water alternatives. The realities of (1) increased demand for potable water, (2) reduced availability of substitute potable water sources, and (3) advances in membrane technology have collectively propelled reuse (and desalination) into the portfolio of economically viable water supply alternatives.

Additional technological advances will be beneficial for further reducing reclamation costs, addressing salinity-related concerns, and increasing the modularity of the technology and its compatibility with alternative energy sources. However, technology is no longer the principal impediment to the development of reuse projects in water-short regions. Instead, the largest impediments to broader pursuit of reuse opportunities often include:

1. The anticipation of relatively poor financial returns (cash flows) for reuse projects, in terms of the utility's cash outflows relative to projected reuse revenues.

2. Uncertainty about the relative environmental, social, and economic net benefits (i.e., benefits minus costs) of reuse compared to other water supply alternatives.

3. Public misperceptions and concerns about the safety or value of reuse.

This report is intended to help address these obstacles.

REUSE MAY SHOW BAD FINANCIALS EVEN WHEN IT IS GOOD ECONOMICS

The use of membranes and other advanced technologies now provides utilities with feasible ways to provide potable or otherwise useable waters (e.g., for safe irrigation) from what had previously been considered low-quality sources, including wastewater effluent. While technological advances and increased demands for water have combined to make water reclamation and reuse increasingly feasible and more cost effective, there are still several economic roadblocks to broader implementation of water reuse.

The cash flow challenge: One of the key challenges for reuse applications is that the financial assessment of such projects may often appear unfavorable, even though there may be total project benefits that outweigh the project's costs. Therefore, at the outset, it is important to make a clear distinction between:

1. A *financial* analysis of reuse (which is based solely on the cash flows of expenses and revenues in and out of the utility) and

2. An *economic* analysis that provides a more suitable and broader perspective of the value of the reuse-generated waters (i.e., provides a suitable benefit–cost perspective for considering if a reuse investment is worth the expense, to the broader region and community as a whole).

In brief, water reuse is often considered relatively expensive in terms of the direct financial cost of installing and operating the required treatment processes and related infrastructure. At the same time, the anticipated revenue stream may appear relatively low. High out-of-pocket costs to the utility, coupled with limited prospects for revenue generation, present utilities with a clear financial challenge that can impede development of water reuse options.

For water reuse, revenue potential may appear low for two main reasons:

- First, reuse water often is priced at a relatively low rate, because it is often capped by the average cost-based rates charged for traditional potable supplies (e.g., because reuse water often is applied to uses, such as green space irrigation, that are valued less than many applications of potable supplies). Concurrently, potable supplies themselves often are underpriced relative to their full marginal costs (e.g., because average costs rather than marginal costs may drive pricing and/or because infrastructure renewal costs may not be fully embodied in cost recovery). These practices raise an important but separate economic issue of how traditional water supplies, and reclaimed water, should be priced.

- Second, revenue projections for reuse projects also may be low relative to cash costs to the utility because, in some locations, there is a limited market of potential applications and customers (e.g., there may be a limited number of large-scale outdoor irrigation users in proximity to available or anticipated reuse infrastructure).

Thus, on a cash flow basis, reuse may appear to be a financial loser: a water district will typically see a relatively high estimate for a total annualized cost per acre-foot of water produced ($/AF), while at the same time, a utility anticipates limited revenues from its reuse program (e.g., because it often feels constrained to price reuse water below the rates charged for traditional potable supplies). Thus, it is difficult (and perhaps impossible) to make a "business case" for reuse projects based solely on the utility's assessment of its internal financial outcomes.

Adding "value" to the equation: While financial analyses are very important and useful in many ways, they typically provide too limited a context with which to evaluate the real social worth of a reuse project. This is because a financial analysis focuses strictly on revenue and cost streams internal to the water agency, and these cash flows are not the same as the true worth or *value* of most water reuse projects to the community and society as a whole.

The problem is not that the value of reuse is too low. Rather, the problem is that a financial analysis provides too narrow a perspective of the "value" of the waters provided. For example, a financial analysis does not include benefits such as the environmental and social costs avoided when reuse enables a community to forgo developing alternative water supply options (e.g., when reuse avoids the need to extract more raw water from flow-limited streams). This report and associated tools provide a suitable economic framework within which the benefits (“value”) of water reuse projects can be more fully identified and evaluated and then properly compared to the full costs of reuse.

In economic parlance, we are developing an analytical tool for conducting a *full social cost accounting* of the benefits and costs of reuse projects (as defined and discussed in greater detail below). We also provide case study illustrations of the benefit–cost framework to (1) help refine and guide the tool’s development, (2) demonstrate how the tool can be used to estimate and portray environmental and other costs and benefits of reuse (relative to other source water alternatives) in an objective and comprehensive manner, and (3) reveal how the benefits of specific reuse projects compare to their costs.

A simple graphical depiction: The difference between a financial analysis and an economic analysis can be depicted in the contrasting bar charts provided in Figures 2.1 and 2.2. In Figure 2.1, a financial analysis is depicted, wherein the costs are typically reflected as annual cash outflows to cover debt service on capital investments (e.g., treatment plant facilities, distribution and storage, and so forth) plus the annual operation and maintenance (O&M) outlays for the reuse project. The financial analysis depicted in Figure 2.1 also shows the expected cash inflow (i.e., revenue stream), based on annual volume of reuse water sold, times the per unit price charged for reuse water. In this illustration, projected revenues are less than annual cash outlays.

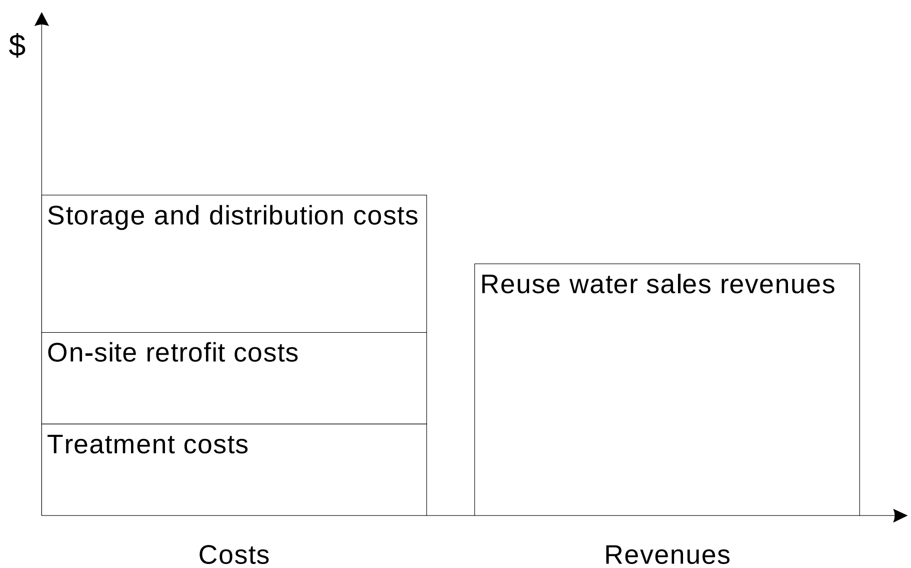

Figure 2.1. Financial analysis

In contrast, Figure 2.2 reveals a hypothetical economic analysis for a reuse project, in which costs can still be depicted in the same manner as in the financial analysis (i.e., either as an annualized total cost or as a present value of costs over the expected useful life of the project), but where the right-hand bar reflects the varied benefits (values) of the reuse project (depicted on either an annualized or present value context, to be consistent with how costs are depicted). Here, when all the varied types of benefits are considered and combined, this illustrative depiction shows the benefits of the reuse project appear to outweigh costs.

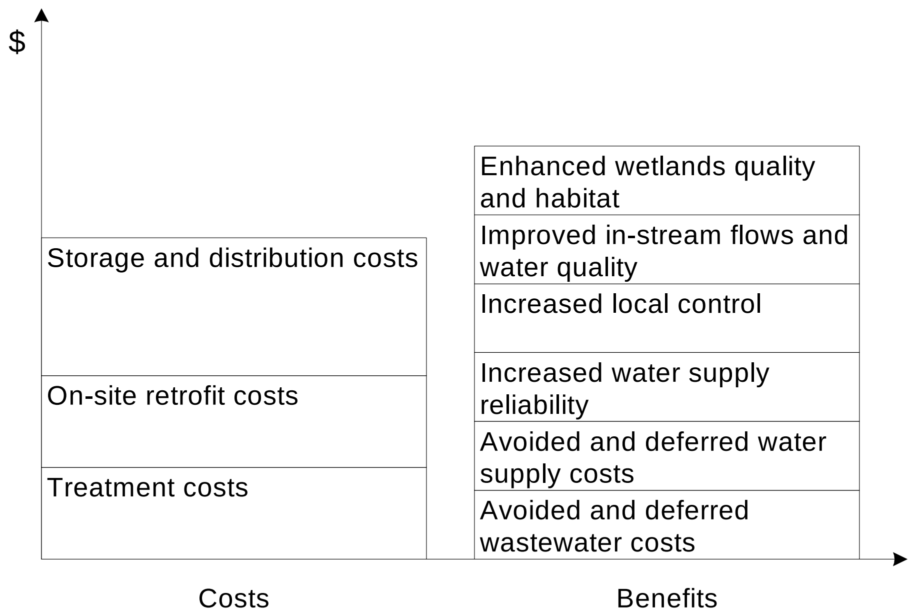

Figure 2.2. Economic analysis

The key in these figures is that, in the financial analysis, it is revenues that are contrasted with costs, whereas in the economic analysis, it is benefits that are compared to costs. Another key observation is that it may often require a compilation of several different types of benefits to recognize that the overall benefits may outweigh costs; if some of the benefit categories are overlooked, the project may not appear to be economically justified. Thus, it typically is important that all the key benefits of a reuse project be recognized in some fashion in an economic analysis, and this report is intended to help agencies and stakeholders properly identify, describe and, where feasible, develop some quantitative measure of those key benefits.

A FULL ACCOUNTING OF SOCIAL COSTS AND BENEFITS

When communities, water agencies, governing officials, environmental advocates, and state agencies look at potential water reuse or desalination projects, several key issues and concerns tend to surface. These include questions such as:

1. What are the potential benefits of using reuse options to replace or reduce freshwater diversions from rivers, streams, and groundwater and thereby protect and enhance instream flows and restore aquatic ecosystems (especially in relatively dry years)?

2. Is there a potential for harm to ecological resources (e.g., by reducing wastewater discharge contributions to instream flows) associated with reuse projects, and if so, what are the benefits and costs of options for effectively mitigating or restoring any such losses?

3. What positive (or negative) consequences may arise for a community if a reuse project is developed (i.e., increased reliability of water supply, reduced likelihood of water shortages and use restrictions, and impacts on growth management), and to what extent is increased supply reliability essential to maintaining the economic vitality of the community (or essential to policies for managing growth)?

4. For reuse options that reduce demands on groundwaters (and/or provide localized recharge), what benefits and costs may arise in terms of water supply reliability, conjunctive use opportunities, management of potential subsidence or salt water intrusion (and thus realizing benefits in the form of avoided costs), and alleviation of pressures on alternative surface water or groundwater sources?

Local communities, water planning agencies, and water providers need a planning tool that can help them organize and conduct a comprehensive and objective assessment of these and related issues. In other words, what is needed is a framework that provides a *comprehensive, "full social cost accounting"–based assessment of the benefits and costs of reuse relative to alternative water supply options.* This need is what this research report helps address.

KEY ISSUES AND APPROACHES FOR BENEFIT–COST ANALYSIS

How does an agency demonstrate that a reuse project is "economically and environmentally appropriate" or that a project has "equitable access to benefits" and provides "the greatest public benefits?" Today, many wastewater and water supply agencies are individually developing their own "templates" for comparing alternatives and selecting water reuse management plans. These individual approaches vary in their quality and extent and are likely to include widely differing approaches with widely differing effectiveness. And as the public grows increasingly aware of and interested in water reuse and supply planning for its communities, the need for thorough, acceptable analyses of alternatives continues to grow. A uniform and well-founded approach is needed to ensure quality, reduce utility effort, and promote broader acceptance and usefulness.

To address this need, we provide an analytical tool for conducting a full social cost accounting–based assessment of the benefits and costs of reuse projects. Benefit–cost analysis (BCA) is a technique that enables program evaluators to undertake structured comparative analyses of alternative approaches to achieve the same general outcome. It is widely used and, in some cases, federally mandated in evaluating complex projects that have substantial environmental and social impacts.

BCA is thus one of several tools that water agency managers and public officials need to have in their "decision support toolbox" to effectively deliberate water reuse options and decisions in the public policy sphere. And while BCA can be very informative and useful, there are several key limitations that need to be acknowledged at the outset. First, BCA is not an exact science and should not be seen as providing a firm "rule" to determine what outcomes (e.g., reuse options) should be pursued. Rather, BCA is simply a "tool" to help systematically organize information and illustrate suitable comparisons across options. Second, a good BCA alone is unlikely to carry the day for a manager or public official attempting to expand water reuse applications. Instead, BCA is among a suite of tools and can be used to complement other types of analysis, perspectives, and communication approaches (e.g., a BCA is unlikely to overcome opposition to a project from those who perceive potential health risks due to a proposed reuse application, and in those cases complementary approaches in risk communication and public dialogue will be needed as well).

Including Internal and External Impacts and Market and Nonmarket Impacts

The term "full social cost accounting" refers to the economics perspective of trying to identify and account for *all* the benefits and costs of a potential action or policy, regardless of who bears the impact or whether the impact can be valued using observed market prices. In other words, our framework is intended to help utilities include benefits, costs, and risks borne "internally" by the wastewater (and/or water supply) agency as well as those impacts borne "externally" by other parties (e.g., households, businesses, and special interest groups).

The approach is also intended to help utilities include, to the greatest degree feasible, "nonmarket" goods and services, meaning impacts that are not typically traded in markets and therefore do not have market-observable values. These values need to be estimated by using nonmarket valuation techniques, i.e., revealed or stated preference methods such as hedonic pricing or conjoint survey analysis, respectively, and/or using results of studies applied elsewhere, an approach referred to as "benefits transfer" (BT).

The "TBL" Approach: a Variant of BCA

The full social cost accounting-based application of BCA can also be portrayed within a "triple bottom line" (TBL) framework. The TBL is a planning tool developed to help agencies track their progress toward promoting sustainability and in essence is a streamlined and often qualitative version of a social BCA. The TBL has been popularized through widespread application in Australian utilities and consists of:

1. A *financial* bottom line that reflects the cash flow accounting stance of the agency (i.e., internal costs and revenues) and then adds

2. A second bottom line to reflect *social* impacts of an agency action (e.g., "helps promote environmental justice by creating employment opportunities for economically disadvantaged members of the community") and

3. A third *environmental* bottom line (e.g., "improves instream flows and thereby enhances and protects habitat for important special status fish and other aquatic species").

This report does not explicitly provide additional detail or methods for implementing a TBL approach. Nonetheless, the TBL is in effect a simplified version of the first several steps of a fuller-scale social benefit–cost assessment (i.e., it essentially is a simplified representation of what is accomplished by steps 1 through 3 in the approach laid out in our economic framework, as introduced in chapter 3). The TBL approach, and the first steps of our framework, provides an intuitive way to promote better communication with stakeholders, governing officials, etc., by explicitly identifying a range of outcomes beyond the traditional internal utility financials.

ENGAGING CUSTOMERS, GOVERNING OFFICIALS, AND OTHER STAKEHOLDERS

In addition to developing a tool to encompass the environmental and economic implications of reuse projects, another key function of the economic framework project is to provide a basis that agencies can use to help communicate their key assumptions, inputs, and findings with impacted communities and stakeholders. The tool developed here can (and should) be used to facilitate a process wherein input is invited from relevant individuals and organizations and through which utilities systematically reveal the key assumptions, input values, sensitivities, and other factors embodied in the analysis.

The framework tools provided here are *not* intended to be used as a "black box" that develops fixed empirical outputs (e.g., dollar values) for all benefits and costs. Instead, the materials provided here are intended as a tool to help organize, document, and communicate benefit–cost information in a transparent manner, so that it can help guide public discourse and policymaking.

There are several important reasons for engaging stakeholders throughout the application and interpretation of the economic framework. First, it is important to ensure that the key benefits of a potential reuse project are well recognized. Water reuse can generate many important types of benefits, but often the full range of benefits is not well recognized because:

- Some benefits are disbursed across political or district jurisdictional boundaries.
- Some beneficiaries may not be engaged in the deliberations.
- Many benefits are not realized until many years in the future.
- Projects often are viewed from a narrow financial perspective (revenues versus costs) rather than in a broader context of social benefits and costs.

In addition, it is important that analysts applying the framework avoid technical jargon and instead try to find and apply lay terms (especially to describe the types of benefits to be derived). The key is to use words and concepts that effectively communicate with the key stakeholders. This can be a challenge, because many reuse benefits are hard to describe in ways that resonate with stakeholders and public officials. This problem may arise because:

- Economic terminology is not always user friendly, intuitive, or communicative.
- The traditional economics labels for key benefit categories (e.g., "passive use" to describe values associated with the motive to preserve endangered species) can foster the impression with some stakeholders that their core issues have not been fully recognized or included in the analysis.

- Benefit measurement and estimation methods developed and used by economists may be seen as smoke and mirrors and lead stakeholders to question the overall credibility of the economic analysis.

- There may be a mistrust of BCA, especially where the approach is seen as incomplete (e.g., missing benefits or costs), biased (e.g., generating predetermined outcomes), or part of a broader political agenda (e.g., to undermine the fabric of environmental and health regulations).

Also, it is important to consider stakeholders within the context of equity, i.e., what is often referred to as environmental justice. The economic framework encourages utility analysts to identify the key beneficiaries of reuse projects. This is intended to help all parties recognize (and consider the implications of) who will realize benefits and who bears the costs of a reuse project. This is important for reuse project evaluations because:

- Real or perceived equity issues (e.g., who gets reuse versus who gets source water) can serve to derail a project.

- Disconnects may arise between who pays and who benefits (e.g., utility customers pay, but large benefits may be generated for many other people and entities in locations beyond the local utility service area or political jurisdiction boundaries).

There are several additional important advantages from applying the broad BCA of the water reuse economic framework. Identifying and describing the full range of benefits, including those that accrue beyond the utility and its customers, will help the water agency:

- Recognize the full range of benefits of each reuse option and portray all these benefits to governing/oversight bodies.

- Facilitate buy-in and support from utility customers and help diffuse or offset possible opposition (e.g., by describing green values attributable to reuse, such as instream flow enhancement, and highlighting the local control benefits of reliance on a local water source).

- Identify beneficiaries beyond the agency's customer base, thereby providing a basis for pursuing broader cost recovery (i.e., by showing who benefits and how he or she benefits, one obtains a more logical and equitable basis for cost allocations that better reflect the distribution of benefits).

- Provide a basis for seeking external funding support by recognizing and systematically characterizing the external benefits (e.g., for seeking state or federal grants to recognize how the water district's reuse choices generate benefits to downstream users and/or for the environment in general).

Therefore, the economic framework provided here is designed to help utility analysts think about the distribution of all life cycle benefits and costs and also to provide a forum around which stakeholder interactions can be structured.

KEY ENVIRONMENTAL AND ECONOMIC BENEFITS AND COSTS TO INCLUDE IN THE ASSESSMENT

For some, a major concern regarding the development of reuse projects is the potential for adverse environmental or public health impacts or both. These issues and concerns certainly need to be given due consideration.

At the same time, comparatively little attention has focused on reuse as a mechanism for reducing adverse environmental impacts. The environmental and other benefits of reuse may include:

1. Increase in ability to meet critical instream flow conditions for fish and other aquatic species and ecosystem services of concern after reduction of demand on existing freshwater surface and/or groundwater supplies.

2. Decrease in energy consumption and air pollution in locations where imported waters would be the alternative to reuse, after reduction of the need for pumping large volumes of source water across great distances and gradients.

3. Increase in protection of groundwater systems from subsidence, reduced storage capacity, and salt water intrusion by reduction of pumping demands on aquifers.

4. Increase in reliability and drought relief (i.e., reducing the variability of and uncertainty about the volume of water available to the community in the event of droughts or other source water–impacting events).

5. Increase in local control (i.e., reuse water can be viewed as a local resource, in contrast to waters imported to a community from regions and/or by agencies beyond the jurisdiction and control of the local community).

6. Sustenance of agricultural communities via reduction of municipal demand for waters currently applied to irrigation.

7. Any cost savings associated with using reuse relative to other water supply and wastewater management options (e.g., costs avoided because new waters and/or related infrastructure expansion will not need to be paid for by the community or because wastewater treatment plant upgrades or expansions can be avoided or postponed and wastewater discharges may be reduced).

Other potential social, economic, and institutional benefits and costs to be considered (and most of which could be considered as specific subcategories under the items listed above) include:

1. Local and regional economic impacts under alternative water supply constraints (i.e., changes in local economic income and tax revenues, with and without reuse or alternative water supplies).

2. The risk-reducing value associated with developing alternative mixes of water supply options within a portfolio approach to water supply management (i.e., diversifying the types and sources of variability in water yields and/or costs, across the supply options in a community's water portfolio).

3. The pros and cons of changing the level of interdependencies between the water supply and power sectors.

4. Comparative risks associated with different levels of dependence on technology for water supply.

In the materials that follow, we describe empirical evidence and a framework to enable water agencies with the means to identify and (in many instances) estimate types and likely level of all relevant benefits and costs associated with desalination or reuse, using a regional and communitywide perspective to better capture the full range of potential societal returns and costs from reuse investments.

A COMPARATIVE CONTEXT, WITH CAREFUL ATTENTION TO DEFINING THE BASELINE

One important key to conducting a proper economic evaluation is to place reuse in a comparative context, evaluating these options in terms of both a default scenario of no new water supplies, as well as comparing reuse to other water supply alternatives specific to given regions (e.g., additional surface water extractions, agricultural–urban water transfers, and water conservation). The key is to set up the economic analysis in a “with versus without” context in which reuse can be compared to a baseline of no new local water supply enhancements and/or a context in which one or more reuse options can be compared to other feasible water supply augmentation alternatives.

Another key aspect of the comparative framework is that it is important to establish and then carefully maintain the suitable accounting stance. For example, if a water reuse project enables a community to forgo (or postpone) capital and/or operating expenditures for alternative water supplies (and/or for wastewater management), then these cost savings need to be included in the economic analysis. However, the side of the benefit–cost ledger in which this entry is placed depends on the baseline scenario and what other water supply alternatives are included in the assessment. For example,

- If the comparative analysis includes the relevant options to supply more water, in addition to the reuse option, then the costs of the alternatives to reuse should be reflected in the cost estimates for those nonreuse options. Further, in this application, these costs of alternative supply-enhancing options should not be double counted as benefits of reuse (i.e., the cost of option A should not also be shown as a cost savings benefit for its alternative, option B; it needs to be shown as either the cost of A or a cost-avoided benefit of B but not both).

- If the baseline is to develop or obtain water from a source other than reuse, then any cost savings from forgoing the baseline supply option can and should be counted as a benefit of the reuse option (i.e., if option A is the baseline and if option B provides cost savings relative to option A, those cost savings should be shown as benefits for option B).

Another challenge to defining the baseline is that the “with” and “without” context can become a place where hidden agendas or disagreements over core assumptions often arise between stakeholders and the utility or other interested parties. For example, setting the baseline may touch off a debate between the utility and stakeholders over future water demand projections (e.g., where some members of the community hold alternative views about the size and pace of future population growth or about the effectiveness of additional conservation opportunities). Therefore, it is important to carefully define the baseline, be transparent about underlying assumptions, and engage relevant stakeholders at this critical stage of the economic analysis.

FINDINGS OF AN ECONOMIC FRAMEWORK WORKSHOP

As part of this research project, a workshop of utility practitioners and other experts was assembled to answer the following core question:

"What are the essential components of an economic framework that would promote broad recognition of the services and benefits that water reuse provides?"

A separate report that provides details on this Nominal Group technique workshop (WRF, 2004) is available from the WateReuse Foundation (WRF), and some of the key findings are summarized here. In total, 62 specific "issues" were identified and developed by the participants. The participants then consolidated the issues to 10 main themes, of which 6 emerged as top priorities:

1. The value of a diverse portfolio, and a regional approach to project formulation, should be principal considerations in evaluating the benefits and costs of water reuse projects (i.e., reuse benefits need to have been viewed from a broad, regional perspective, and one should recognize the value of a diversified regional water supply portfolio).

2. Stakeholder perceptions need to be elicited and accounted for when conducting and reviewing an economic analysis of water reuse projects (i.e., make sure stakeholders are engaged in helping to identify, label/describe, and recognize the benefits of reuse).

3. Risk, reliability, and uncertainty need to be addressed when analyzing water reuse project economics (i.e., recognize that the reliability of reuse can be of appreciable value as a benefit, given the uncertainty of other supply yields over time).

4. Fees and cost allocations should be a function of the worth of the water to the users and the community at large (i.e., try to capture full range of societal benefits and promote highest and best uses by reflecting the value of reuse waters in its pricing).

5. Satisfy social obligations and improve living conditions by maintaining community assets and supporting community values (i.e., make sure a reuse project provides community members what they want and value, and the water district should communicate with stakeholders so that the community recognizes that a reuse project would provide things that its citizens value, such as green space).

6. Account for how water reuse promotes the long-term sustainability of water resources (i.e., recognize the benefit of reuse in terms of its contributions to long-term sustainability as future demands grow and supplies become more strained).

WHAT THE FRAMEWORK TOOL AND GUIDANCE OFFER

The framework and its associated tools have been developed with the objective of providing water agency professions with a way to:

- Provide a technically sound, objective basis for identifying, quantifying, and monetizing benefits and costs (and net benefits)
  - Include and describe all the relevant benefits and costs of reuse;
  - Adhere to principles of economics for professional integrity and rigor; and
  - Reveal how to address benefits that cannot be readily quantified or valued.
- Work with stakeholders and public officials and water agency professionals to develop a "common parlance" for benefits (and costs)
  - Ensure that technicians (economists and engineers) do not talk past public officials, customers, constituencies, and stakeholders;
  - Embrace and integrate stakeholder perceptions and value systems; and
  - Ensure broader recognition of all the applicable benefits of reuse (and costs).

The economic framework is intended to be generic, since each water reuse project and location have their unique properties. Thus, the framework tool should not be seen as a "plug and play" or "one size fits all" model. Rather, it is a practical framework or tool to organize, develop, and communicate credible analyses of benefits and costs. The framework tool and associated user guidance are provided in the chapters and appendices that follow.

CHAPTER 3

WHAT IS AN ECONOMIC ANALYSIS, AND HOW TO CONDUCT ONE FOR WATER REUSE PROJECTS

This chapter provides overall guidance on what an economic analysis is for reuse projects, what questions need to be addressed and considered, and what steps need to be executed. A question-and-answer format is used here, and the guidance is supplemented through cross-references to supplemental materials (e.g., technical appendices, resource guides, and a spreadsheet tool) provided as part of this project report.

1. WHAT IS ECONOMIC ANALYSIS, AND HOW DOES IT DIFFER FROM FINANCIAL ANALYSIS?

Financial analysis and economic analysis are both used in the planning and development of water projects. However, there is an important distinction between the two analyses.

- *Financial analysis* considers only direct costs to the agency and project revenue sources. It is typically used by the utility or agency as a cash flow analysis. The purpose of the financial analysis is to determine if a water project can be financed and what the debt service, O&M, and other recurring costs will be over time. A financial analysis answers questions such as:

    - Will projected revenues and other funding sources be sufficient to pay for project capital and operating costs?

    - What would reuse water rates need to be to cover costs?

- In contrast, an *economic analysis* is a more comprehensive investigation of potential water projects and management decisions. Economic analysis takes into account not only the financial costs and revenues accounted under the financial analysis but also the wider range of benefits and costs of a project from all perspectives, including the customer and society (i.e., the broader community) as a whole. These can include direct benefits such as avoided cost of the development of a new water supply as well as nonmarket benefits and costs (e.g., environmental impacts from the new recycled water project). Economic analysis answers questions such as:

    - Is the value of all of the benefits of a project greater than the value of all the costs; i.e., are net benefits positive?

    - How does the cost of (or values generated by) one project to supply a given amount of water compare to the cost (or values) of other projects?

The focus of this report and the associated framework tool is on economic analysis.

2. WHY IS ECONOMIC ANALYSIS APPROPRIATE FOR REUSE PROJECTS?

Water reuse projects typically produce a wide range of direct and indirect benefits to society, many of which may not be fully acknowledged or appreciated, in part because they are of a less tangible, less quantifiable nature. All of these benefits need to be considered to determine if a project makes economic sense; omitting some benefits may lead erroneously to a conclusion that benefits are outweighed by costs, when in fact the opposite might be true.

Although it may not seem to the layperson that some categories of benefits are suitable for quantification or monetization, there is a well-established toolkit of economic valuation approaches that can be used in many cases. In addition, a wealth of economic literature provides experience and examples of the use of these techniques, and some works provide useful empirical information on the potential magnitude of the values. Even if a specific site or project has not been previously analyzed, it is often the case that similar or equivalent issues have been addressed in a different context but one from which some insights may nonetheless be "transferable" to a given water reuse context.

3. WHY LOOK AT THE FULL RANGE OF DIRECT (INTERNAL) AND INDIRECT (EXTERNAL) BENEFITS AND COSTS?

Economic analysis allows for a comparison of the full range of costs associated with the project to the full range of benefits. Unless all the benefits and all the costs are recognized and considered, policymakers may make inefficient decisions (e.g., projects with positive net social benefits may mistakenly be considered economically inefficient).

In choosing between project alternatives, the alternatives can be ranked according to their net present values (NPVs), which represent the present value of net output that will be generated over the life of the project (present values and discounting are described in greater detail later). The project with the highest NPV (assuming the same discount rate) is more desirable (all else equal).

In addition, economic analysis can also be applied to determine the allocation of costs and funding responsibility on an equitable basis. This effort can be supported by identifying the proportion of total project benefits a stakeholder is expected to enjoy (i.e., it can help identify who bears the costs versus who receives the benefits).

4. WHAT ARE THE STEPS THAT MAKE UP THIS ANALYSIS FRAMEWORK?

There are a series of steps that should guide an economic analysis of reuse (or other) water projects. These steps provide a logical and consistent process through which the analyst can proceed through the assessment. The framework tools supplied here also provide a way for the analyst to document each step and thus offer a structured basis for communicating with utility managers, governing officials, customers, and other stakeholders. These steps can be documented via the spreadsheet tool and/or in the comparable paper-version templates provided in chapter 4 and on the accompanying CD.

The following steps make up the economic framework for analysis of water reuse projects and are summarized in Figure 3.1. Additional guidance on how to implement each step is provided later in this report.

Step 1. Establish the Baseline

Define the outcomes associated with the "no action" status quo. This base case may entail doing nothing (i.e., not pursuing a water reuse project or not augmenting the utility's water supply through an alternative to reuse) or undertaking already planned actions. The baseline is the mark against which changes resulting from the project alternative(s) are measured. It is important to define the scale and timing of the impacts of the baseline, articulate what problems the proposed project (or range of project alternatives) are intended to resolve, be explicit about assumptions, and engage stakeholders about their perspective of what happens under a no-action, status quo baseline. (Additional discussion is provided under question 5.)

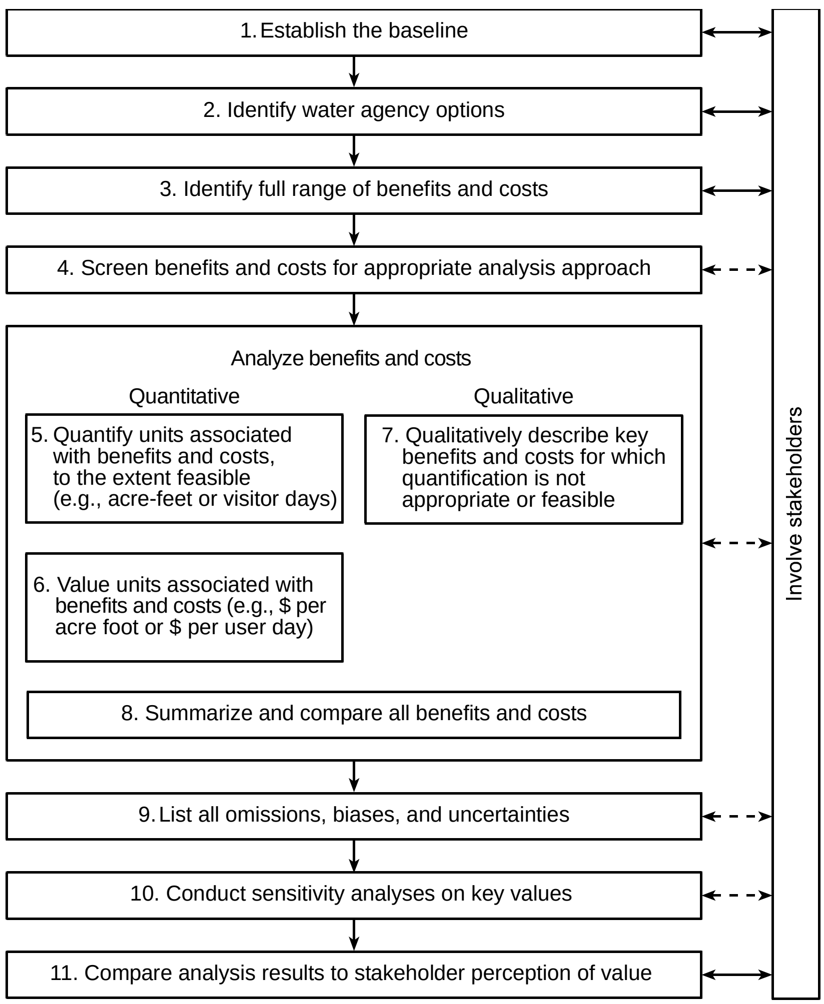

Figure 3.1: Steps in an economic analysis framework

Step 2. Identify Water Agency Options

Identify and develop all the relevant utility options that will be compared to the baseline and to each other. It is useful to scale project options to a common size or objective (e.g., to meet projected minimum water delivery requirements). For options available at different scales, it is helpful to consider staging or combinations of options. (Additional discussion is provided under section 6 of this chapter.)

Step 3. Identify the Full Range of Relevant Benefits and Costs for Selected Option

Develop a thorough inventory of all likely costs and benefits associated with each of the project alternatives (options). Include costs and benefits beyond those faced by the utility alone or customers alone. In other words, try to identify all the benefits and costs, regardless of to whom they may accrue or where they might be realized. (Additional discussion is provided under questions 7, 8, and 9 of this chapter.)

Step 4. Screen Benefits and Costs for Appropriate Analysis Approach

In the screening step, the analyst determines which costs and benefits can and should be analyzed quantitatively, which should be described only qualitatively, and which are insignificantly small and can be eliminated from further analysis. (Additional discussion is provided under questions 9 and 10 of this chapter.)

Step 5. Quantify Units Associated with Benefits and Costs, to the Extent Feasible

In the first step of valuing a benefit or cost, the amount (quantity) of the outcome (e.g., water or resource use) should be established. These quantity outcomes may be a volume of water delivered (e.g., acre-feet), number of recreational user outings enabled by enhanced instream flows or provided by reuse-fed wetlands (e.g., recreational hiking or angling days per year), or whatever units most readily and meaningfully measure the outcomes. It is important to match the quantity units of measurement to whatever metric is available for the corresponding dollar values (e.g., if the valuation in step 6 uses a $/household measure, then the quantification in step 5 should be aimed at estimating the number of households affected). Ranges of quantity estimates (rather than a single point estimate) may be used to better represent variability or uncertainty associated with resource use estimates.

Step 6. Value Units Associated with Benefits and Costs in Monetary Terms

Once the quantity of resource use has been estimated, a per-unit dollar value often can be assigned to the benefit or cost, to reach a total value (quantity times per unit value). The per-unit values can be expressed as dollars per unit of water (e.g., dollars per acre-foot) or dollars per unit of resource use (e.g., dollars per visitor day). Ranges of values may be used to better represent per-unit resource valuations. Annual benefit or cost values should be projected over the project life (either annualized or as an NPV, as per step 8). (Additional discussion is provided under questions 12 and 13 of this chapter.)

Step 7. Qualitatively Describe Key Benefits and Costs for Which Quantification Is Not Appropriate or Feasible

It may not be feasible or desirable to express some types of benefits or costs in quantitative or monetary terms (as per screening in step 3). However, it is always important to describe these nonquantified benefits and costs in a meaningful, qualitative manner. These benefits and costs may be described qualitatively, in part, by using a simple scale indicating the likely impact on net project benefits. Impacts can be qualitatively ranked on a five-point scale, ranging from −2 to +2, to reflect unquantified relative outcomes that span from very negative to very positive (e.g., a "−1" may signify an outcome with moderate unquantified costs, and a "+2" may represent a high unquantified benefit). Qualitative ratings should be accompanied by descriptions of the impact and should be explicitly carried through the analysis. (Additional discussion is provided under question 11 of this chapter.)

Step 8. Summarize All Present Value (or Annualized) Costs and Benefits, and Compare Benefits to Costs

Quantitative benefit or cost projections over time (from step 6) should be discounted to present value at an appropriate discount rate. (Additional discussion is provided under question 14 of this chapter.)

The NPV of monetized benefits and costs should be summarized in one location (i.e., a summary table), along with the listing and ranking of those benefits described only qualitatively (from step 7). It is important that one summary table include both the monetized benefits and costs, as well as a listing and some qualitative assessment of the nonquantified benefits and costs, so that reviewers do not overlook potentially important outcomes when reviewing the empirical results. (Additional discussion is provided in chapters 4 and 5.) Distributional aspects also should be presented (see question 14 of this chapter).

Step 9. List and Assess All Omissions, Biases, and Uncertainties

All omissions, biases, and uncertainties associated with the estimated benefits and costs should be explicitly documented. The impact that these may have on the final outcome of the analysis (e.g., in terms of their likelihood of increasing or decreasing net benefits or an uncertain direction of change in net benefits) should be noted. (Additional discussion is provided in chapters 4 and 5.)

Step 10. Conduct Sensitivity Analyses on Key Values

Sensitivity analyses should be conducted on key variables or benefit and cost estimates to explore and communicate the impact of assumptions, uncertainty, or natural variability. Use sensitivity analyses to identify which assumptions or uncertainties have the largest impact on the outcome of the analysis (e.g., identify which assumptions might change the net benefits of an option from positive to negative or alter the ranking of options in terms of their relative net benefits). (Additional discussion is provided in questions 16 and 17 of this chapter.)

Step 11. Compare Analysis Results with Values from Stakeholder Perspective

The quantitative and qualitative values that result from the analysis and from the various sensitivity analyses should be compared with stakeholder expectation of values. This comparison of expected values to the values derived in the analysis can be informative both as a check on the reasonability of the analysis results and as a process for working with stakeholders to realize (or at least better articulate) the values that the reuse project provides to stakeholders. This understanding of values may become the basis for cost-sharing agreements with stakeholders to share costs for a project according to the relative shares of benefits derived from the project.

The diagram developed to illustrate this project identification and valuation process was shown in Figure 3.1. The vertical box on the right side of the diagram emphasizes that stakeholder involvement should be sought throughout the project identification and valuation process, with stronger involvement (represented by the solid-line arrows as opposed to the dashed-line arrows) recommended at certain portions of the process (e.g., especially at the outset and again to review and discuss findings).

5. HOW AND WHY IS THE BASELINE DEFINED?

Defining the baseline is a very critical step, not just because it establishes the accounting stance within which reuse (and/or other water supply augmentation options) are evaluated and compared but also because it establishes the problem-solving context within which the water reuse (and, possibly, other alternatives) are being considered by the agency and the community as a whole. Thus, the baseline needs to be defined carefully, explicitly, and in a manner suitable for local circumstances; it is the pivotal foundation for not just the BCA itself but also for framing the policymaking dialogue with governing officials, customers, and other stakeholders.

Accounting stance issues. From the technical perspective of establishing the suitable accounting stance for the economic analysis, the baseline should typically be defined as the "status quo" or "do nothing" alternative to a reuse project (and/or other alternatives) being considered. For example, in relatively simple circumstances under which an agency is considering whether or not to pursue a reuse project, the baseline should reflect the future water supply situation for the community "without" the reuse option in the agency's supply portfolio. The reuse option is then the alternative compared to the "without reuse" baseline.

One important aspect of defining the baseline, even in relatively simple contexts, is that it must reflect the future. The baseline is *not* the same thing as the "current" situation. Defining the baseline means looking into the years ahead, and since the useful lifetime of most water supply investments typically is 20 or more years, a matching long-term time frame needs to be applied for the baseline and reuse options. Thus, developing the baseline in most circumstances means considering the projected increases in water demands over the coming decades and assessing how those future demands compare to the region's long-range water supply absent reuse. For example, supply may adequately cover demand in the present, but in the future, demand may be expected to outpace supply. In this example, the projected long-term shortfall in supply (and the time path to that shortfall) should be used in defining the baseline.

Water agencies typically develop demand forecasts that embody different regional growth scenarios, and they should be reviewed and used as applicable to define the "without project" baseline. The assumptions underlying these future projections should also be clearly stated and may become a focal point for discussions with stakeholders (and/or serve as a basis for sensitivity analyses), as discussed later in this chapter.

Policy framing and public discourse issues. Presumably, a water agency or community is considering water reuse (and perhaps other water supply augmentation options) because it is seen as a possible solution to a current or anticipated problem and/or because it is seen as a way to promote or enhance values that are important to the community (e.g., embracing a recycling ethic or providing urban green space). Thus, in defining the baseline for the economic analysis, it is critical that the baseline be defined in a manner that helps articulate what problem and/or value enhancements the reuse project (or its alternatives) would address. By specifying “what is the problem to be solved,” the economic analysis is then suitably framed to compare how well reuse (and/or other options) serve as vehicles to solve the problem and provide the community with outcomes it values.

As noted above, different stakeholders may have different views about the size or nature of the problem and may even argue whether the problem exists. An example would be where a water agency sees reuse as a potential solution to a future supply shortfall that is forecast due to anticipated growth in local population and economic activity. Some local stakeholders may question whether that future growth is inevitable or desirable and thus argue the very premise for why the agency is considering reuse. This illustrative baseline-associated issue may boil down to a debate between developers who seek to stimulate growth, utility managers who more neutrally see a need to serve the community by accommodating growth, and no/slow-growth advocates who wish to limit growth. Water resource planning then often becomes a de facto vehicle through which various stakeholders may try to promote a desired land use planning perspective (in lieu of using zoning and other land use planning tools). This obviously creates headaches for water agency managers, yet it is important to recognize these underlying issues at the outset rather than proceeding blindly with a presumption that the community views the problem the same way that the agency does. For all these reasons, the baseline should be defined with care and in concert with public discourse.

Finally, a challenging proposition associated with framing the problem and evaluating solution options can arise in the case where the baseline in a water-short area does not include any water supply augmentation (or aggressive conservation), because the baseline then needs to reflect what is likely to happen in a future where either growth is effectively capped or where there is a likelihood of persistent water shortages. Will economic and population growth be curtailed if new water supplies are limited (and what are the costs and benefits of that outcome)? Or will growth continue despite the limited water supply, thus forcing the community eventually to endure severe water use restrictions on a regular basis? This can be a very thorny issue, and in some instances baseline scenarios may instead be framed as including the most feasible traditional potable water supply augmentation option (e.g., developing a new wellfield, where feasible). This baseline then becomes the point of comparison against which reuse (and other options) is compared.

6. WHAT WATER SUPPLY OPTIONS SHOULD BE CONSIDERED?

This economic framework is designed primarily to address a situation where one or more water reuse options are being considered. However, the approach is very generalizable, and its most suitable use is in looking at multiple water supply options that may be feasible for a utility and the community it serves. Thus, the approach can be used for a wide range of circumstances, including (1) a baseline that might reflect what is likely to happen in the future if the agency does nothing to enhance its water supply portfolio; (2) one or more water reuse projects that might be pursued by the agency; and (3) a range of other feasible water supply enhancement options that might, for example, include desalination, water conservation, importing water from distant river basins, and so forth. Obviously, the more relevant options considered, the more complex the analysis will become, but the results will also be most valuable if all the relevant feasible options are evaluated.

Also, it typically is most useful to limit the analysis to options that are technically, politically, and legally feasible. For example, if a water supply option is not viable because of restrictions imposed by state or federal regulation (e.g., the Endangered Species Act), then that option is probably not worth including in the economic analysis. If options that are not feasible are included, they should clearly be labeled as such and the cause (technical, ethical, or legal) should be articulated.

7. WHAT ARE THE BENEFIT AND COST CATEGORIES THAT APPLY TO REUSE PROJECTS?

There are numerous types or categories of benefits and costs that may apply to a water reuse project. Natural resource economists have developed a general taxonomy of benefits categories, but it does not provide a very intuitive way for water agencies or their stakeholders to assess or communicate their reuse situations. Therefore, we offer the following general view of broad benefit (and cost) categories:

a. Direct/Internal/Financial

The out-of-pocket costs borne by the water agency are the direct financial costs associated with the proposed water supply option. They should be life cycle costs and include capital equipment or construction costs, O&M costs, water supply acquisition costs, treatment and distribution costs, administration fees paid to a water supplier (e.g., water district), and the agency's additional administration costs. If a subsidy or cost share is provided by an outside source (e.g., the state), these should be considered part of the economic analysis of costs.

The proposed reuse project may also mean that some alternative water supply and/or wastewater costs can be avoided, compared to the baseline. The reuse project may avoid water supply acquisition and capital costs, avoid treatment plant or wastewater plant expansion capital costs, or avoid the variable costs associated with the expanded water supply treatment plant or wastewater plant. These cost savings, or avoided costs, should be considered a benefit of reuse, insofar as the baseline scenario reflects the alternative water and/or wastewater projects.

b. Environmental

Aquatic ecological impacts can be divided into three subcategories: source water protection, downstream habitats, and environmental restoration. Other environmental impacts may include those associated with groundwater resources (such as subsidence or salt water intrusion) or loss of wetlands. Coastal ecosystems, threatened or endangered species, and terrestrial ecosystems may also be affected by some options in some settings.

c. Recreation

Recreation impacts may occur instream (e.g., rafting and swimming) or near stream (e.g., bird watching) and can include impacts on flatwaters (i.e., in lakes or reservoirs) as well as instream in flowing waters. Wetlands created with reuse waters (e.g., to provide natural system filtering before release to surface streams or groundwater) may also generate appreciable levels of recreational values (e.g., for wildlife observation and walking paths that may be provided within the wetland area). Also, where reuse water enables development of sports fields (e.g., soccer and softball fields) or other parks, then the reuse application provides increased recreational opportunities and values for the community.

d. Public Health

This reflects any change in the risks of illness (morbidity) or of premature death (mortality) due to changes in the quality of water delivered by one option as compared to an alternative. For example, some source water options or treatment plant process alternatives may pose greater or lesser degrees of exposure to microbial agents, chemical contaminants, disinfection by-products, and so forth. To the extent that options are associated with changes in potential exposures (and, hence, risks), they should be articulated and included in the analysis. Quantifying and valuing changes in risks to public health are challenging exercises, but at a minimum the potential changes need to be described in an informative, qualitative manner. For a further discussion of challenges and options available to quantify or value changes in health risks, the AWWA Research Foundation report *Quantifying Public Health Risk Reductions* provides useful summaries and examples (Raucher et al., 2002).

e. Economic, Social, and Equity Considerations

Social, equity, and economic development issues may include consideration of the location of impacts, resource access issues, aesthetics, or cultural values. They also include the impact of the project on the local economy, whether considered in a positive light such as helping to build or sustain community economic development or weighing the negative impacts that may be associated with growth. Overall, the objective is to identify who the likely beneficiaries are, who is likely to be affected by the impact, and whether they will be impacted in a manner they will consider negative or positive. This approach enables the utility to consider stakeholder outreach efforts (e.g., to enlist beneficiaries) in recognition of positive outcomes and possible ways to compensate or offset potential negative outcomes.

8. HOW DO THE BENEFIT CATEGORIES CORRESPOND TO DIFFERENT REUSE PROJECT IMPACTS?

The above types of benefits may be generated in numerous ways by a water reuse project. Table 3.1 provides a way to help identify which types of benefits (e.g., recreation) may arise from the various types of water reuse project outcomes or impacts. For example, impacts on surface water resources or creation of wetlands may create recreational and/or environmental benefits. The table provides a way to link or map what benefit categories may be most applicable for a given type of reuse project impact.

Table 3.1: Guide for linking types of potential benefits to impacts that may be generated by reuse projects

Water reuse project impact	Types of benefits potentially generated	Likely beneficiaries
A. Improve or preserve surface water flows and/or quality (e.g., by reducing surface water extractions, and/or by improving quality of discharged effluent)	+ Recreational benefits to downstream users of instream and near-stream services (e.g., anglers, boaters, hikers, and wildlife viewers), plus related organizations (e.g., Trout Unlimited). See appendix A.	All downstream recreational users, including many people from outside the utility service area/customer base.
	+ Environmental benefits via improved downstream flows and aquatic and riparian habitat (e.g., protect or enhance populations of fish and wildlife, some of which may be special status species such as endangered salmon). See appendix B.	All people with nonuse (passive use) motives (e.g., stewardship, existence, and bequest values) for preserving ecosystems. Includes mostly people and organizations from outside the service area (e.g., Sierra Club and Audubon Society).
	+ Financial and other benefits to downstream extractive users (e.g., enabling greater surface water extractions by community systems).	Customers and owners of downstream water agencies and/or agricultural or other extractive users (as applicable).
B. Create or improve wetlands (e.g., providing habitat, green space, outdoor activity opportunities)	+ Recreational benefits to walkers, hikers, picnickers, wildlife observers and photographers, and others who enjoy the natural outdoor amenities of the wetland area. See appendix A.	Many or most users are likely to be from the local utility customer base, but others from beyond the service area may visit and benefit as well.
	+ Environmental benefits from providing habitat and improved environmental conditions. See appendix B.	People from a wide area who value ecosystem preservation and enhancement.
	+ Financial and other benefits to downstream extractive users (e.g., if wetland-treated reuse water provides flows to surface waters or groundwaters).	Customers and owners of downstream or down-gradient water agencies and/or agricultural or other extractive users (as applicable).
C. Create or enhance recreational facilities, including sports fields, urban parks or greenbelts, or golf courses	+ Recreational benefits to ballplayers, golfers, walkers, picnickers, or anyone else who uses reuse-irrigated facilities. See appendix A.	Many users are likely to be from the local utility customer base, but others from beyond the service area may visit and benefit as well.
	+ Aesthetic, cultural/spiritual, and property value benefits to residents of neighborhoods that are enhanced by parks and other green space.	Utility customers and others who reside in or near the reuse service area.
	+ Environmental benefits, to the extent that reuse-irrigated green spaces provide habitat, shading, carbon sequestration, etc. See appendix B.	People from a wide area who value ecosystem preservation and enhancement.

Table 3.1: Guide for linking types of potential benefits to impacts that may be generated by reuse projects (continued)

Water reuse project impact	Types of benefits potentially generated	Likely beneficiaries
D. Improve groundwater resource quality and/or quantity (e.g., by reducing pumping demands and/or by providing recharge)	+ Increase water supply reliability (e.g., drought protection) through conjunctive use and storage capacity of local aquifer systems. See appendix D (and item E in this table). + Decrease subsidence and avoid related elevated pumping costs, potential damages to infrastructure, and risks to public safety. + Manage salt water intrusion and preserve water quality. + Enhance water quality by using aquifer to provide more in situ treatment and uniformity.	All of these potential benefits typically will accrue predominantly to the water supply agency and its customers. These benefits also may extend considerably beyond the service area boundaries, depending on the size and uses of the impacted aquifer system (e.g., where the groundwater system is used or underlies other communities, they also are likely to realize benefits).
E. Increase reliability and diversity of community water supply portfolio	+ Reduce likelihood of water shortages and use restrictions. See appendix D. + Reduce impacts on growth management and maintaining the economic vitality of the community (see item G in this table). + Reduce the variability and uncertainty about the volume (and cost) of water available to the community in the event of droughts or other source water-impacting events.	Customers of the water supply agency, and the utility itself, will be the primary beneficiaries. Empirical estimates suggest residential and business customers place considerable value on steps that will reduce the probability of future water use restrictions. There are possible spillover benefits to neighboring communities if reuse in town X enables more raw water availability for town Y.
F. Provide a “local” water source (i.e., using a local resource, under local control in lieu of waters imported from other areas and/or agencies)	+ Enhance local autonomy and local control (where reuse is used in lieu of imported waters). + Reduce energy consumption and air pollution where imported waters would be the alternative to reuse by reducing the need for pumping large volumes of source water across great distances and gradients.	Members of the local community (a potentially very important benefit but one that may need to be addressed only qualitatively). Benefits accrue over a large area (e.g., region- or statewide) and potentially globally.
G. Promote or sustain desired levels of community growth and economic development	+ Provide basis to sustain or support growth in local economic activity (e.g., jobs, incomes, and tax revenues). + Provide a mechanism that the community can use to help manage growth in manner consistent with community goals.	Primary beneficiaries will be the community as a whole, including local government, the water agency, businesses, and general public. Debates over what types and level of growth can be contentious: what some consider beneficial, others may consider to be a cost.

Table 3.1: Guide for linking types of potential benefits to impacts that may be generated by reuse projects (continued)

H. Avoid or postpone investments for expanding water supply and/or wastewater capacity	+ Decrease capital outlays for treatment plant upgrades or expansions and/or buried infrastructure. + Postpone or avoid one-time initial expenses for any required acquisitions of additional water rights, land, etc. + Decrease ongoing O&M.	Beneficiaries are the water supply and/or wastewater agencies and their customers for all these benefits.
I. Promote sustainability and "doing the right thing" by recycling and protecting water resources	+ Largely covered by items A, B, and D in this table above. + Generate general "feel good" value for "doing the right thing" from a natural resource/environmental perspective.	May be very important benefit to members of the local community, some public officials, and some stakeholder organizations. May need to limit analysis to a qualitative discussion (hard to measure empirically).

9. WHAT TYPES OF BENEFITS MAY BE MOST IMPORTANT FOR WATER REUSE PROJECTS?

The type of benefits that apply to a particular water reuse project, and the potential magnitude of those benefits, will be very site and circumstance specific. However, when one reviews several water reuse projects around the United States, there are several types of benefits that often appear to be among the most important motives for adopting the reuse project. These types of important benefits are not always amenable to quantitative analysis (i.e., often it has not been feasible to assign monetary values to these benefits). Nonetheless, they often are stated as key reasons for backing the reuse project. If any or all of these issues are central values for why a utility is considering a reuse option, then it is important to identify the applicable benefit categories and carry them through the analysis. Even if some or all of these benefits cannot be readily valued in monetary terms, they may represent important values that should at a minimum be described quantitatively in the final summary of results.

Reliability. Most traditional sources of potable water supply are vulnerable to drought and other events that periodically curtail the amount of water available to a utility and the community it serves. Many areas have endured droughts and faced associated curtailments in water extractions and restrictions on customer water use. There is strong empirical evidence that the public (and hence governing officials as well) places a high value on having a local water supply that is sufficiently reliable so that water use restrictions do not occur in the future or at least occur very infrequently.

Reclaimed water is not drought sensitive, and it provides a yield that is reliable because it is drawn from a source (treated wastewater) whose flow is largely independent of local weather conditions. Thus, reuse offers a way to diversify the yield risk in a local water supply portfolio, and this reduced risk has a real (and often considerable) economic value. Additional discussion of the source and potential magnitude of this reliability value is provided in appendix D.

Local control. Many regions depend on water supply options that originate from sources outside local jurisdictional boundaries, and this reality typically implies that the locality can become subject to rules or policies that are dictated by outside parties. Communities and local officials often place a high value on maintaining local autonomy. There is often a large value to the community in having local needs and issues managed locally, rather than relying on the resources of (or being subject to governance by) neighboring localities or state or federal entities.

Reuse water can be viewed as a local resource. It typically is generated from locally collected and treated wastewaters and managed by the local water supply and/or wastewater agencies. This means that reuse water is not subject to competing uses from other jurisdictions, and yields are not governed by state or federal policies that may limit future yields (e.g., restrictions on the community's extractions from rivers, due to environmental or other policies). It is likely that many community members and local governing officials would place a considerable value on the degree of local control (and associated reliability) that is linked to reuse options. There is no available empirical evidence as to the potential magnitude (monetary worth) of the local control benefit of most reuse projects, but it is nonetheless a potentially important value that reuse provides to many communities.

Cost offsets. Reuse water can be relatively expensive, compared to most potable supplies now in use. However, reuse may be relatively cost effective when one notes the *marginal cost* of adding new water supplies to meet growing local needs. This is because new water sources typically are increasingly scarce, require more pumping to extract and deliver, require more treatment to render potable, and/or have more competing uses (including environmental uses as habitat). Thus, tapping reuse in lieu of expanding traditional potable supply options may entail a significant net cost savings. Likewise, reuse options may save localities considerable expenses associated with how they would otherwise need to treat and dispose of wastewater.

Thus, in some settings, there may be considerable cost offsets (net cost savings) that are provided by reuse programs. These cost offsets should be relatively straightforward to estimate in monetary terms (considering both capital and operating expenses avoided in water supply and/or wastewater management). However, as noted previously, care needs to be taken as to how these cost offsets are taken into account in the economic analysis, so as to avoid potential double counting (i.e., the cost savings can be shown as a benefit of reuse, or the higher costs can be shown in the cost estimates for the baseline or nonreuse options, but they should not appear as both a benefit for reuse and a cost of alternatives).

Environmental improvements. Water reuse projects can generate appreciable value by improving local or regional environmental conditions. For example, decreasing extractions for surface waters that are periodically subject to critical low-flow conditions can improve instream flows and sustain better habitat for aquatic species of ecological, recreational, and/or commercial value. Likewise, the role of reuse projects in wetland creation and in reducing or improving wastewater discharges can also generate these types of environmental improvements and associated beneficial values.

The types and magnitudes of these benefits will be very dependent on the circumstances specific to each location and reuse project. However, in some cases, the estimable monetary value associated with ecological benefits (e.g., helping to preserve critical habitat for threatened or endangered species) or recreational benefits (improving fishing or boating experiences along rivers and streams) may be very sizable (e.g., see appendices A and B).

10. HOW DO I SCREEN THE VARIOUS OUTCOMES TO DETERMINE WHICH BENEFITS AND COSTS REQUIRE DETAILED QUANTITATIVE ANALYSIS, AND WHICH SHOULD BE DESCRIBED QUALITATIVELY?

It is useful to screen the list of potential costs and benefits for a project to determine which impacts are so small (or mitigated) that they can be dropped from the analysis, which must be qualitatively described (because quantification is not generally feasible) and which impacts can and should be quantified. The three screening criteria used in this step are described below. Figure 3.2 shows the screening analysis process as a flow chart. Note that the screening process described here reflects a way to assess how much effort should be devoted to estimating the various different benefits and costs, and the process assumes that a previous screen would separate out options that were infeasible either because of technical/physical limitations or institutional constraints (e.g., regulatory, political, or legal barriers that in effect "veto" an option and thus remove it from the choice set).

Screen 1: Is the Impact Relatively Small?

This screen considers whether the cost or benefit will be very small in absolute terms, or in relative terms compared to the other impacts. If the impact is so small as to be insignificant, then perhaps it can be eliminated from the analysis in an effort to save or focus resources. This is a matter of judgment, and it is important to document the reasons behind such a decision.

Some impacts can be dropped from the assessment, even if they are not small, when the impacts are going to be mitigated through some activity embedded in the project design and cost. For example, if a supply option may adversely impact some wetlands, but as part of the

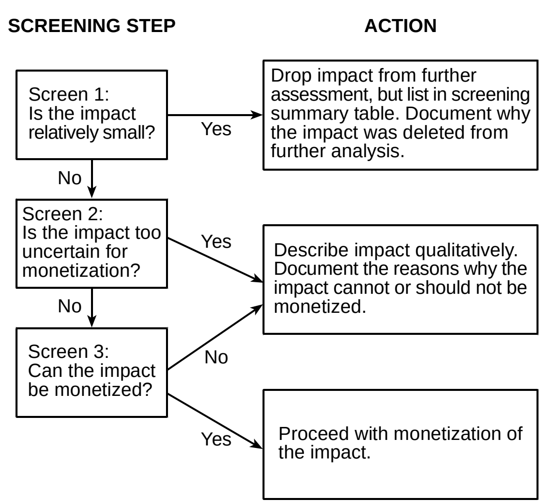

Figure 3.2: Screening analysis flow chart

project there will be restoration or creation of other nearby wetlands, then the wetland impact will be mitigated and does not belong in the analysis. However, it will be important to carefully assess and document that the impacts are indeed mitigated (e.g., that the newly restored wetlands will provide the same or better ecological services than those that may be adversely impacted). Further, the mitigation should then not be counted as a project benefit (since it was used to offset a unincluded project cost).

Screen 2: Is the Impact So Uncertain or Changing So as to Resist Economic Quantification?

This screen considers the situation where the impact is so changing or uncertain (e.g., due to scientific uncertainty or time lags in natural processes) or sensitive (e.g., due to political considerations, legal uncertainties, or cultural sensitivity) that any attempt at economic assessment would be impossible or not useful. In this case, it is important to explicitly recognize that economic valuation may not be possible or useful but that continued recognition of the impact is important through qualitative characterization.

Screen 3: Can the Impact Be Quantified in Economic Terms?

This screen considers whether available data and methods are sufficient for monetization of the impact. If the data and methods are available, then the analyst can proceed with quantifying the impact and then converting the impact into monetary terms. If monetization is not possible, it is important to continue recognition of the impact through qualitative characterization.

In some instances, it will be feasible to quantify the impacts in physical terms (e.g., acres of wetlands, numbers of fish, and acre-feet of water) but not in monetary terms. In these instances, the analyst should provide results in quantified physical units, even though monetization may not be feasible.

11. FOR BENEFITS (OR COSTS) THAT ARE NOT READILY QUANTIFIABLE OR MONETIZABLE, HOW DO I DESCRIBE THEM QUALITATIVELY?

If an important benefit (or cost) cannot be quantified in a reliable or readily feasible manner, it is still very important to make sure that impact remains a visible part of the analysis and is routinely included in any summary table or results sections. It is more important to keep a focus on "what counts" rather then to focus only on what may be "countable."

In developing qualitative descriptions, it generally is useful to have short but clearly stated descriptions of what type of benefit value is generated and why it is important to the community. Also, even where it may not be feasible (or desirable) to monetize some benefits, one often can nonetheless portray whether the benefit (or cost) is likely to be of *relatively* high importance and value.

Thus, using some indication of relative magnitude can be very useful when summarizing the benefit–cost findings, including the qualitative outcomes. We suggest using a five-point scale, ranging from a negative 2 to a positive 2, wherein a "+2" signifies a very high relative benefit, and a "−2" represents a large relative negative value (a high cost), while "−1" and "+1" represent the intermediate outcomes of relatively smaller costs and benefits, respectively (and zero represents a very small relative impact of little consequence in either direction). Other options include using a "+" or "–" sign.

12. WHAT METHODS CAN BE USED TO COME UP WITH VALUES FOR THE BENEFIT CATEGORIES?

There are numerous approaches for developing estimates of the monetary value of many of the benefits and costs associated with a reuse project.

Market Price

Where there is a functional market for a good or service that is impacted by a water reuse project, then one can use the observed market price as the dollar value to insert in the benefit–cost framework. Market prices typically are used for the direct costs of the project (or its alternatives), such as the cost of capital equipment, labor, and so forth. These market prices are sufficient to cover the needs of a financial analysis. However, for an economic assessment of benefits and costs, many of the important outcomes pertain to "nonmarket" goods and services. This means that there are no market prices to observe for many key outcomes (e.g., for a day enjoying an outing in a wetland or fishing on flow-enhanced streams). Thus, nonmarket valuation approaches are required for many benefits and costs.

Of course the primary product from a reuse project is the water itself. If a functional "perfectly competitive" market for reuse water existed (i.e., a market in which many sellers competed for the business of many buyers), then the most direct method for estimating the value of water is to look at the market price for reuse water. While a market price may be observed for water, the simple single observation of what people pay for water or the price at which it is sold by the agency does not allow one to develop an estimate for the overall value of water. Revenues collected from the reuse water thus reflect only a partial perspective of the value of the water provided.[1]

Nonmarket Valuation

Because many of the important benefits provided by water reuse involve nonmarket goods and services, monetary values need to be derived using various well-established methods developed by economists for "nonmarket valuation." These nonmarket valuation approaches can help develop dollar estimates for some important types of reuse benefits and thereby help decision-makers and the public better recognize the value of a reuse option. These nonmarket valuation methods are summarized below.

---

1. To use market price to estimate the value of water to consumers, market transactions for water must be observed across a number of different price levels and demand situations. By tracing the relative amount of water demanded at different prices, one can map out the demand curve for reuse and other waters. These demand curves for water reflect the consumers' willingness to pay (i.e., value), which could then be used to estimate the change in consumer surplus for a reuse project that changes either the demand or the supply of water.

Primary Methods

Many goods and services associated with water are not traded in markets. For example, there rarely are well-defined markets for many water-based recreational activities. There are two main approaches that economic researchers can use to estimate nonmarket values via primary research. These are known as *stated preference* methods and *revealed preference* methods. Stated preference methods are survey based and include contingent valuation and conjoint analysis, and revealed preference methods include travel cost and hedonic modeling (see summaries in Table 3.2).

Table 3.2: Primary economic valuation methods for nonmarket goods and services and comparative advantages and disadvantages

Travel cost	
+	Uses observed tourist and recreational traveling behavior
−	Measures use values only, often expensive and time intensive to collect adequate data
Hedonic pricing	
+	Uses observed housing, property, or labor market behavior to infer values for environmental quality changes
−	Measures use values only, requires extensive market data, assumes market prices capture the environmental good's value
Contingent valuation	
+	Only method that can estimate nonuse values, also can estimate use values
−	Time intensive and expensive to implement, challenges in framing survey questions to elicit valid responses, potential response biases
Conjoint/stated choice	
+	Similar to contingent valuation, except respondents are surveyed about a set of choices instead of a single willingness-to-pay question
−	Time intensive and expensive to implement, challenges in framing survey questions to elicit valid responses, potential response biases

Revealed preference methods are based on observing individuals' behavior and associated voluntary cost bearing to infer the value of a nonmarket good or service. While there may not be active markets to buy and sell days of outdoor recreation, there are often costs that individuals incur to undertake direct-use activities. For these types of uses, often we can apply incurred costs to develop proxy "prices" for the activity and use that information in developing the demand curve and thus value of water-related services. This approach uses observations of people's behavior, or their associated expenditures, as indications of "revealed preferences" for the good. Methods have been developed and are discussed below; they use these revealed preferences to develop estimates of the value of nonmarketed goods and services such as many water uses.

For other activities, where there is no direct use of the resource, and thus no behaviors or expenditures available as a measure of people's preferences, methods have been developed to directly elicit preferences and estimate value. These direct methods are often described as stated preference methods because they most commonly elicit value through direct statements on value rather than using observations on behavior or expenditures to infer value.

The most common revealed preference methods are the hedonic pricing method and the travel cost method. The travel cost method is used to value recreational uses of natural and environmental resources. The hedonic pricing method can be used to value a wide variety of factors that influence observed prices and is often used to infer the value of environmental goods.

Two common stated preference methods are the contingent valuation method and the conjoint/stated choice method. The contingent valuation method can value not only direct use values but also nonuse (e.g., existence and bequest) values for natural and environmental resources. The conjoint/stated choice method asks for a ranking of choices instead of an answer to one willingness-to-pay question and can also be applied to derive estimates of either use or nonuse values.

Secondary Methods

Primary research is often expensive to execute correctly and often not feasible due to budgeting, scheduling, and other constraints. It is often more practical to turn to secondary methods (described below) and to use an approach that helps identify the critical values in the BCA. If a particular value is identified as critical, then perhaps it will become desirable to invest in a primary research study to more definitively determine that value.

BT

An expeditious method for valuing water and related environmental resource services is known as benefits transfer (BT). The BT approach involves taking the results of existing valuation studies and transferring them to another context, e.g., a different geographic area or policy context. Under suitable circumstances (as described below), estimates for use or nonuse values may be derived, for example, using BT by applying an annual willingness-to-pay estimate per household to all the households in the geographic area in question with the same use or nonuse motives for the resource.

There are numerous challenges and cautions to consider when using BT. While it is relatively simple to develop a BT-based value monetary estimate of many types of benefits (e.g., there is a large literature on user day values for recreational experiences associated with improved surface water or wetland conditions), there are numerous ways in which the approach can generate potentially inaccurate (and misleading) results, even when a well-intentioned and objective analysis is being attempted. The most significant challenges to the accuracy and credibility of BT-generated findings are that there often are important differences between what type of natural resource conditions were studied in the primary empirical research (i.e., the study context for the published monetary estimate) and the reuse context and site to which an analyst may wish to transfer the results.

One such challenge in the BT approach is defining the appropriate “market” for the impacted site (e.g., what are the boundaries for defining how many households are assigned a BT-based value, such as dollars per year to preserve wetland habitat?). Another challenge arises due to the frequent need to attribute a BT estimate for a large outcome (e.g., avoiding a species extinction in a state) to the fractional contribution to the whole (e.g., the marginal additional protection for the endangered species provided by a single reuse project in a single location). These and other challenges are illustrated in the case studies provided in chapter 5 and reflect various challenges associated with properly matching the primary research scenario to the site and impacts in question.

Well-developed literature is available to guide those applying BT in the choice and use of appropriate studies (e.g., Desvousges et al., 1992), and the key steps are described below. When implemented correctly, the BT approach is accepted as a suitable nonmarket estimation method for estimating the use and nonuse benefits of changes in the level or quality of environmental resources, especially when used cautiously and transparently and with a recognition that the estimates are not intended to be precise. However, primary research is broadly considered a far better alternative when time and resources allow.

The advantages of using BT include time and financial savings, as conducting original research can be time consuming and expensive. The disadvantages of using BT include decreased accuracy as compared to primary research specifically tailored to the issue and site at hand and the potential difficulty in obtaining relevant, high-quality existing studies.

When conducting BT, one should make certain that each of the following steps is carefully done (as stated in U.S. EPA, 2000):

- Describe the issue (including characteristics and consequences) and the population impacted (e.g., will impacts be felt by the general population or by specific subsets of individuals such as users of a particular recreation site?).

- Identify existing, relevant studies through a literature search.

- Review available studies for quality and applicability. The quality of the study estimates will determine the quality of the BT. Assessing studies for applicability involves determining whether available studies are comparable to the issue at hand. Below are several guidelines for evaluating usefulness of a particular study for BT for a particular situation (based on guidance provided in U.S. EPA, 2000):

    - The technical quality of the study should be assessed. The original studies must be based on adequate data, sound economic and scientific methods, and correct empirical techniques.

    - The expected changes in site conditions should be similar in magnitude and type in the project being appraised and in those projects from which the data are obtained.

    - If possible, studies that analyze locations and populations similar to those of the project being evaluated should be used.

    - The cultural differences between project location and the source of data should be carefully considered.

- Transfer the benefits estimates. This step involves the actual transfer of benefits over the affected population to compute an overall benefits estimate. The transfer may simply involve applying a user day value as derived from the primary study or a more complex transfer of the benefits function derived empirically by the original researchers or from a meta-analysis of multiple studies.

- Address uncertainty. Because BT involves judgments and assumptions, the researcher should clearly describe all judgments and assumptions and their potential impact on final estimates, as well as any other sources of uncertainty inherent in the analysis.

Societal revealed preference

Nonuse values may be deduced (under limited circumstances) by using voluntarily incurred restoration-based costs as a proxy for the value of the change in resource conditions. For example, for threatened or endangered species, the costs of voluntary or consensus-driven restoration programs and the costs imposed by various widely endorsed resource-use restrictions may indicate the revealed preference value of restoring species populations to sustainable levels.

Avoided costs (cost offsets)

Avoided costs are an important part of valuing the range of benefits likely to be generated by water reuse projects. These benefits accrue from reducing or eliminating expenditures related to additions to potable water supply or wastewater treatment capacity. These costs can also be deferred to later years. Use of NPV analysis will allow comparison of benefits accrued in different years to be made on an apples-to-apples basis.

However, there are potential issues to be alert to when using avoided costs as a proxy for benefits values. Avoided costs can be used as measures of benefits when they would actually be incurred in the absence of the reuse project. Thus, and as noted several times above, there is a potential for double counting avoided costs in a BCA, and analysts need to be alert to this possibility when defining the baseline (and determining that costs of some options do not simultaneously appear as cost savings benefits of their alternatives).

Replacement costs

In some cases, a lower bound value for a lost resource can be estimated according to the costs necessary to replace the resource. For example, with loss of wetlands, an estimate can be derived for the cost to replace that habitat. Using cost-based measures as proxies or lower bounds for values can be tricky, however. Costs should be used in this manner only if they have been incurred voluntarily or through a consensus-based process. Otherwise, it is inappropriate to assume that costs also reflect values.

Response cost: averting or mitigating behavior

The averting behavior approach examines the expenditures people make to avoid damages that result from environmental degradation. The mitigation approach examines the expenditures people make to correct a problem after the potential impact has occurred. This could include measures such as installing water cleaning or filtering devices in the home. Averting costs are those costs associated with avoiding impacts from environmental degradation. This could include the cost of purchasing bottled water to avoid impacts from a tap water source.

Analysis strategies

Values are often not available for many benefit categories. A useful strategy in conducting an economic analysis when one or more key types of benefits is not measurable is to conduct an initial analysis that makes use of readily available data for the other categories of benefits and costs. Once the results are available for the existing data, then the analyst can attempt to determine whether or not valuation of other, omitted benefit or cost categories would influence the final outcome.

This approach, sometimes referred to as ***implicit valuation*** or a ***"break-even" analysis***, attempts to determine what value for an unknown benefit would be needed to make the NPV of the analysis turn from negative to positive. For example, if monetized benefits exceeded costs by $10 million, then a nonmonetized benefit would need to be worth at least $10 million for the BCA to "break even." It may be quite obvious that the omitted benefit is (or is not) likely to be worth this amount of money. If values are available for comparison in the literature, this value can then be compared to values in the literature to determine how realistic that implied value might be, i.e., whether or not it passes the "laugh test."

Another similar method to help ascertain the relative importance of values is to conduct ***sensitivity analyses*** on key variables, or variables with large uncertainty, to help understand the effect of changes in those variables on the performance measures being used (e.g., NPV). See "What is sensitivity analysis and how does it help?" in question 16.

13. WHAT ARE THE VALUES FOR THESE CATEGORIES THAT ARE AVAILABLE IN THE LITERATURE?

Many of the direct financial cost and benefits will likely be available based on engineering cost studies that have been performed for the utility. These values may include items such as the capital and O&M costs of constructing a reuse facility.

For indirect benefits and costs associated with reuse projects (i.e., the benefits and costs beyond financial, cash flow impacts, and often entailing nonmarket goods and services), there is a significant amount of literature available to help derive values. A summary of the literature is presented in the appendices of this document for key areas including recreation, environmental, cultural and aesthetic, and water supply reliability values. An outline of those benefit and cost areas and associated subcategories is listed below. Several databases that are useful sources for many of these values are described in some detail in appendix E to this document. Most of these databases are available free of charge and are useful collections of values from the literature.

- Recreation (appendix A)
  - In-water recreation (e.g., fishing)
  - Near-water recreation (e.g., hiking and picnicking)
  - Greenbelts (e.g., uses of urban/suburban area parks)
  - Golf

- Environmental (appendix B)
  - Water quality
  - Groundwater related
  - Habitat for threatened and endangered species
  - Habitat in general (for species that are neither threatened or endangered)
  - Coastal ecosystems
  - Wetlands

- Cultural and aesthetic (appendix C)

- Water supply reliability (appendix D).

14. DISTRIBUTIONAL PERSPECTIVES: WHO BENEFITS? WHO PAYS?

There are several perspectives to consider when analyzing benefits and costs of a water project. These include the water agency perspective, the wastewater agency perspective, the regional water agency perspective (if applicable), the customer perspective, the government regulatory perspective, and the societal perspective. A benefit from one perspective may be a cost from another perspective. For instance, reduced water cost is a benefit to the customer but is a cost to the water agency (forgone revenue). Understanding and tracking all of these perspectives are the key to understanding motivations for supporting water reuse projects and possibilities for cost-sharing arrangements.

Water supply agency – If a water supply agency is building the project, then the agency takes on the direct financial costs (capital and O&M costs) and benefits (namely, revenues) of the project, as well as some of the indirect costs and benefits.

Wastewater agency – The wastewater agency may be involved in several ways, through selling the wastewater for use in the reuse project or as a partner or a lead agency.

Regional water agency – A regional water agency may take on the roles of combined water supply agency and wastewater agency or may be a supporting agency providing funding and support to reach regional goals. The regional water agency may also be a provider of wholesale water to the local water supply utility.

Government regulatory – Local and national regulatory agencies may provide funding to support water reuse projects or to drive policy goals and may regulate the quality and applications of reuse waters. Regional benefits from the project may become benefits from the governmental perspective as well, showing that investment of government funds does not just help local interests but also helps generate broader benefits to the state or region as a whole.

Customer – Costs to customers may include the cost of extending reuse water lines to the customer's property, retrofitting plumbing to accommodate reuse water, and adding backflow prevention devices. Benefits may include lower water costs or reduced fertilizer costs.

Out-of-service-area stakeholders – Benefits may accrue to people or entities outside the service area. For example, if reuse improves instream conditions by enabling higher flows and healthier ecosystems, users of the waters in downstream locations will benefit. These are benefits that are external to the community that pays for the reuse and can become an important basis for gaining external funding (e.g., subsidies or grants from state agencies or cost shares from downstream communities).

Societal – This perspective includes the total sum of benefits and costs associated with a project. It can include recreational, environmental, cultural, aesthetic, economic, and social costs and benefits that may not be captured by other perspectives.

A key intent of exploring the different perspectives is to help examine the equity (i.e., fairness) implications of who pays versus who benefits from a reuse project. Equity concerns are important to identify as part of a policy discourse and may include explicit consideration of "environmental justice" as described below. In addition, understanding the distributional incidence of benefits and costs can serve as a useful basis for considering how to pursue a more equitable distribution of project costs (e.g., to seek cost sharing from neighboring jurisdictions that may benefit from a reuse project but not otherwise bear any of the costs) or to justify a state or federal subsidy (to reflect external benefits provided to a broad area). As a general principle, fairness considerations suggest that parties should bear costs in proportion to the extent they receive benefits.

Environmental justice is a term used more specifically (especially under federally mandated analyses) to explore the fair treatment of people of all races and incomes with respect to actions that affect the environment. Here, fair treatment implies that no group bears a disproportionate share of the negative impacts of an action. A group can be defined by race, ethnicity, income, community, or other relevant characteristics. In evaluating reuse projects, a qualitative assessment of potential environmental justice impacts should be considered part of the broader processes of policy evaluation, decision-making, and public discourse.

15. WHAT IS DISCOUNTING, AND HOW DOES IT RELATE TO COST ESCALATORS USED IN FINANCIAL ANALYSIS?

Benefits and costs from water projects often occur as a stream of values over time. That stream may change in magnitude over time. Water projects usually have large capital costs that are paid for either up-front or more likely over an amortization period at the beginning of a project, whereas benefits may accrue over the economic life of the project, which for some projects can be substantially longer than the amortization period. Values that occur in different time periods need to be adjusted to their comparable "present values" to compare them or make calculations with them.

There are two interrelated factors to consider when comparing values from different times: inflation and the "time value of money." When inflation is accounted for in recording or projecting values over time, the values are said to be in "nominal" terms. Many financial analyses are conducted in nominal dollars. However, for economic analyses, benefits and costs are normally *not* entered in inflation-adjusted dollars. The use of "real" (i.e., not inflation-adjusted) dollars makes analyses easier and keeps inflation-related projections from clouding the analysis. In real dollars, a dollar today has the same purchasing power as a dollar 10 years from now.

The second factor to account for in comparing values over time is that most people prefer a dollar today to an inflation-adjusted dollar available in the future. Most prefer to have a real dollar today instead of a real dollar in the future because they prefer to use that dollar to consume today or they prefer to invest that dollar today to yield a return. This preference for near-term consumption over deferred consumption is referred to as the "social rate of time preference" or the "time value of money." This social rate of time preference is the real (i.e., inflation-free) net-of-tax and risk-free rate of interest that would need to be paid to a person to entice him to consider delayed receipt of a real dollar.

The annual rate at which present values are preferred to deferred values is known as the discount rate (and is similar to an interest rate). The greater the preference for immediate benefits (time preference) or the greater expected rate of return on other investments today (known as the opportunity cost of capital), the greater the discount rate. The discount rate can be expressed in nominal or real terms. A real discount rate is the nominal discount rate with the inflation rate subtracted. The key is to use a real discount rate when analyzing dollars in real terms and a nominal discount rate when analyzing values in nominal terms.

Economic theory suggests that, in a world with no taxes, no financial transaction costs, and zero risk, there would be a clear signal about what discount rate to use. If consumption today would come at the expense of investments in the future, then the opportunity cost of capital should be used to discount the stream of future benefits and costs. In that case, the discount rate should be equal to the rate of return that could be earned by investing the money. If inflation is expected to be 4% in the future and if there is a 3% risk-free real return on capital, then the real discount rate would be 3% and the nominal discount rate should be 7% (3% + 4%). If instead the use of funds or resources today predominantly displaces future consumption (instead of investments), then a social rate of time preference is more suitable as the discount rate.

There are philosophical and practical aspects to the choice of discount rate, and there is not always general agreement among economists or policymakers about the correct discount rate to apply to evaluating projects. For BCAs of reuse and other water supply projects, which are generally investments made for broad public benefit, it may be most appropriate to use a real, net-of-tax social rate of time preference as a real discount rate to convert all values to their present values. However, justifications can be made for a range of rates, from a zero discount rate to a discount rate reflecting the private cost of capital. The argument for a zero discount rate is that discounting distorts project benefits that may occur far into the future and thus affect future generations or that include irreversible outcomes (e.g., species extinctions). Others suggest that the discount rate should reflect prevailing interest rates on low-risk bonds because such risk-free, net-of-tax rates best reflect the rate of social time preference. This might be reflected by the real cost of capital to municipal agencies in raising capital through bonds or the cost of long-term federal government bonds. Another argument is that, for projects that will be paid for through water rates, the cost of capital to ratepayers is the appropriate measure. This cost of capital might reflect an average of credit card debt rates, home and automobile finance rates, and other consumer rates and may average around 8 to 10% in nominal terms. The argument for using the private cost of capital is that the project's funds might be otherwise invested in private ventures and therefore reflect the true opportunity cost.

Various governmental entities have specified discount rates to be used in analyses. The federal Office of Management and Budget (OMB) regularly updates discount rates in appendix C to its circular number A-94 on *Guidelines and Discount Rates for Cost–Benefit Analyses of Federal Programs* (OMB, 1992). OMB recommends using real interest rates on Treasury notes and bonds matched to the project time period for the real discount rate. The real interest rate on a 30-year note as of February 1994 was 3.5%. OMB also mandates that federal agencies apply a 7% real rate of discount when evaluating the costs and benefits of federal regulatory actions (U.S. EPA, 2000), although other rates often are used in sensitivity analyses (and a 3% real rate is typically used by the U.S. EPA to reflect the social rate of time preference). Finally, federal water resource agencies also are directed to use specific rates to evaluate water project alternatives by the Federal Code of Regulations, Plan Formulation and Procedures (for federal fiscal year 2006, the general planning rate is 5.125%).

To compare streams of value over time from different projects, the stream of values for each project is discounted to "present value" by using the discount rate. If both benefits and costs are involved, the present value of the costs is subtracted from the present value of the benefits to get the NPV of the project. If the NPV of a project is greater than zero, then the present value of the benefits is greater than the present value of the costs. The NPV of different projects can be compared if they are adjusted to be in the same year's dollars. Comparison of NPV of projects allows apples-to-apples comparisons of project values regardless of possible differences in the timing of benefits and costs for each project.

16. WHAT IS SENSITIVITY ANALYSIS, AND HOW DOES IT HELP?

In many cases it will be useful to explore the impact of uncertainties or key assumptions (such as the choice of discount rates or the use of BT-based estimates) through the use of sensitivity analysis. Sensitivity analysis involves systematically changing the value of some key input variable to see how it affects the outcome of the analysis. The change in results with the change in inputs can illuminate how important the impact is of uncertainty in a particular variable to the outcome. Sensitivity analysis is often performed by varying a particular input by equal amounts greater to and less than the current value.

For example, if a discount rate of 9% has been chosen for the main analysis, that value might be varied in increments of three percentage points from 0 to 15% for the sensitivity analysis. Table 3.3 shows an example of a sensitivity analysis for the discount rate applied in this fashion to the water-reuse example

Table 3.3: Sensitivity analysis applied to discount rate for the water reuse project (thousands of dollars)

Discount rate	Monetized benefit	Cost	Monetized net benefit (NPV)
0%	49,000–51,500	30,000	19,000–21,500
3%	39,500–41,700	26,000	13,500–15,700
6%	29,500–34,000	22,000	7,500–12,000
9%	15,950–21,300	16,000	(50) –5,300
12%	8,500–14,000	11,000	(3,500) –3,000

17. HOW SHOULD UNCERTAINTY SURROUNDING THIS ANALYSIS BE HANDLED?

In an ideal situation, data would be available to statistically estimate confidence intervals for benefit or cost estimates. When this is possible, confidence intervals for estimates should be noted on the framework templates as the analysis is being conducted. However, statistically estimated confidence intervals are most often not possible. When it is possible with available data, ranges should be developed for an estimate by stating the upper and lower bounds. When bounding of an estimate is not possible, one can at least characterize uncertainty qualitatively by describing the sources of uncertainty and stating whether an estimate developed is likely to over- or underestimate the true value (see “Omissions, biases, and uncertainty,” which is step 9 of the framework process, as described earlier in this chapter, under question 4 above).

It should be noted that are two main sources of imprecision in estimates of values. One is ***variability***, i.e., the natural variations in an estimate due to its properties or the forces acting on it (e.g., water use or surface water yields can vary by season and from year to year). The other is ***uncertainty*** about an estimate due to a lack of knowledge on the part of the analyst about the true value (e.g., is the value of improved delivery reliability to a customer $25 per acre-foot, or is it $250 per acre-foot?). Both variability and uncertainty can lead to imprecision of estimates and are reasons why estimates should be represented with a range of values instead of just a single value. A single “best estimate” or mean value can be used, but the range of possible values should be identified and explored with sensitivity analysis. Using a range of values instead of only a single estimate can avoid giving any impression that the analysis is tilted toward a desired outcome.

Scenario analysis or sensitivity analysis is an important tool to help in understanding the effect of uncertainty. By examining different scenarios with different values from the range of uncertainty for key variables, the analyst can determine whether the uncertainty in the underlying variables is important to the ultimate outcome of the analysis. Knowledge of whether uncertainty regarding key variables is likely to affect the outcome of analysis or the decisions to be made can help focus future research efforts on the most productive topics.

A concept related to uncertainty is *risk*, which, for the purposes of this discussion, can be thought of as reflecting the probability and consequences of an event. For example, droughts carry risks in terms of the reliability of surface water yields. Drought events reflect variability in precipitation from year to year (i.e., there is variation in surface water flows over the years), and we are uncertain about when the next drought will occur or how severe it will be.

The risk associated with a drought is that there is some probability that, in a given future year(s), there will not be enough surface water to meet demands, and the consequence is that in those years water use restrictions will need to be imposed. Not all water supply options bear the same types and/or levels of risk, and these differences are important to articulate in the analysis. In some instances, monetary values may be assigned to differences in risks across options (e.g., the added reliability of reuse compared to drought-sensitive source water alternatives).

18. HOW DOES THIS ANALYSIS RELATE TO THE IMPACT ON WATER RATES FROM PROJECTS?

The net direct costs for the water reuse project from the agency perspective minus the benefits (mostly revenue from reuse water sales) are net costs that must be covered from several possible sources, one of which may be potable water rates. Reuse water rates are often set at a discount compared to their full cost to encourage use. This is a public policy decision, and the remainder may be covered by any one of a number of sources that may include grants, loans, tap connection fees, and increases in potable water rates.

19. HOW CAN THIS ANALYSIS BE USED TO EXPLORE/UNDERSTAND POTENTIAL COST-SHARING ARRANGEMENTS FOR PROPOSED FACILITIES?

Estimates of how much each stakeholder benefits from the project that is made using an economic analysis can be used as a basis for a fair cost-sharing arrangement. The key is to have buy-in from stakeholders on the values estimated (or at least to have stakeholders acknowledge the types of benefits realized). If stakeholders do not understand the estimates or if the estimates do not match well with stakeholders' understanding or expectation for the value of their benefit from the project, then it will be more difficult to suggest the results of the economic analysis as a basis for cost sharing. Results of the analysis should be discussed with stakeholders, with adjustments made to either better align the results with expectations or to educate stakeholders on the valuation process. This tool and analysis can be used as a learning process to educate all parties and help lead to an equitable arrangement based on sound analysis.

20. WHAT'S NEXT?

This chapter has described what an economic (benefit–cost) analysis is and has provided guidance on how to develop one. Chapter 4 provides the templates that can be used to implement the economic framework (a spreadsheet version of the tool is also available on the CD provided with this report). Case studies are also provided to offer illustrations of how the templates can be completed.

CHAPTER 4

TEMPLATES FOR CONDUCTING AN ECONOMIC ANALYSIS

Chapter 3 described the various steps involved in conducting an economic analysis of reuse projects and provided background information and guidance related to each of the steps. In this chapter, we provide a series of forms or "templates" that are useful for helping to systematically organize and transparently document information as an analyst works through each step. The templates also are designed to be useful for communicating the contents and findings of the analysis to decision-makers, customers, governing officials, and other stakeholders.[1]

There are two versions of the templates: one set (presented in this chapter) that is provided as paper versions and the other set that is built into the software version of the economic framework. In this chapter (and in chapter 5), we focus on the paper (hard-copy) versions that can be used by analysts. These paper versions replicate what is on the spreadsheet (though in a more paper-friendly manner) and provide a way that utility analysts can implement the economic framework offline (i.e., without relying on the electronic spreadsheet version). This chapter provides the blank versions along with some guidance, and chapter 5 provides some case studies in which most of the templates are partially filled in so that they can serve as useful illustrations of how to use them. These blank templates are also available in electronic form (in MS Word) on the CD that accompanies this report, so that users can download them and use them as needed.

In addition to the hard-copy templates provided here, we also have developed a spreadsheet version of the economic framework that embodies the same logic and approach. Each tab in the spreadsheet version represents a step-specific template. The software versions of the templates in the MS Excel-based software tool do not exactly correspond to their hard-copy counterparts, because the software version is designed to enable use of the functionalities the spreadsheet offers. However, the software tool replicates the same logic and intent as the hard-copy versions shown here. Appendix F helps users gain a visual overview of the software tool by providing a hard-copy version of the spreadsheet tool. The electronic version of the software tool is provided on the accompanying CD.

OVERVIEW OF THE STEPS

In question 4 of chapter 3, an overview of the steps for conducting an economic analysis of a water reuse project was provided. The flow diagram that summarizes these steps is repeated here (Figure 4.1) to provide a visual road map to users as they examine the accompanying templates and spreadsheet tool materials.

1. These templates are not unique to this WRF project and have been developed and applied in various other efforts produced by the research team (e.g., the AWWA Research Foundation report on the value of water [Raucher et al., 2005]).

Note too that the economic analysis embodied in the steps portrayed in Figure 4.1 is only one part of the broader decision-support toolkit that water planners and decision-makers will need to deploy in the public policy context of water reuse decisions. An economic analysis is only one tool, and the application of complementary tools in the decision support arsenal will also be necessary.

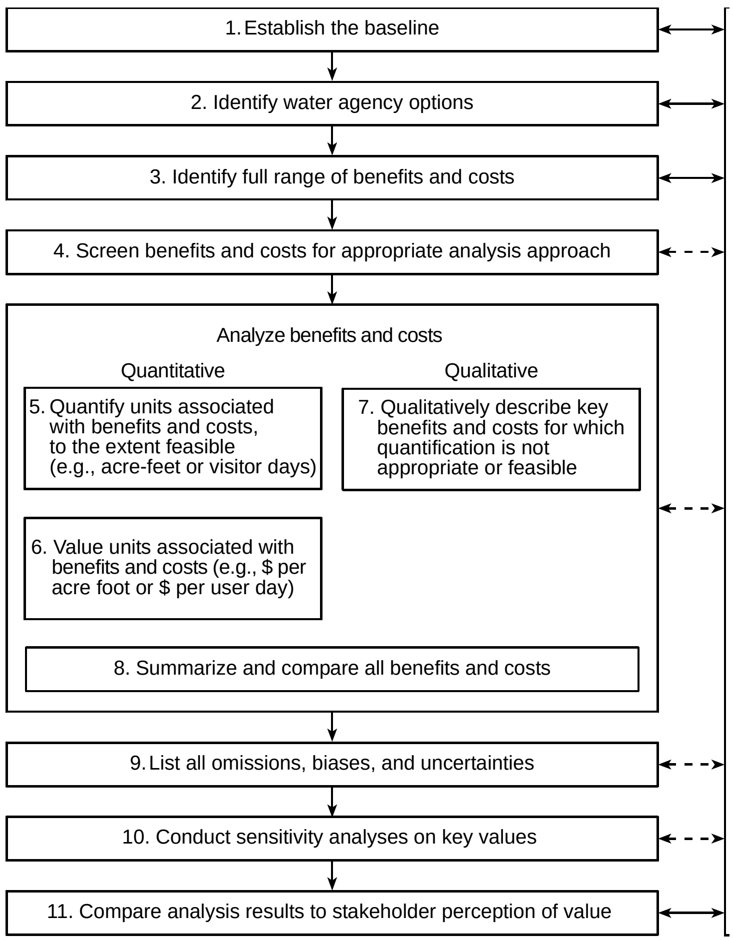

Figure 4.1: Steps in an economic analysis framework

PAPER VERSIONS OF FRAMEWORK TEMPLATES

The following templates are intended to help guide users and provide a systematic way to organize and present information. A formal template is not provided for every "step" in the economic evaluation process, as some steps do not necessarily entail the need for a formal assessment. However, a user should follow the process steps from Figure 4.1, regardless of whether worksheet templates are provided here.

Step 1 has no formal worksheet but entails defining and recording baseline information. This typically will entail considering what the future will look like in terms of water supplies (quantities, qualities, and cost) and future demands (embodying one or more possible growth scenarios). It is good practice to explicitly state key assumptions and to provide a clear statement of what problem(s) the potential project is intended to help address (and/or state what desired objectives the project would help the utility and community attain).

Step 2 also has no formal worksheet template but is the step in which the analyst defines the water reuse project(s) and possibly other options that the agency considers feasible for its water supply portfolio. This is a place to record information regarding the water reuse project to be evaluated. This includes information on the type of project (e.g., direct nonpotable and indirect potable), the type and number of customers associated with a project, other entities associated with the project, key project dates, and key project stakeholders.

Step 3 includes a template (below) to help users with the identification of benefits and costs for the reuse project(s) and includes columns for multiple alternative projects (each option has its own column). This is a simple checklist to get the process rolling, in which the user should place a check in the rows for which a benefit or cost (relative to the baseline) would probably apply.

Step 4 includes a template for summarizing and reporting the findings of the screening analysis, i.e., separating the various identified benefits and costs into three categories: (1) those for which some level of quantitative analysis is feasible and pursued; (2) those that are not amenable to quantified analysis but are nonetheless important and require/deserve a meaningful qualitative discussion; and (3) benefit and cost impacts that exist but are deleted from further analysis because they are likely to be too insignificant to be of relevance or because they are impacts mitigated by other actions embodied in the project. In the second category, a simple relative scoring scheme is useful to apply (e.g., the +2-to-−2 scale described earlier or, as shown in the example template below, a simple + or − sign).

Steps 5 and 6 are summarized in a single template offered below, which provides space to indicate the types and levels of physical units used to quantify the benefit outcomes, as well as indicating what dollar value is applied to each unit. The user can thus enter the relevant quantity and units of measurement associated with a given type of benefit (e.g., acre-feet of water or number of recreation days) and the range of $/unit values associated with that item (e.g., $/AF or $ per angling day). If the units and/or values are expected to change over time (e.g., the volume of water or use does not become available until *x* years in the future), this can and should be described in these entries as well, since projection of the potentially changing units and $/unit values over time should be used to calculate total benefits and costs over time.

Finally, the "comments" column should be used to document the information sources (e.g., citations) for the quantified values selected for each impact, as well as some indication of the confidence (or lack thereof) held in the values applied. Overall, this template is intended to provide clear documentation of the basis for each quantified outcome used in the analysis, so that the analyst and reviewers can retrace the information and defend or critique it later, if warranted.

Step 7 entails considering the qualitative benefits and costs identified in steps 3 and 4. In using the suggested template, users are encouraged to (1) develop short but meaningful qualitative descriptions of the important qualitative outcomes, (2) convey a sense of relative ranking of whether the benefit (or cost) is likely to be of high or low relative importance compared to other benefits and costs in the analysis, and (3) identify who are the likely beneficiaries.

The relative ranking aspect can be done using (for example) a five-point scale to indicate the likely impact on net benefits (net benefits are the monetized benefits minus the monetized costs for the project). This rating scale can use +2 (or ++) for showing a very positive impact on net benefits, −2 (or −−) showing a very negative impact on net benefits, and 0 showing a neutral impact on net benefits. Users can also insert a +1 (or a single + sign) or −1 (−) for modest positive (or negative) impacts on net benefits, respectively.

Step 8 is a template for summarizing all the benefit and cost findings, including both quantified and qualitative information on all the benefits and costs of significance associated with the project. This page shows a summary of net benefits for the project along with the qualitative assessments developed in previous steps. This summary of benefits and costs is likely to be a table that is often used by those considering the project; therefore, it is very important that the qualitative benefits and costs be included in every table that also contains the monetized benefit and cost findings (otherwise, there is a tendency for too much focus to be placed on the numeric results and too little attention, or none at all, on the qualitative outcomes that may be of considerable importance.

Step 9 is a template listing the various omissions, biases, and uncertainties associated with all values in the analysis, both quantitative and qualitative. Here, "omissions" refer to possibly important benefits or costs that could not be explicitly included in the analysis. "Biases" refer to quantified outcomes that the analyst knows are likely to be skewed to be lower bound or upper bound (rather than "most likely") estimates, as may occur due to data limitations or other unavoidable reasons (note that the term "bias" here does *not* imply any intentional intrusion of opinion over fact and instead refers to empirical outcomes arising from data limitations). "Uncertainties" reflect results that quite possibly are inaccurate but for which it is not clear whether they may be too low or too high.

Step 10 provides a template for conducting and reporting the results of sensitivity analyses. The template was shown earlier (Table 3.3) in a simple version in which the sensitivity analysis is based on how the NPV benefits (present value benefits minus present value costs) are impacted under alternative discount rates. However, sensitivity analyses can (and generally should) be based on multiple variables (not just the discount rate) and often are helpful if alternative scenarios or assumptions for multiple variables can be conducted simultaneously.

Template for step 3
Checklist overview of benefits and cost categories across water supply options

Category	Option 1	Option 2	Option 3	Option 4	Option 5
Costs to water agency (internal financial costs)					
Capital					
Water					
Land					
Treatment					
Distribution					
Administrative fees					
Administrative costs					
Avoided water supply and wastewater costs (relative to baseline)					
Supply costs					
Treatment capacity					
Wastewater capacity					
Treatment variable costs					
Water reliability and quality					
Water quality (aesthetics)					
Water quality (regulatory compliance)					
Quality reliability					
Supply reliability					
Public health and safety					
Change in risk of illness (morbidity)					
Change in risk of premature fatality (mortality)					
Environmental and recreational impacts					
Sourcewater protection					
Downstream habitats					
Environmental restoration					
Groundwater					
Coastal ecosystems					
T&E species					
Terrestrial ecosystems					
Recreation					
Economic, social, and equity impacts					
Economic development/growth					
Resource access					
Resource location					
Aesthetics					
Cultural values					

✓ indicates that the category of impact exists for the given supply option.

Template for step 4
Summary screening analysis

Benefits and costs receiving full or partial economic valuation

❍
❍
❍
❍
❍
❍
❍
❍
❍
❍

Benefits and costs requiring qualitative assessment[a]

(+)
(+)
( )
(-)
(-)

Impacts deleted from further analysis: impacts that are relatively small or mitigated

❍
❍
❍
❍
❍
❍
❍
❍
❍
❍
❍
❍

[a]Place “+” or “–” in parentheses for positive benefits or costs (negative benefits), respectively.

Template for steps 5 and 6
Detail on benefit value derivation for water reuse project

Benefit category	Annual quantity	Unit value used	Comments

Template for step 7
Qualitative benefits description

Type of benefit	Relative importance[a]	Brief description	Key beneficiaries

[a]Expected relative impact on project net benefits: ++ (or +2) for relatively large positive addition to net benefit, + (or +1) for moderate added benefit, − (or −1) for moderate negative impact, and −− (or −2) for relatively large negative impact on net benefits.

Template for step 8
Costs and benefits of water reuse project
(present values, *x*% discount rate, <enter year> dollars)

	Dollar amount	Stakeholder accruing cost or benefit
Cost components		
Total costs		
Benefit components		
Total monetized benefits		
Benefits requiring qualitative assessment[a]		
Monetized net benefits (monetized benefits minus costs)		

[a]+ indicates positive benefits anticipated, but not monetizable with readily available data, and – indicates costs anticipated but not monetizable with readily available data. Or use +2-to-–2 five-point scale.

Template for step 9
Omissions, biases, and uncertainties and their effect on the project

Benefit or cost category or variable	Likely impact on net benefits[a]	Comment

[a]Direction and magnitude of effect on net benefits:
++ = Likely to increase net benefits significantly.
+ = Likely to increase net benefits relative to quantified estimates.
– = Likely to decrease benefits.
–– = Likely to decrease net benefits significantly.
U = Uncertain; could be + or –.

Template for step 10
Sensitivity analysis applied to discount rate
(thousands of dollars)

Variable/ scenario	Monetized benefit	Cost	Monetized net benefit

CONCLUSIONS

This chapter has provided several templates that can be used to help guide and document the economic analysis, as well as some guidance on the use of these templates. The economic analysis framework (and these templates) is illustrated in a series of case studies in chapter 5. In addition, a software tool (a spreadsheet model) is provided with this report (see the accompanying CD and appendix F); it generally replicates these templates and provides a computerized and interlinked alternative method for applying the economic framework.

CHAPTER 5

CASE STUDY ILLUSTRATIONS

Previous chapters have described why it is important and useful to conduct economic analyses of water reuse and related options, and also provided guidance on how to perform such BCAs. This chapter provides some useful illustrations, tips, and lessons learned from case study applications of the framework to water agencies that have participated in this research project.

It is important to note that it is not typically a straightforward or simple task to develop a credible economic (benefit–cost) analysis of a water reuse project. Many of the important benefits (and some of the important costs) are not readily quantifiable or monetizable. Further, some of the streamlined valuation methods that can be applied, such as BT, are often not as straightforward as may initially appear. This pitfall raises the possibility that unintended errors may be introduced that could yield misleading results or cast doubt on the credibility of the analysis (or both). Therefore, the illustrations provided here are intended to help reveal some of the challenges and potential pitfalls that users need to be alert about and try to avoid and to concurrently offer suggestions for how to best approach these issues and avoid these problems.

Also, the case studies below are not in and of themselves comprehensive evaluations of any single water reuse project. We have selected illustrative elements from the various projects so that we can provide some focused discussion and examples and highlight some lessons learned and associated tips for practical application. We have extracted from the case studies the benefit estimation issues that appear to be important in many reuse applications and have focused on the ones that typically are challenging to value. A summary overview of the case studies and associated benefit types that we explore is provided in Table 5.1.

Finally, because these case studies are intended to be useful as illustrations, we have taken some liberties with simplifying some of the facts, and in some instances we may gloss over some important details. Our intent is to provide illustrations and not to offer materials that might be misconstrued as comprehensive or fully accurate depictions of any particular water reuse project or utility. All monetary figures cited here reflect 2003 price levels and are stated in United States dollars (US$), unless otherwise specified.

Table 5.1: Overview of case illustrations

Case study	Benefits illustrated	Comments and key lessons
Los Angeles Basin, CA	Enhanced water supply reliability. Improved coastal ecosystems.	Need to recognize "whole versus part" nature of both reliability enhancement and coastal water improvement and thus to develop explicit "attribution" approach to apply $ values via BT.
Pinellas County, FL	Enhanced water supply reliability. Improved coastal ecosystems.	As above, attribution issues of adjusting values for large-scale changes to the fractional improvements provided by a given reuse project. The need to define the "market" to which benefits apply (in this case, how many households value improved water quality in Tampa Bay).
Phoenix, AZ	Increased ecological and recreational values associated with wetland creation. Cost offsets from avoided wastewater treatment plant upgrades.	Values include examining the value of preserving or enhancing habitat for T&E species. Attribution issues (part versus whole) addressed for applying literature values in the BT. Recreational opportunities (day hiking and wildlife observation) also quantified and valued. Draws upon visitation data for similar wetland park facility in neighboring state.
Santa Clara Valley, CA	Reuse as an essential component to accommodate planned community development.	Qualitative discussion of how reuse is a necessary component of the water supply portfolio, in order to accommodate projected community development (no specific empirical estimates developed for this case).
Las Vegas, NV	Value added by reuse in golf course irrigation.	Values are described according to various relevant perspectives, ranging from the golf course owners alone (internal cost savings calculations) to the broader societal context.

ILLUSTRATION 1: REUSE APPLICATIONS IN WEST AND CENTRAL BASINS, CA

Background

There are two major groundwater basins under the heavily urbanized Los Angeles coastal plain: the West Basin and the Central Basin. Together they underlie 437 square miles. The basins have been a central focus of the area since the 1870s, when settlers first drilled wells into the underground water supplies. Development of the groundwater basin advanced dramatically with the economic growth of the coastal plain and the introduction of the deep well turbine pump in the early 1900s. By 1920, water levels in the West Coast Basin had dropped below sea level, and saltwater intrusion forced the abandonment of many wells close to the ocean's edge. By 1932, the entire coastal reach of the West Coast Basin had succumbed to saltwater intrusion (CDWR, 2005).

Through the 1940s and early 1950s, groundwater quality continued to deteriorate in both basins. As a result, the West Basin Association and the Central Basin Association, later to be known as Water Districts, were formed to manage the water resources in the respective basins. Today, the West and Central Basin Water Districts purchase imported water from the Metropolitan Water District of Southern California (MWD) and sell wholesale the imported water to cities, water utility companies, municipal water departments, and private companies. The two districts serve a combined population of more than 2 million residents in 41 southern Los Angeles County cities (Central Basin and West Basin Municipal Water Districts). For the last 45 years, the Water Districts have been involved in groundwater replenishment efforts and barrier well programs to halt saltwater intrusion into the coastal aquifers.

Water Recycling Programs

In order to alleviate pressure on traditional water supplies, both districts became actively involved in water recycling initiatives. Following a severe drought in 1987–1990, water recycling "took center stage" as a means to increase supply reliability (Rich Nagel and Joe Walters, West and Central Basin Municipal Water Districts, personal communication, August 3, 2005). Recycled water continues to become increasingly important in the region as demands for water and limitations on imported water supplies increase and the threat of drought is ever looming. Demand increases are primarily linked to population increases. It is estimated that another 400,000 people will move into the West and Central Basins over the next 20 years (Rich Nagel and Joe Walters, West and Central Basin Municipal Water Districts, personal communication, August 3, 2005). Simultaneously, entities are losing traditional water supplies to new regulations and environmental flow mandates. The need to develop new supplies of water is imperative.

The West Basin and Central Basin Water Recycling Program consists of the West Basin's West Basin Water Recycling Facility (WBWRF) and the Central Basin's two distribution systems, i.e., the E. Thornton Ibbetson Century Water Recycling Project and the Esteban Torres Rio Hondo Water Recycling Project. The West and Central Basin Water Districts treat and distribute approximately 30,000 acre-feet (AF) of recycled water per year for municipal, commercial, and industrial uses, as well as supplying recycled water for groundwater replenishment and barrier activities (the WBWRF produced the majority of the program's recycled water, almost 25,000 AF in fiscal year 2004–2005). The basins continue to expand their treatment capacity.

The WBWRF is the only treatment facility in North America that is able to provide five different qualities of recycled water, each having undergone various advanced treatment processes to meet the specific needs of customers. Lower-quality water is used for purposes such as irrigation, and higher-quality water is applied to many industrial activities. Medium-quality water is used for aquifer replenishment and serves two purposes. First, the medium-grade water injected into the aquifer can later be extracted for potable use (i.e., indirect potable reuse), and second, the efforts help prevent saltwater intrusion into the aquifer. Currently, the injection program utilizes 50% reuse water and 50% potable water, but expansion efforts should allow increasing the contribution of recycled water to 75% by 2006 (Rich Nagel and Joe Walters, West and Central Basin Municipal Water Districts, personal communication, August 3, 2005).

Benefit Types and Estimation

The West and Central Basin Water Districts have not quantitatively assessed the benefits of their water reuse programs. However, they have considered the potential benefits and qualitatively assessed them through discussion and brainstorming. As described above, there are a plethora of potential benefits to a recycling program of this size and scope, especially in the arid region of Southern California. However, the benefits that are the most apparent to the districts include enhanced water supply reliability, increased local control, and improved coastal water quality (Rich Nagel and Joe Walters, West and Central Basin Municipal Water Districts, personal communication, August 3, 2005).

Enhanced Water Supply Reliability

Recycled water is extremely reliable in terms of helping to avoid water rationing, because it is not sensitive to local or regional droughts that impact most other water supply options. The benefit of drought proofing is extremely important to both customers and the districts. The districts' goal is to provide a constant, noninterruptible supply of water to their customers. Recycled water aids the districts in meeting this goal because recycled water is available regardless of the current hydrological conditions. Industrial customers want a constant supply of water that is not subject to water rationing which interrupts business. For example, three oil refineries in the area use recycled water in their production efforts. They have to provide additional treatment to the water upon receiving it, so the lower cost of the recycled water (relative to alternative water supply options) is a negligible benefit, but the reliability (not having to build the threat of drought into the business plan) of the water supply provides significant benefit (Rich Nagel and Joe Walters, West and Central Basin Municipal Water Districts, personal communication, August 3, 2005).

Polls have shown that California water customers support these types of recycling programs. A recent survey sponsored by the San Diego County Water Authority (Rea & Parker Research, 2004) asked residents which of 10 policies they would most support to help alleviate the shortage and prevent water rationing if the state were short of water. The most preferred option was the use of recycled water for nonpotable use (Rich Nagel and Joe Walters, West and Central Basin Municipal Water Districts, personal communication, August 3, 2005).

Although interest in water supply reliability is increasing, few studies have directly attempted to quantify its value. The studies that have attempted to quantify the value of reliability used stated preference and revealed preference methods (see appendix D). One such relevant stated preference study was conducted in 1993 by Barakat and Chamberlin, Inc., which was retained by the California Urban Water Agencies (CUWA) to design, conduct, and analyze the results of a contingent valuation survey to estimate the value of water supply reliability in 10 California water districts to residential users.[1] More specifically, they sought to estimate how much residents are willing to pay to avoid water shortages of varying magnitude and frequency. Shortage magnitudes ranged from 10 to 50%, and frequencies ranged from once every 3 years to once every 30 years. The study found that the mean willingness to pay (WTP) on monthly water bills over all counties varied from a low of $14.49/month ($143/year) to avoid a 20% shortage once every 30 years to a high of $21.10/month ($253/year) to avoid a 50% shortage once every 20 years. All monetary figures cited here reflect 2003 price levels and are stated in U.S. dollars, unless otherwise specified. These results are consistent with another study conducted in Northern and Southern California by Carson and Mitchell (1987) (appendix D).

The challenge for a BT interpretation of these studies is in how to reasonably interpret these survey-based household monetary values (WTP of $143 to $253 per household per year). A series of three questions should be considered by the analyst:

- First, are the underlying studies of suitable technical quality? Here the answer is a qualified yes. The studies appear to be well designed and implemented. However, stated preference survey efforts, such as conducted here using the contingent valuation method to derive monetary values, can be subject to various biases and suspected imprecisions. Thus, the numeric results of the underlying studies need to be considered as rough approximations rather than precise monetary estimates. It might therefore be useful to apply a range of values in a sensitivity analysis.

- Second, are the underlying studies relevant to the situation to which they would be transferred? Here the answer is again a qualified yes. The studies estimate the value of water supply reliability to residents of the same general region. However, the values are derived from data that are more than 12 years old (such values may change over time). More important, the values reflect a WTP to ensure complete reliability (zero drought-related use restrictions in the future), whereas the districts' reuse program enhances only overall reliability but does not guarantee 100% reliability (since the majority of the region's total water supply is still drought sensitive). Thus, the dollar values from the studies will probably overstate the reliability value provided by the reuse program. One simple way to roughly adjust for this "whole versus part" problem is to attribute a portion of the total value of reliability to the portion of the problem that is solved. For example, if reuse water constitutes 10% of the service area's total water supply, one might assume it provides a 10% improvement toward total system-wide reliability and thus use 10% of the per-household values provided by the study as a rough measure.

- The third question is how to best transfer these results to generate good benefits estimates. One approach, as outlined above, is to apply some suitable fraction (e.g., 10%) of the total household WTP for complete reliability and then to apply that apportioned $/household figure to all the households served by the districts. Another

---

1. The participating agencies included Alameda County Water District, Contra Costa Water District, Los Angeles Department of Water and Power, Metropolitan Water District of Southern California, Municipal Water District of Orange County, Orange County Water District, San Diego County Water Authority, San Diego Water Utilities Department, San Francisco Public Utilities Commission, and Santa Clara Valley Water District.

possible approach is to convert the $-per-household figure into a $-per-AF equivalent (e.g., see Raucher et al., 2005, and appendix D), and apply that reliability premium to the volume of reuse water produced each year by the program. Both approaches are illustrated below.

Approach 1: To derive empirical estimates based on the above discussion, consider that the combined population that the two districts serve is approximately 800,000 households (based on 2 million residents). Next we assume (explicitly) that the annual WTP values from the literature are scaled to 10% (e.g., from $250 per year to $25 per year) to reflect an assumed apportionment of how large a share of the value of absolute water supply reliability can be attributed to the fractional gain in overall reliability that is provided by the current reuse program. Then a rough monetary estimate would suggest that the benefit of increased reliability and drought reduction potential in the West and Central Basins may range from $11 to $20 million per year (e.g., $25/household per year, over 800,000 households, equals $20 million per year).

Approach 2: An alternative approach is to place a $/AF reliability value onto the 30,000 AF per year of reuse water produced by the districts for direct reuse (although a value could also be assigned to the reuse water applied to the aquifer replenishment effort as well). The household WTP studies noted above (as well as other studies of similar nature) can be melded with data on typical household water use to translate the reliability values into a comparable $/AF metric. As described by Raucher et al. (2005), these imply a full reliability value of at least $4,000 per AF (and the Barakat and Chamberlin study may imply household total reliability values as high as perhaps $14,000 per AF). For our illustration, we apply a range of $4,000 to $8,000 per AF.

As in approach 1 above, these values need to be considered potentially imprecise because (1) they are based on survey methods, and more important, (2) they are based on complete reliability for the households, and the water reuse program provides only a partial contribution toward that absolute goal. Assuming again that 10% is a suitable portion of total reliability value to apportion to reuse, we derive a reliability value of $400 to $800 per AF produced by the reuse program. Given that the reuse program produces more than 30,000 AF/year, the reliability value may be in the range of $12 million to $24 million per year.

Discussion and caveats. The illustrations developed above should not be taken too literally, as they embody a series of assumptions that, in a real application, would require more analysis and scrutiny (and testing via sensitivity analysis). The fact that both approaches derive similar magnitude benefit estimates may be viewed as a comforting "weight of evidence" but should also not be taken too literally, since both approaches ultimately are driven by the same underlying data and assumptions. Nonetheless, this discussion has been provided to reveal to readers the method for deriving "order of magnitude" level monetary estimates and the pitfalls and challenges that typically need to be recognized and addressed in order to derive those estimates. In this example, a critical issue is how to attribute (or apportion) a fraction of a total value to the small part of the overall problem that the reuse program addresses (in this example, the attribution issue revolves around how much a drought-insensitive reuse program contributes to the region's total absolute water supply reliability).

Increased Local Control

The use of recycled water allows the districts to diversify their water supply portfolio with a source that is devoid of water rights or other potential restrictions that might be imposed by entities outside the region. The diversification of the water supply portfolio is imperative to help guarantee water delivery reliability. However, as water becomes scarcer, traditional water sources in the region are under increasing threat of legal disagreements, such as the need for water for environmental flows. The water recycling programs have allowed the West and Central Basin Water Districts to reduce their demand for imported water. Currently, recycled water is secure in its availability because there is more wastewater available to be recycled than can be used and because no outside entities (e.g., state or federal agencies) have any direct control over how much reuse water the districts produce and use.

One of the principal uses of recycled wastewater in the districts is for aquifer recharge and barrier projects. Currently, injection water consists of 50% imported MWD water and 50% recycled water. Expansion plans will reduce imported injection water to 25% imported supply. The injection program increases storage availability of the districts, provides greater local control of water resources, and prevents saltwater intrusion into the aquifer, all which have significant avoided costs associated with them. If the groundwater basins and their storage capacity of the West and Central Basins were to be lost to saltwater intrusion, the districts would need to establish an alternative water supply to make up for the anticipated shortfall. One option that may be available to the districts would be to increase their reliance on imported water (if available) at imported water noninterruptible rates. Potential costs associated with this option may be expanding existing facility costs, O&M costs, pipeline construction costs, and imported water costs. We have not attempted to value the avoided costs associated with this scenario, although they would easily be in the hundreds of millions of dollars per year.

Improved Coastal Water Quality

If recycled water is not used, it is discharged into the Pacific Ocean as wastewater. Environmental groups support using the districts' recycling program because it reduces the amount of effluent at the outfall and because the resulting water quality improvements are a benefit to the general public. For example, the optimization of the WBWRF has reduced wastewater discharge into Santa Monica Bay by 25%, resulting in a cleaner coastline and bay waters (Mantovani et al., 2001).

The values associated with maintaining a clean, healthy bay can be significant. Pollution in a bay can negatively impact a coastal economy, directly affecting commercial and recreational fisheries and other water-based tourism and leisure activities (beaches, boating, etc.). Additionally, studies have shown that the public places a positive value on improvements and protection of coastal ecosystems. Annual values range from ten to hundreds of dollars per household (see appendix B.5), and for our illustration we start with a range of $29 to $120 per household per year as the WTP to improve coastal waters appreciably.

As in the case of reliability, the literature-based per-household WTP estimates probably apply to water quality improvements that are larger than those attributable solely to the reduced discharge of treated municipal wastewater. In other words, the reuse program probably contributes only some fraction of the water quality enhancements that would be linked to the household WTP estimates found in the literature. These estimates are based on noticeable improvements in water quality, and thus a suitable percentage needs to be deduced (or at least explicitly assumed) to apply to the reuse contribution to larger, noticeable water quality improvements. One basis for this attribution percentage could be the percentage of total contaminant loads that the West and Central Basins recycling programs have reduced from entering the bays along the Los Angeles County coast. Assuming here that the reuse program has reduced the loads by 1% per year (e.g., in terms of pounds of effluent-based contaminants reaching the bays), then the applicable annual household WTP range for the reuse contribution becomes \$3 to \$12 per year. Aggregated across the combined population of roughly 800,000 households served by the two districts, benefits to coastal ecosystems may be in the neighborhood of \$2.4 million to \$10 million per year.

Additionally, the Sanitation District may see direct benefits from the recycled water program in terms of avoided costs for permits to discharge wastewater and revenues from the fees (though small) the West and Central Basins pay for their recycled wastewater. The Sanitation District may also realize significant benefits in water being diverted to recycling because it may delay or avoid the need for ocean outfall expansion. A study conducted in Orange County, California, estimated that the groundwater replenishment system in the county leads to a \$5.5 million annual benefit in delayed ocean outfall and capacity construction needs (Richardson et al., 1999).

Conclusions

The above illustration reveals how some key water reuse program benefits may be estimated, albeit imprecisely, to help gauge the potential value of water reuse to the broader community. The illustration uses several simplifying assumptions that, in real applications, would need to be investigated and supported with some logical empirical basis, if at all feasible. The goal here is to reveal the method for deriving estimates and the steps and limitations typically inherent in doing so.

Below, several of the economic framework templates are provided in Tables 5.2 through 5.5. These reveal how the information described above might best be portrayed. Here the goal is to make the estimation process transparent and as defensible as possible by documenting key data sources and assumptions.

Table 5.2: Template for step 4
Summary screening analysis

Benefits and costs receiving full or partial economic valuation
❍ Water reliability (+)
❍ Coastal ecosystem improvement (+)
Benefits and costs requiring qualitative assessment[a]
(+) Local control
(+) Avoided costs of importing water
(+) Avoided wastewater discharge costs
Impacts deleted from further analysis: Impacts that are relatively small or mitigated
❍ None
[a]Place "+" or "–" in parentheses for positive benefits or costs (negative benefits), respectively.

Table 5.3: Template for steps 5 and 6
Detail on benefit value derivation for water reuse project

Benefit category	Annual quantity	Unit value used	Comments
Reliability in terms of avoiding potential future water rationing in dry years	800,000 households receive the districts' 30,000 AF of water per year	\$143−253/year per household, scaled down to \$14−\$25/year per household (10% of total WTP) to reflect the overall increase in water availability from the reuse program (i.e., reuse improves but does not assure 100% total water supply reliability	WTP values are based on a contingent valuation study (CUWA) that asked about a number of different magnitudes and frequencies of water shortages. These results are consistent with Carson and Mitchell (1987), but both studies imply 100% supply reliability (see appendix D).
Coastal ecosystem improvement	800,000 households	\$29−\$120 per household for noticeable improvements and protection of coastal ecosystems, scaled to \$3−\$12/year per household (1% of total WTP) to reflect the limited contribution of the reuse program to the reduction in total contaminant loads to the bay	The West and Central Basin recycling programs have significantly reduced contaminant loads entering the coastal waters along several coastal stretches of the region (i.e., Santa Monica Bay). The WTP values are based on a study by Whitehead et al. (1995) for improved water quality to protect a coastal system in North Carolina (see appendix B.5).

Table 5.4: Template for step 8
Costs and benefits of water reuse project
(2003 US$ per year)

	Dollar amount	Stakeholder accruing cost or benefit
Cost components		
No information at this time (na)	na	na
Total costs	***na***	***na***
Benefit components		
Reliability	$11 million to $24 million per year	Water customers
Coastal ecosystem improvements	$2 million to $10 million per year	Public
Total monetized benefits	***$13 million to $21 million per year***	
Benefits requiring qualitative assessment[a]		
Avoided costs for discharging wastewater	+	Sanitation District
Avoided costs in established new water supplies for those lost to saltwater intrusion and/or to meet new demand	+	Water supply utility and its customers
Monetized net benefits (monetized benefits minus costs)	***na (no cost estimates here, to net from estimated benefits)***	

[a]+ indicates positive benefits anticipated but not monetizable with readily available data, and
− indicates costs anticipated but not monetizable with readily available data.
na indicates no data available at this time.

Table 5.5: Template for step 9
Omissions, biases, and uncertainties and their effect on the project

Benefit or cost category	Likely impact on net benefits[a]	Comment
Reliability (industrial users)	++	The WTP values used to calculate the benefit of reliability are based on surveys of residential customers. If the WTP values held by industrial water users were also taken into account, then the total benefit of reliability would likely increase, perhaps significantly.
Reliability (residential users)	U (+ or −)	The WTP values taken from the literature are scaled to 10% to reflect an assumed apportionment of how large a share of the value of absolute water supply reliability can be attributed to the fractional gain in overall reliability provided by the current reuse program. The 10% assumed here could be an overestimate or an underestimate. Further analysis would be needed to refine this scaling factor.
Coastal ecosystems	U (+ or −)	The WTP values are determined through a specific set of questions for a specific circumstance. BT should be used only to assist in gauging the potential general magnitude of the reuse program/ project.

[a]Direction and magnitude of effect on net benefits:
+ = Likely to increase net benefits relative to quantified estimates.
++ = Likely to increase net benefits significantly.
− = Likely to decrease benefits.
−− = Likely to decrease net benefits significantly.
U = Uncertain; could be + or −.

ILLUSTRATION 2: EXPANDING REUSE IN PINELLAS COUNTY, FL

Background

Pinellas County, Florida, is located on the west coast of Florida, in the Tampa Bay region. The county has a population of approximately 926,000 residents living in or around 24 incorporated municipalities (U.S. Census Bureau). Historically, residents of Pinellas County and the other counties of the Tampa Bay region relied on groundwater from the Floridian Aquifer as the primary source water, with the exception of the City of Tampa, which utilized the Hillsborough River. However, by the late 1980s, the South West Florida Water Management District (SWFWMD), the district responsible for the regulatory management of the hydrological basin in which the Tampa Bay area rests, had determined the groundwater source had been overpermitted, leading to overextraction (Rand, 2003). Overextraction posed serious economic problems for the region, as growth in the region required an available water supply. Overextraction also created numerous environmental problems, such as saltwater intrusion under the coastal communities of St. Petersburg and Pinellas County and the loss of groundwater-fed wetlands and estuaries in the region that are home to many species, including the endangered manatee (Rand, 2003).

In response to the increasing threat, the SWFWMD and the counties began to focus on alternative water supplies through a water sources development program that centered on surface water, desalinization, and reclaimed water initiatives. A cooperative funding program, begun in 1987, has provided more than $205 million in district grants to 249 reuse projects in the district's counties, resulting in 200 mgd of reclaimed water supply and 131 mgd of traditional water supplies offset by the use of reclaimed water (SWFWMD, Annual Agency Reuse Report). In addition, in 1993, SWFWMD recognized the need to accelerate the development of alternative water sources in certain areas of the district, such as Pinellas County. Therefore, SWFWMD initiated the New Water Sources Initiative (NWSI) program, a $10 million annual program, in addition to cooperative funding programs (SWFWMD, Annual Alternative Water Supply Report FY2005).

Reuse Interconnect Project

Pinellas County is very active in its commitment to the development of reclaimed water sources (Wayne West, Pinellas County Utilities, personal communication, August 24, 2005). The county's efforts in wastewater treatment are demonstrated through a number of projects, such as upgrades to two of its large wastewater treatment plants (WWTPs) to advanced water treatment standards and the construction of major reclaimed water transmission mains (SFWMD, Water Supply Document; Pinellas County Utilities).

One of the current Pinellas County projects in development, with help from the NWSI program, is the North Pinellas County Reuse Interconnect Project. The $3.2 million project will connect the wastewater transmission lines of the utility with the municipalities of Oldsmar and Clearwater by the end of 2006. The project will allow the county to purchase 3.8 mgd of unused reuse water at $0.10 per 1,000 gallons, which is water currently being discharged into Tampa Bay (Wayne West, Pinellas County Utilities, personal communication, August 24, 2005).

Estimating Benefits of the Reuse Program

There are significant benefits and avoided costs that are realized through the water reuse program in Pinellas County and the surrounding region. However, as Wayne West of Pinellas County Utilities notes, the county has not begun to attempt to quantitatively evaluate the benefits of different reclaimed water programs and projects. Potential benefits for the Reuse Interconnect Project include improvements in reliability, enhanced coastal water quality, increased protection of the endangered manatee, and the restoration of overland flows and river channel habitat. Here we attempt to quantify the benefits associated with increased reliability and general coastal water quality.

Enhanced Water Supply Reliability

System interconnects, like the Reuse Interconnect Project being constructed by the county, offer a means to increase both the efficiency and reliability of reuse systems. When the reuse transmission lines of Pinellas County, Oldsmar, and Clearwater are all interconnected, there will be additional flexibility and enhanced reliability to meet the demands of their reuse system customers (SWFWMD, Water Supply Document). For example, while Oldsmar and Clearwater currently have a surplus of 3.8 mgd of wastewater, if one of the municipality's reclaimed water facilities were to experience failure or if drought conditions placed greater strain on one municipality's demand, the interconnect can provide a means for the municipality to continue to meet its customers' reclaimed water demands.

As noted in the West and Central Basin case study, customers generally show a willingness to pay to increase water supply reliability (i.e., decrease the probability of their water supply being interrupted in times of drought). For households, drought usually impacts water availability to irrigation, landscaping, and other water-intensive amenities. For commercial and industrial activities, water is often crucial to production activity and drought may curtail or disrupt production. Consequently, studies indicate that residential, commercial, and industrial customers value supply reliability quite highly (appendix D). Here we provide two approaches to develop illustrative estimates of potential reliability benefit values.

Approach 1: A number of stated preference studies conducted from 1987 to 2000 find that the annual value of reliability ranges from $80 to $421 per household for total reliability. These values generally need to be apportioned down to some percentage because reuse programs in and of themselves do not ensure 100% reliability for all regional water supplies.

There are approximately 356,000 households (926,000 residents/2.6 residents per household) in Pinellas County that may receive a portion of the 3.8 mgd of additional water that the interconnect will make available. Using an annual payment of $80 per household for this illustration, the result is $28.5 million per year for total increased reliability. However, given that the total water demand of the county is approximately 86 mgd (assuming 93 gallons/day/resident), the Reuse Interconnect Project will provide only a small increase in reliability. The interconnect project will provide an additional 4% of water supply as compared to overall demand. Therefore, the value of the project is estimated at approximately 4% of $28.5 million per year or $1.4 million per year.

Approach 2: In addition to the stated preference studies mentioned above, a number of revealed preference studies have estimated the value of water reliability per AF. Values ranged from $51 to $353 per AF (these values also are similar to the range developed in the West and Central Basins illustration of about $400 per AF, based on an interpretation of the stated preference studies). The system connect will create approximately 4,300 AF per year of new reclaimed water supply (325,850 gallons per AF). Using an annual value of $250 per AF, the value of reliability increased by the Reuse Interconnect Project is approximately $1.1 million per year. This result is consistent with the calculation based on the stated preference studies.

Improved Coastal Water Quality In Tampa Bay

Water quality of Tampa Bay is of significant concern. The Tampa Bay Estuary is Florida's largest open water estuary and home to a number of species, including a population of the endangered manatee. The Tampa Bay National Estuary Master Plan cites reclaimed water as one of the major components in improving the health of the bay (Wayne West, Pinellas County Utilities, personal communication, August 24, 2005). Increases in the amount of reclaimed water used by residents result in the reduction of wastewater discharges entering the bay, and that reduction in turn implies a positive effect on water quality (i.e., reductions in nutrients and dissolved solids from runoff and outfalls). It should be noted that, while in this case, the project will provide an overall environmental benefit to the bay, the suspension of all wastewater flow into the bay could also have serious adverse impacts by choking off freshwater supplies and raising salinity levels in brackish estuaries (Wayne West, Pinellas County Utilities, personal communication, August 24, 2005).

The value associated with maintaining a healthy bay can be significant. Pollution in the estuary and bay can negatively impact a coastal economy, directly affecting commercial and recreational fisheries and other nature-based tourism activities. Additionally, studies have shown that the public places considerable value on improvements in or protection of coastal ecosystems. Annual values range from ten to hundreds of dollars per household (appendix B.5). These estimates are based on noticeable improvements in water quality.

For our analysis, we choose to use a range of values spanning from a lower bound estimate of $30 to an upper end value of $130 per household per year for appreciable improvements in coastal water quality. The Reuse Interconnect Project reduces the amount of the nutrient- and dissolved-solid-laden water entering the Bay by 3.8 mgd. However, this is only a small percentage of the overall contaminant load and would not likely result in noticeable improvements in water quality. Therefore, an annual WTP value of $30 to $130 per household is probably an overestimate of the public's value of the project. Consequently, the WTP values need to be adjusted to indicate that the reuse project contributes only a portion of the total value.

The Tampa Bay National Estuary Program estimates that more than 1 billion gallons per day (gpd) are discharged into Tampa Bay from WWTPs. The 3.8 million gallons of wastewater discharge avoided is thus perhaps 0.4% of total loads. This fact implies that a reuse project–specific WTP per household may be roughly $0.12 to $0.52 per year. While this is a small per-household value, the number of households within reasonable proximity to Tampa Bay or those that otherwise value improved Tampa Bay water quality exceeds 2 million.[2] Thus, this finding suggests that the reuse program's contribution to improved Tampa Bay water quality could be on the order of $250,000 to perhaps over $1 million per year.

2. There are approximately 4 million households in the state of Florida.

Conclusions

This illustration reveals another instance in which supply reliability and coastal water quality are key factors in motivating this reuse project, and the approach and caveats are similar to those shown in the previous case study. The issue of attributing a portion of a monetary value from the literature is also evident in both benefit categories monetized here, as it will be a challenge typical to most BT applications to reuse projects. Some sample templates covering the issues discussed here are provided below, in Tables 5.6 to 5.9.

Table 5.6: Template for step 4
Summary screening analysis

Benefits and costs receiving full or partial economic valuation
❍ Enhanced water reliability (+)
❍ Improved coastal water quality in Tampa Bay (+)
❍ Purchase 3.8 mgd at $0.10/1,000 gallons (−)
❍ Capital costs (−)
Benefits and costs requiring qualitative assessment[a]
(+) Downstream habitat improvement due to water quality improvement
(+) Protection of endangered manatee in Tampa Bay Estuary
(−) Downstream habitat degradation due to loss of water flows
Impacts deleted from further analysis: Impacts that are relatively small or mitigated
❍ None

[a]Place "+" or "−" in parentheses for positive benefits or costs (negative benefits), respectively.

Table 5.7: Template for steps 5 and 6
Detail on benefit value derivation for water reuse project

Benefit category	Annual quantity	Unit value used	Comments
Water reliability (approach 1)	A total of 4,300 AF provided to 356,000 households (based on 926,000 residents/2.6 residents per household)	$80 per household, scaled down to reflect that the reuse project provides only a small increase in overall reliability. Scaled WTP used in this analysis is estimated to be $3.20 per household (4% of $80).	The WTP values are derived from a number of stated preference studies with values per year per household ranging from $80 (Howe and Smith, 1994) to $421 (Carson and Mitchell, 1987) for ensuring 100% water reliability (see appendix D).
Water reliability (approach 2)	4,300 AF/year (based on 3.8 mgd)	Estimated value of $250 per AF is applied for our calculations.	The WTP values are based on a number of reveled preference studies with values ranging from $51 (Fisher et al., 1995) to $353 (Thomas and Rodrigo, 1996) per AF (see appendix D).
Water quality improvement of Tampa Bay	2 million households	$30–$130 per household/year, scaled to $0.12–0.52 per household/year to reflect impact of the reuse project in reducing the overall contaminant load to Tampa Bay (perhaps about 0.4% of overall contaminant load to the bay per year is prevented from entering the water body due to the reuse project).	Studies have shown that the public places value on improvements to or protection of coastal ecosystems. Annual values range from ten to hundreds of dollars per household for noticeable improvements in coastal ecosystem health (Croke et al., 1987; Kaoru, 1993; and Whitehead et al., 1995) (see appendix B.5).

Table 5.8: Template for step 8
Costs and benefits of water reuse project
(2003 US$ per year)

	Dollar amount	Stakeholder accruing cost or benefit
Cost components		
Capital cost (annualized)	$320,000/year	Pinellas County
Water purchase costs	$120,000/year	Pinellas County
Total costs	***$440,000***	
Benefit components		
Water supply reliability	$1.1 million	Public
Improved coastal water quality in Tampa Bay	$250,000 to $1 million	Public
Total monetized benefits	***$1.4 to $2.2 million***	
Benefits requiring qualitative assessment[a]		
Downstream habitat improvement due to water quality improvement	+	Public
Protection of endangered manatee in Tampa Bay Estuary	+	Public
Potential downstream habitat degradation due to loss of water discharge flows	−	Public
Monetized net benefits (monetized benefits minus costs)	***$960,000 to $1.8 million***	

[a]+ indicates positive benefits anticipated but not monetizable with readily available data, and − indicates costs anticipated but not monetizable with readily available data.

Table 5.9: Template for step 9
Omissions, biases, and uncertainties and their effect on the project

Benefit or cost category	**Likely impact on net benefits**[a]	**Comment**
Potential downstream habitat degradation due to loss of water supply	− (but likely to be very small)	It is unlikely that the amount of water reclaimed from the project will have any negative impacts on downstream habitats (river channels, estuaries, etc.) because 3.8 mgd is a small overall contribution to the total freshwater flows to the bay. However, it is important that the removal of large amounts of freshwater supplies entering the bay could raise salinity levels in traditionally brackish water and have adverse environmental impacts.
Coastal ecosystems	U (+ or −)	The WTP values are determined through a specific set of questions for a specific circumstance. BT should be used only to assist in gauging the potential general magnitude of a reuse project. Additionally, we assume that 2 million households would have a WTP value for coastal ecosystem improvements. The estimated number of households could be an overestimate or an underestimate.
Water supply reliability	U (+ or −)	The WTP values taken from the literature are scaled to 0.4% to reflect the reduction in total contaminant loads discharged to the bay that could be credited to the reuse program. The 0.4% could be an overestimate or an underestimate. Further analysis would be needed to refine this scaling factor.

[a]Direction and magnitude of effect on net benefits:
+ = Likely to increase net benefits relative to quantified estimates.
++ = Likely to increase net benefits significantly.
− = Likely to decrease benefits.
−− = Likely to decrease net benefits significantly.
U = Uncertain; could be + or −.

ILLUSTRATION 3: WETLAND CREATION IN PHOENIX, AZ

Background

Historically, the Lower Salt River, located in the vicinity of Phoenix, Tempe, and Scottsdale, Arizona, was a perennial stream (flowing year-round). The river was characterized by many channel meanders, sand bars, and backwater areas, which were conducive to riparian growth and wildlife habitat. However, beginning in the late 1800s and over the next 100 years, the river environment changed dramatically. Upstream diversions and dams removed water from the river system and prevented the perennial and high-winter flows. Consequently, the lower portion of the Salt River became an ephemeral system (only flowing at certain times of the year).

In 1958, the cities of Phoenix and Glendale constructed the original 91st Avenue WWTP and began discharging 5 mgd of treated wastewater into the Salt River. This plant was replaced with a 45-mgd plant that was subsequently expanded throughout the years. The capacity of the 91st Avenue WWTP eventually reached 153 mgd. With the construction of the WWTP, the river once again became perennial. The 91st Avenue WWTP discharge into the lower river channel provided an artificial flow and supplied the water needed for habitat along the river banks of the Lower Salt River, although it was not of optimal quality (Paul Kinshella, City of Phoenix Water Service Department, personal communication, August 15, 2005).

Tres Rios Project

In 1990, the Arizona Department of Environmental Quality (DEQ) released new water quality standards for wastewater discharges into Arizona waterways. To meet the new stringent standards, the City of Phoenix estimated that upgrades totaling $600 million would need to be completed to the 91st Avenue WWTP (Paul Kinshella, City of Phoenix Water Service Department, personal communication, August 15, 2005). However, the proposed upgrades would not give the plant additional treatment capacity, and the city decided to seek an alternative solution. The city had two options:

- Option 1: The city could move to a zero-discharge scenario at the WWTP. If no water was discharged, the new regulation would have no impact. Zero discharge would be attained through the 100% recycling and reuse of the 153 mgd of wastewater effluent from the WWTP. While this option solved the problem of meeting water quality standards, the action also would have resulted in the drying-up of the river, causing the loss of riparian habitat and downstream water availability to irrigators.

- Option 2: The city would construct a wetland project near the WWTP at the convergence of the Salt, Gila, and Agua Fria rivers. Wastewater from the 91st Avenue Plant would be discharged into the wetland. When secondary treated effluent is discharged into a wetland system, the wetland reduces the whole effluent toxicity of the water (Paul Kinshella, City of Phoenix Water Service Department, personal communication, August 15, 2005). Concentrations of nitrogen, other nutrients, and metals are reduced dramatically, and the water is naturally “polished.” The polished water draining from the wetland into Salt River would meet the new standards.

The second option was selected, and in 1995, under a cooperative partnership among the cities of Phoenix, Tempe, Mesa, Scottsdale, Glendale, and the Bureau of Reclamation, construction began on the Tres Rios Demonstration Project. Today, the $3.6 million, 12-acre demonstration project consists of three operational wetlands: the Hayfield site (6 acres), the Cobble site (4 acres), and the Research Cell (1 acre) (U.S. EPA, River Corridor and Wetland Restoration). The flow of water from the wetlands has helped sustain a 1-mile corridor of riparian habitat below the project site. The goal by 2009, using the design criteria developed in the demonstration project, is to increase the size of the Tres Rios wetland project to 800 acres, creating up to 10 miles of riparian habitat along the river corridor (City of Phoenix, Tres Rios Constructed Wetlands Demonstration Project Articles). The 800-acre full-scale project will be capable of receiving the 91st Avenue WWTP's entire outfall of 153 mgd of secondary treated effluent (City of Phoenix, Tres Rios Constructed Wetlands Demonstration Project Articles). It is estimated that the total cost of the full-scale project will be approximately $100 million, with a yearly operating cost of approximately $10 million (Megdal).

Estimating Benefits of the Project

Cost Offsets

The city realized significant cost avoidance benefits through the construction of the Tres Rios Project. The $600 million upgrade was avoided, and with the completion of the full-scale project, the city will be able to treat 100% of its wastewater to Arizona DEQ standards by using the wetland technique. This feat translates to a net savings in capital outlays of about $500 million (and probably also would include O&M cost savings).

While the cost savings are appreciable in their own right, there are also numerous wider-range benefits associated with Tres Rios Demonstration Project that will grow as the full-scale project is completed, such as habitat creation, aesthetic improvements, and recreation. In order to evaluate the full benefit of wetland creation, we must not only consider the local benefits but also the broader, regional-scale benefits. There are clear local benefits to the Tres Rios project, but benefits such as habitat creation for threatened and endangered (T&E) species hold value not only to those that live within walking distance of the Salt River. These various benefits are described in the following sections.

Habitat Creation

The Tres Rio Project is restoring critical riparian and wetland habitats that have been lost to the region as a result of water resources development in the Phoenix metropolitan area. The design phase of the demonstration project targeted improving aquatic and riparian habitats for T&E species that have habitat ranges that overlap the metropolitan area. Specifically targeted T&E species include the Yuma clapper rail, the south western willow flycatcher, the yellow-billed cuckoo, and the lesser long-nosed bat (City of Phoenix, Tres Rios Constructed Wetlands Demonstration Project and Tres Rios Constructed Wetlands Demonstration Project Research). There are also a number of species that receive or are candidates for state protection and inhabit the project area, such as the lowland leopard frog, the desert tortoise, and the Mexican garter snake (City of Phoenix, Tres Rios Constructed Wetlands Demonstration Project Research).

There have been a number of studies on the value of instream flows on ecological systems and the public's willingness to pay to protect instream flows and the riparian habitat created. Studies have estimated the value of instream flows for protecting T&E fish species. Values ranged from $7 to $112 per household for various specific aquatic T&E species (appendix B). A meta-analysis (Loomis and White, 1996) of studies covering 18 different T&E species resulted in similar annual WTP results ($6 to $95 per household). The majority of T&E species in the Tres Rios area are birds. Therefore, using a 1999 study (Reaves et al., 1999) from the meta-analysis is appropriate. This study evaluated households' WTP for the protection of an endangered species's habitat that had been severely decimated by a hurricane. Reaves et al. (1999) estimated that households are willing to pay $8 to $16 per year to protect the red-cockaded woodpecker habitat. More specifically, the study indicates that households are willing to pay $8 to $16 per year to increase the woodpecker's chance of survival from 0 to 50%, a significant change in the probability of survival.

In order to estimate the benefits of the Tres Rios Project, it is necessary to estimate how the project might increase the target species' prospects for continued survival. Unfortunately, this information is not easily available. Therefore, using the Yuma clapper rail as an example, it is known that approximately 400 to 750 pairs of Yuma clapper rails exist in the United States (California and Arizona) and another 450 to 970 inhabit Mexico (Arizona Game and Fish Department). Studies show the year-round home ranges of rail pairs average approximately 18.5 acres (Arizona Game and Fish Department). Thus, we can estimate that, at best, the Tres Rios Project may support an additional 45 breeding pairs of rails, increasing the total population of rails by 2.5% (45 additional pairs with a current estimated population of 1,750 in the United States and Mexico). Using a scaling factor of 2.5% and the Reaves et al. (1999) original WTP values, we estimate a WTP of $0.20 to $0.40 per household for habitat creation. This is very conservative, given there are a number of species other than the Yuma clapper rail that also will benefit from the project.

We conservatively assume that only those residents in the immediate Phoenix metropolitan area have a positive WTP for T&E habitat creation in the river corridor. This assumption most likely results in an underestimate, because it is highly probable that people outside the Phoenix metropolitan area do have a WTP for the protection of the T&E species living along the Salt River corridor. Currently, there are approximately 1.1 million households in the metropolitan area (based on 3.1 million residents and 2.6 people per household; U.S. EPA, Urban Rivers Restoration Pilot Fact Sheet Tres Rios, Arizona).

Using annual WTP values of $0.20 to $0.40 per household, we estimate an annual net benefit for habitat creation for T&E species of approximately $220,000 to $440,000 per year. Again, this is likely to be a conservative (i.e., low) estimate, because multiple T&E and other potentially special status species are likely to be supported by the enhanced habitat and also because households outside the Phoenix metropolitan area are themselves likely to value enhancing the habitat for these species.

Aesthetic Improvements

Where the river was once fed by a WWTP outfall pipe, now wetlands will feed the river system. The entry of wastewater into the river channel through an artificially created "natural" system has important implications for the public perception of the river below 91st Avenue. The wetlands are an aesthetic improvement over an outfall pipe, and this improvement is valued by residents. However, as Paul Kinshella of the city of Phoenix's Water Service Department notes, the public perception of the project may be even more complex than simply an aesthetic improvement. The wetland may be seen as a buffer. Treated wastewater is converted back to source water in the minds of the public if it is filtered through a natural system, such as a wetland (Paul Kinshella, City of Phoenix Water Service Department, personal communication, August 15, 2005). Although no one is withdrawing water for potable purposes immediately downstream of the Tres Rios Project, the Buckeye Irrigation District, 7 miles downstream, does rely on the treated effluent to meet its 30,000-

AF/year irrigation needs (Paul Kinshella, City of Phoenix Water Service Department, personal communication, August 15, 2005).

It is difficult to quantify aesthetic attributes, and their estimated values are not provided in this study. However, the aesthetic improvements to the river corridor may be assessable through a hedonic analysis of property values in the vicinity of the river or through a valuation of recreational amenities that increase with improvements in aesthetics.

Recreation

The creation of open space for recreation and wildlife habitat is often a top priority in creating livable, people-friendly communities. The Tres Rios Project has the opportunity to provide significant educational and recreational benefit to the Phoenix metropolitan area. Wetland habitats attract diverse wildlife, making them an appealing destination to bird watchers, photographers, and day hikers. However, up to this point, the demonstration project sites have provided very scant recreation benefits because public access is very limited. Security concerns after September 11, 2001, coupled with the close proximity of one of the demonstration wetland sites to the WWTP, has prevented public access (Paul Kinshella, City of Phoenix Water Service Department, personal communication, August 15, 2005). The other existing reuse-based wetland site has been receiving negative use from late-night "partiers," and their presence has been destructive (Paul Kinshella, City of Phoenix Water Service Department, personal communication, August 15, 2005). While recreational opportunities have been limited to date at the Tres Rios demonstration site, it has been successful in providing educational opportunities. For example, the site is the focus of investigation at both state universities, as well as at several high schools in the area.

The future goal is that a significant portion of the full-scale wetlands project will contain trails tied into the Sun Circle trail system, and these will be monitored by the parks department, which will take some of the monitoring burden off the WWTP staff (Paul Kinshella, City of Phoenix Water Service Department, personal communication, August 15, 2005). Although it is uncertain what the annual number of visits will be to the completed 800-acre Tres Rios site, the site will potentially provide considerable opportunities for the public to come to view wildlife, picnic, hike, etc. A 1996 meta-analysis of near-water recreational activities demonstrates that the public places significant values on these types of activities (appendix A.2).[3] For example, the average value per adult user day for wildlife viewing, picnicking, and hiking across numerous studies ranges from $32.00 to $44.02 per person per outing.

Since estimates of the number of visits are unavailable, we assume that user days at the Tres Rio site will be compatible to those at the Urban Wetland Project in the Las Vegas Wash. The Las Vegas wetland is larger than the Tres Rios Project; however, the 8-mile, 2,700-acre Las Vegas wetland is in a less residential area than the Tres Rios site. The Las Vegas wetland project contains 45 miles of trails and has parking for 90 cars. A detailed count of visitor use has not been conducted at the time of this report, but the Parks and Recreation Department roughly estimates that at least 15,000 user days occurred in 2004 (Karen Esteen, Las Vegas Parks and Recreation Departments, personal communication, December 6, 2005). Using the Las Vegas Wetland Project annual use number, annual recreational benefits at the Tres Rios site might range from $480,000 to $660,000 per year.

---

3. A meta-analysis is used to combine the strengths of many different studies that use different valuation methods to try to ensure that a single outlier study does not mislead the valuation result.

Conclusions

The Tres Rios project in Phoenix is a prime example of how water reuse-based wetland creation can generate significant benefits. Given the emergence of more stringent wastewater discharge regulations, the wetlands provide an effective polishing step for wastewater effort that can provide significant cost savings. However, cost savings should not be the only rationale for wetlands projects; this example reveals that considerable economic value can be linked to the habitat creation, recreational, and aesthetic improvements that wetlands provide. Some sample templates are provided in Tables 5.10 through 5.13.

Table 5.10: Template for step 4
Summary screening analysis

Benefits and costs receiving full or partial economic valuation
❍ Habitat creation (T&E species) (+)
❍ Recreation (+)
❍ Avoided expansion of treatment capacity (+)
❍ Capital costs of Tres Rios Project (−)
❍ Operation and maintenance costs (−)
Benefits and costs requiring qualitative assessment[a]
(+) Water quality (regulatory compliance)
(+) Aesthetic improvements
Impacts deleted from further analysis: impacts that are relatively small or mitigated
❍ None
[a]Place “+” or “–” in parentheses for positive benefits or costs (negative benefits), respectively.

Table 5.11: Template for steps 5 and 6
Detail on benefit value derivation for water reuse project

Benefit category	Annual quantity	Unit value used	Comments
Habitat creation/T&E species	1.1 million households in the Phoenix Metro area	$8 to $16 per year/household, scaled to $0.20 to $0.40 per household to reflect the level of impact that this project might have on the total species survival (a possible 2.5% increase in habitat for the Yuma clapper rail population)	WTP values for protection of T&E species range from ten to hundreds of dollars per household per year. However, these estimates are based on scenarios that result in a significant change in the probability of survival of a species. This is not appropriate for the Tres Rios Project example. We use WTP values from Reaves et al. (1999) because the types of species evaluated in the study (birds) were generally consistent with those found in the region of Tres Rios.
Recreation	Estimated that the 800-acre site might receive 15,000 user days per year, based on rates of visitation to the Las Vegas Wash Wetland Nature Preserve	$32 to $44 per user day	A 1996 meta-analysis (Rosenberger and Loomis) found that average WTP values per user day for near-water recreational activities ranged from $32 to $44 per day (see appendix A.2).

Table 5.12: Template for step 8
Costs and benefits of water reuse project
(2003 US$ per year)

	Dollar amount	Stakeholder accruing cost or benefit
Cost components		
Total capital and operating cost (annualized) for full-scale wetlands construction (Megdal)	$10,000,000/year	Phoenix, Tempe, Mesa, Scottsdale, Glendale, and the Bureau of Reclamation
Total costs	***$10 million***	
Benefit components		
Habitat creation/T&E species protection	$220,000 to $440,000	Public
Recreation at the Tres Rios site	$480,000 to $660,000	Public
Avoided expansion of WWTP treatment capacity (annualized capital cost avoided)	$50,000,000	WWTP (cities) and customers
Total monetized benefits	***$50.7 to $51.1 million***	
Benefits requiring qualitative assessment[a]		
Aesthetic improvement due to wetland areas	+	*General public*
Monetized net benefits (monetized benefits minus costs)	***~$41 million per year***	

[a]+ indicates positive benefits anticipated but not monetizable with readily available data, and − indicates costs anticipated but not monetizable with readily available data.

Table 5.13: Template for step 9
Omissions, biases, and uncertainties and their effect on the project

Benefit or cost category	Likely impact on net benefits[a]	Comment
Recreation	U (+ or −)	It is unclear what the use level at the full-scale project site will be. We assumed it would be similar to the user-day-per-acre data found in the Las Vegas Wetland Project, given their similar size and scope. However, the Tres Rios site may receive more use because of the proximity to residential areas. Additionally, the records of use estimate for the Las Vegas Wetland Project are imprecise.
Habitat creation/T&E species	U (+ or −)	The WTP value used in our calculation may be an overestimate or underestimate of the WTP that households possess for habitat creation for T&E species. The Reaves et al. (1999) study calculates WTP values for habitat creation that results in a significant probability increase of a species's survival. A project of the Tres Rios scale would most likely not result in significant changes in species survival probability. We have attempted to correct this overestimate. It is unclear if our 0.025 scaling factor is too high or too conservative, resulting in a WTP range that might overstate or understate benefits.
Habitat creation/T&E species	++	We conservatively assume that only those residents in the immediate Phoenix metropolitan area have a positive WTP for T&E habitat creation in the river corridor. This assumption most likely results in an underestimate, because it is highly probable that people outside the Phoenix metropolitan area do have a positive WTP for the protection of T&E species living along the Salt River corridor within which habitat will be improved.
WWTP: O&M costs saved	+	The costs avoided from not having to expand and upgrade the WWTP reflect only capital outlays. O&M savings are also likely but are not included in the cost savings estimate used here (data not available).

[a]Direction and magnitude of effect on net benefits:
+ = Likely to increase net benefits relative to quantified estimates.
++ = Likely to increase net benefits significantly.
− = Likely to decrease benefits.
−− = Likely to decrease net benefits significantly.
U = Uncertain; could be + or −.

ILLUSTRATION 4: COMMUNITY DEVELOPMENT IN SANTA CLARA VALLEY, CA

Background

In Santa Clara County, the City of San Jose is considering a new development in Coyote Valley, which would support 25,000 new households (~60,000 new residents). It would also serve as the location of new commercial and industrial enterprises and other supporting business and institutional entities, supporting 50,000 new jobs locally. The development of Coyote Valley would also include greenbelt areas, and water demand and supply issues are being explored through the Coyote Valley Specific Plan (CVSP). Because the county has no additional surface water supplies available, the development will require water provided from limited remaining groundwater resources and expanded use of county reuse water.

Preliminary estimates of projected total water demands for the new development of Coyote Valley are approximately 18,000 AF/year, at build-out. This includes an estimated 8,400 AF/year for the 25,000 residences, assuming high water use efficiency and smaller than typical lot sizes, as consistent with the overall development plan. Another 4,000 AF/year is projected as the demand associated with 50,000 employees in “industry-driving” jobs (Santa Clara Valley Water District, 2005). The balance of projected total demand would cover retail and other supporting jobs created in the region, greenbelt and open area irrigation, and other community uses (as yet unspecified).

Out of this total projected demand, the potential demand for reuse water has not yet been fully estimated. Current greenbelt area water use is about 4,000 AF/year (Santa Clara Valley Water District, 2005). After the planned development, the community will include large landscaped areas (parks, schools, rights of way, and open space) totaling 730 acres, with an estimated water use of 4,000 AF/year. In addition, the remaining greenbelt area, including a golf course, may require another 1,000 AF/year of water that could be supplied via reuse. Thus, total large-scale outdoor irrigation uses that could be supplied with reuse water is at least 5,000 AF/year. In addition, other possible reuse applications include dual plumbing to supply outdoor irrigation (and possibly indoor nonpotable uses such as for toilets) for office buildings and/or residences, but these potential demands for reuse have not yet been estimated.

To meet the projected demand, local groundwater supplies could be tapped. However, the mean total supply in the local “Coyote Subbasin” has been estimated at approximately 8,000 AF/year. Therefore, the mean yield is less than half the projected total demand. Thus, even if the local groundwater basin were set aside for the new development, it could reliably meet only a fraction of projected total demand.

Augmentation of the locally available groundwater is therefore necessary to accommodate the Coyote Village development at the scale currently planned. As noted above, total demand is projected to be roughly 18,000 AF/year, whereas average local groundwater yields are perhaps 8,000 AF/year. This equation leaves an average annual shortfall of about 10,000 AF/year, of which 5,000 AF/year (or more) could be supplied via nonpotable reuse.

Reuse and Other Water Supply Augmentation Options

As described above, locally available groundwater supply is not sufficient to meet total projected demands. Therefore, other water needs to be delivered to the Coyote Valley development area to make up the long-term projected shortfall of 10,000 AF/year.

A combination of two sources is available.

- First, local Coyote Subbasin groundwater withdrawals can be increased by 5,000 AF/year through the use of aquifer recharge basins. There are various options for the possible source of the recharge water that are being considered. Reuse water could be applied for this indirect potable reuse option in some other locations, but groundwater residence times in the relevant portions of the subbasin preclude that option in this instance.[4] Instead, potable supplies will need to be diverted within the county for this purpose, including the possibility of using surface water already imported to the county from the federal Central Valley Project (via a pipeline that runs proximate to potential recharge basin locations). Whatever source is tapped for local recharge in the Coyote Valley area, however, will reflect a transfer of needed water from another part of the county outside Coyote Valley, and the resulting shortfall in the donor area will in turn need to be offset, probably through the increased utilization of reuse water in that donor location outside the Coyote Valley.[5]

- Second, the outdoor irrigation of large green space areas in the planned development can be accommodated through the application of reuse water. This nonpotable reuse would account for the remaining 5,000 AF/year in excess demand. This option entails expanding reuse production at the San Jose/Santa Clara Water Pollution Control Plant and piping it to the Coyote Valley for distribution to nonpotable outdoor irrigation uses (to meet demands for large landscape areas, greenbelts, etc.). This option generates reuse at quantities that match anticipated large-area outdoor irrigation demands (~5,000 AF/year) and relies on using existing capacity in the Silver Creek pipeline (5 mgd) that matches the annual projected large-scale green space outdoor irrigation demands projected for Coyote Valley. This option uses existing reuse production capacity at the San Jose/Santa Clara Water Pollution Control Plant (although reuse in the Coyote Valley area would require supplemental advanced treatment at the end of the process in order to comply with local groundwater protection policy).[6]

Therefore, reuse water is essential to accommodating the planned Coyote Valley development. By combining the two expanded reuse applications, a total of 10,000 AF/year can be supplied to the area and thus bring total supply into balance with projected demands.

---

4. This is because of the sensitivity of the local groundwater basin (high groundwater table with unconfined conditions) and because the local groundwater basin is the sole source of drinking water for that area.

5. If the reuse water is developed using advanced treatment, then it would be possible to apply the reuse water to aquifer recharge within Coyote Valley.

6. Local groundwater protection policies are motivated by the vulnerability and importance of the local aquifer, as described in prior footnotes.

Estimating the Benefits of Reuse

As the water supply planning for this community development project is in the early phases of consideration, there are not yet any firm options to evaluate in terms of quantifying benefits or costs. However, the overview above suggests several important benefits may well arise from the application of water reuse.

Accommodating economic development. While additional economic and population growth is not always favored by all segments of the regional population, the Coyote Valley Project has been made a part of local city and county plans and presumably would provide considerable economic benefit to the region. Absent the available water reuse options, there would not be enough water available to accommodate the development at its current planned scale (i.e., demands would need to be cut by more than half, meaning a far smaller project that might not be economically viable).

Improved receiving water conditions. The source of the reuse water would be wastewater effluent that otherwise would be discharged to the ecologically sensitive San Francisco Bay estuary. This would probably contribute to what might be significant improvements in habitat and ecological values.

Increased local control, reliability, and flexibility. Reuse is a locally generated supply and thus not subject to influences from external entities (e.g., state or federal influences and constraints on imported water options). Also, having additional reuse supplies in the local water portfolio increases flexibility, and they are not subject to drought conditions that impact the yield reliability of other supply options.

Conclusions

This case study indicates how water reuse can become a component instrumental to accommodating the planned development of communities in areas that are water limited. While the preliminary nature of the development project has not enabled an empirical assessment at this time, it reveals how creative use of reuse waters can enable localities to proceed with planned development activities without increasing reliance on imported water or diverting waters away from one part of the community in order to serve another.

ILLUSTRATION 5: REUSE FOR GOLF COURSE IRRIGATION IN LAS VEGAS, NV

This case study evaluates the benefits and costs associated with recycled water distributed by the Las Vegas Valley Water District (LVVWD) from two different perspectives. The first is the societal perspective, which encompasses all of the benefits and costs associated with the recycled water system. We spotlight one of the benefits from this perspective, i.e., the value added to residential real estate from being located adjacent to or near a golf course. The second perspective is that of the major users, i.e., golf courses. This analysis compares the yearly cost savings to golf course owners. These cost savings arise from their paying for recycled water instead of potable water, as compared to the up-front investment made by golf courses by retrofitting to enable the use of recycled water.

Background

In addition to its three main wastewater treatment plants, the Las Vegas Valley has three satellite treatment plants with a fourth in the planning stage. Two of the satellite recycled water treatment facilities are joint efforts: the Durango Hills Water Resource Center (DHWRC), which is owned and operated by the City of Las Vegas, and the Desert Breeze Water Resource Center (DBWRC), which is owned and operated by the Clark County Water Reclamation District. The LVVWD owns and operates two separate recycled water distribution systems (RWDS), one for each of the satellite treatment facilities.

The Durango Hills system is designed to produce 10 mgd. The RWDS for this facility includes a reservoir and three pumping stations and pipelines and also includes four recharge/recovery wells that recharge potable water into the groundwater aquifer during the winter and withdraw supplemental water to meet summer peak demands. The four wells have a combined capacity of 9.2 mgd, and the RWDS has a combined maximum capacity of 22 mgd.

The Desert Breeze system has been constructed with a 5-mgd treatment plant, which is expandable to 10 mgd, and the RWDS is capable of delivering 10 mgd of recycled water. Supplemental summer water is provided through the transfer of winter-recharged water via the potable distribution system, since effective well construction was not feasible at the Desert Breeze site.

Golf courses are the largest user of recycled water from these facilities. Eleven golf courses on the Durango Hills system have a combined peak summer demand that approaches 15 mgd. Of the 11 golf courses, 10 existed or were under construction when the Durango Hills system was built, and one was proposed. All but the proposed course were originally designed and constructed to use only potable water. The proposed course was eventually designed with the use of recycled water as a requirement. There currently are five golf courses on the Desert Breeze system. These courses were also originally designed to use potable water. Four of the five were required to include designs to accept recycled water when it became available. Parks and schools also are envisioned as ultimate users of these recycled water systems, but they have not been connected to date.

Each golf course using potable water was retrofitted to begin using recycled water from July 2001 to January 2004. Some examples of the retrofit work done were relining of irrigation and golf course hazard ponds to eliminate seepage, replacing grass types on greens that were not salt tolerant or that exhibited poor drainage characteristics, and installing new delivery pipelines to the irrigation ponds since the RWDS pipeline was located in a location different from that of the potable pipeline.

Societal Perspective

There are a number of benefits and costs from a societal perspective related to the recycled water facilities in Las Vegas. Benefits and costs are summarized in table form by using the templates at the end of this case study. To determine the benefits, a baseline, or without-project situation, must be determined. This typically is the water supply situation in the absence of the recycled water program. As mentioned in the background section above, all but one of the golf courses connected to the Durango Hills recycled water system were originally designed to use potable water. Without the recycled water system, those golf courses would have stayed on potable water. With potable water prices higher than recycled water prices, some golf courses would likely continue to be in business in the future, but some would experience more difficulty in remaining profitable.

As a practical matter, the effect of moving golf courses from potable water to recycled water is to free up capacity in the potable water system to help meet the growing demands in and around Las Vegas.

Benefits

There are several kinds of avoided costs due to the recycled water system, and each of these avoided costs can be identified and estimated quantitatively. There are avoided O&M costs of potable water treatment. Removing potable demands from the system also alleviated the capital costs associated with expanding the main water treatment plant and the increased O&M costs associated with that expansion. Removal of wastewater flows from the wastewater collection system at the satellite treatment plant also delayed expansion of the crosstown wastewater collection system. Use of the recycled water system also means reduced pumping costs: instead of pumping water up 2,000 feet in elevation from Lake Mead during the summer peak, water demands can be met by recycling wastewater that was generated locally.

There are several types of environmental benefits resulting from the recycled water program. One benefit is the element of source water protection from recycling the water instead of using potable water. With potable water, water is returned to Lake Mead after use, where it can deposit contaminants such as phosphorus from the wastewater treatment plant. There is a TMDL limit in Lake Mead for all phosphorus contributors combined. Direct use of recycled water keeps that water from being discharged to Lake Mead with possible contaminants. Reduced wastewater flows in the Las Vegas wash to Lake Mead can reduce erosion in the wash. And, finally, recycled water use has increased the efficiency of water use and limited excess water runoff beyond property lines. This increased efficiency means less runoff of chemicals applied to golf courses. None of these environmental benefits are quantified here but instead are recognized qualitatively.

There was one specific recreation benefit identified with recycled water use. Development of one new golf course was enabled by using recycled water; therefore, the use benefits can be attributed to the presence of recycled water. This benefit can be estimated by taking the average consumer surplus per day of golf and then multiplying this consumer surplus times the number of golf days since creation of the golf course and projected over the time horizon for the analysis.

A public health benefit also is expected from recycled water use. When golf courses were using potable water, irrigation water was held in ponds on the course. Chemicals from the course collect in these ponds, and waterfowl attracted to the ponds rendered them not potable. With recycled water, signs are posted that clearly state that recycled water is applied and that water in ponds is not potable.

An economic value from the societal perspective as a result of recycled water use is the value added to real estate development when it is located on a golf course or near a golf course in a golf community. The private open space and cooling effect of irrigated grasses are among the effects that increase housing values. These effects commonly outweigh the danger of stray golf balls entering a homeowner's property.

Costs

Included in the direct costs for recycled water are the capital and O&M costs for the recycled water treatment facilities. Other costs are the capital and O&M cost associated with the recycled water distribution systems and the cost of potable water to supplement recycled water supplies to meet peak summer demands. These facilities were financed through bonds, and so the capital outlays also carry some financing costs.

There are several administrative cost categories. There are administrative costs associated with recycled water delivery such as the backflow prevention program. In addition, there are some public information campaign costs associated with the initial introduction of recycled water and the ongoing costs of keeping the public and key users informed. These costs have not been tracked separately in LVVWD's accounting system and so can be estimated only qualitatively at this time.

Value Added by Location on a Golf Course

Several studies have been conducted on the value added to residential housing from location on or near a golf course. Those studies indicate a wide range of increase in property values, from 2.7% to 50% (Quang and Grudnitski, 1995; Asabere and Huffman, 1996; Rinehart and Pompe, 1999; Bible and Hsieh, 2001; SRI). A recent study used a range of 10 to 15% of housing value as a relatively conservative value (SRI). However, we take the midpoint of the range, approximately 25%, as the addition to housing value in the Las Vegas area. This value reflects a higher perceived contribution of golf course location to housing value in desert locations such as Las Vegas than in relatively more lush locations in the United States.

Average housing value in Las Vegas as of 2005 was used as a proxy for average golf course development housing value: approximately $330,000. A representative number of housing units in a typical golf community development was assumed to be 400. The typical number of homes multiplied by the average housing value gives the total housing value for a representative golf development: $132 million. The contribution of golf course location to total housing value in this development is calculated as 25% of the total value or $33 million in capitalized value.

It should be noted that this benefit can be confidently attributed exclusively to recycled water for newly constructed golf courses using recycled water. The applicability of this benefit to the other courses depends on the yet-to-be-determined role of the lower cost of recycled water in allowing these golf courses to stay in business (compared to cases in which if they had stayed on potable water, they might have gone out of business or experienced a decline in profit).

Customer Perspective—Golf Course Owner/Operators

As mentioned above, golf courses are the major customers of recycled water systems in Las Vegas. Benefits and costs from the perspective of the golf course owner are different from those from a societal perspective. This analysis assesses benefits and costs from a hypothetical golf course owner or operator perspective and determines the number of years required into the future for a golf course owner to recoup up-front investment costs of converting a golf course designed to use potable water to use recycled water effectively.

The major benefit to golf courses from using recycled water is the reduced cost of recycled water compared to the cost of potable water. To encourage the use of recycled water, LVVWD's policy is to price recycled water more cheaply than potable water. Table 5.14 compares the price of recycled water to that of potable water delivered by LVVWD over the time period for which potable water has been available, i.e., 2001 to the present. Savings per year for our hypothetical golf course vary according to the timing of the change in potable and recycled water prices and range from $104,000 to $285,000 per year.

Table 5.14: Simplified comparison of recycled[a] and potable water prices, LVVWD, 2001–2006

Year	2001	2002	2003	2004	2005	2006
Potable	$2.27	$2.27	$2.27	$2.52	$3.02	$3.02
Recycled	$1.69	$1.69	$1.69	$1.85	$1.85	$2.20
Difference	$0.58	$0.58	$0.58	$0.67	$1.17	$0.82

[a]Recycled water prices compared to Tier 4 potable water prices. Price in effect during irrigation season of a calendar year assumed to be in effect for all of that calendar year.

Another benefit of recycled water use from the golf course owner's perspective is the avoided cost of fertilizer application allowed by the nutrient value of recycled water. Nutrients such as phosphorus are present in recycled water unless specifically removed and are a proven replacement for routine fertilizer applications. An estimate of the value of avoided fertilizer applications was not specifically estimated for golf courses on the Las Vegas recycled water system. Instead, the value of $25/AF estimated in California is used as an approximation. Savings in fertilizer value for our hypothetical golf course are approximately $28,000 per year.

The major cost for golf course owners from using recycled water is the cost of retrofitting golf courses originally designed for potable water so that they can use recycled water. Some of the typical retrofits needed to enable recycled water use include relining of irrigation and golf course hazard ponds to eliminate seepage, replacing grass types on greens that are not salt tolerant or that exhibit poor drainage characteristics, and installing new delivery pipelines to the irrigation ponds. Backflow prevention devices on adjacent potable systems also are required when installing recycled water lines.

Retrofits installed by our hypothetical golf course include pond relining, maintaining separate potable water lines to greens, and installing new delivery pipelines to site recycled water in locations different from those for potable water. All of these improvements were assumed to be installed during the same year, and their cost is approximately $670,000.

Another cost of recycled water use is the higher concentration of salts found in recycled water. In the Las Vegas area, potable water has a total dissolved solids (TDS) value of approximately 600 to 700 parts per million (ppm). Typical TDS values for recycled water approach 850 to 1,100 ppm; thus, the recycled water has TDS levels that are 250 to 400 ppm higher than the potable supply. This contribution to TDS values is enough to retard the growth of grass species commonly used on golf courses. In order to mitigate the effect of higher TDS on golf course greens, it is often recommended that golf courses apply an additional 15% of the normal volume of water to ensure salts are flushed from the soils. The cost of additional salts in recycled water compared to potable water is the cost of purchasing 15% more water when using recycled water. For typical water use for our representative golf course, this means 147 AF per year. If valued at current recycled water prices, this means an additional cost of $88,900 per year.

The question for golf course owners is how many years of the benefits of reduced recycled water prices and savings in fertilizer costs will it take for the golf course to recoup their investment in retrofitting a golf course to use recycled water and the additional annual cost for properly flushing greens to remove additional salts from recycled water. With our hypothetical Las Vegas area golf course, it takes five years for the golf course to recoup the up-front costs of retrofitting the golf course for recycled water use. This is the point at which the discounted yearly benefits from lower water costs and fertilizer savings outweigh the up-front costs of golf course retrofit and the annual increased water use to flush salts (a 5% discount rate was used for discounting future benefits and costs). After the course recoups the up-front investment costs, it continues to accrue benefits due to lower water costs and fertilizer savings in the future at approximately $185,000 per year. Over a 25-year period, the total discounted present value of benefits of water costs and fertilizer savings outweigh salt flushing and retrofit costs by more than $1,861,000. In other words, the availability of competitively priced reclaim water generates a net benefit to golf course owners of nearly $1.9 million in present worth.

Conclusions

This illustration has provided two important perspectives regarding the costs and benefits of a water recycling program. From a societal perspective, the recycled water program in Las Vegas has provided a valuable option to a water-limited region experiencing rapid growth in demand. This has, at a minimum, enabled the region to postpone expanding its potable water supply system, which probably saves the community considerable expense in terms of potable system operation in treatment and distribution. In addition, it has contributed to enhanced property values of perhaps $30 million in each typical impacted golf course community. Environmental and other benefits are also applicable.

This illustration also explores the narrower but nonetheless important financial perspective of a key water recycling customer class: local golf course operators. From this private business perspective, the net financial gain realized by golf course owners may be on the order of $1.9 million, in present worth terms, over a 25-year time horizon. Sample templates for this case study are provided in Tables 5.15 through 5.19.

Table 5.15: Template for step 4
Summary screening analysis

Benefits and costs receiving full or partial economic valuation
❍ Avoided O&M costs of water supply treatment (+)
❍ Avoided capital costs of wastewater treatment and disposal (main plant) (+)
❍ Avoided O&M costs for wastewater treatment and disposal (+)
❍ Reduced pumping costs (+)
❍ Avoided capital cost of wastewater collection system expansion (+)
❍ Avoided O&M cost of wastewater collection system expansion (+)
❍ Creation of green belts for recreational use (new golf course) (+)
❍ Increased property values from location near golf development (+)
❍ Capital costs for recycled water treatment (−)
❍ O&M costs for recycled water treatment (−)
❍ Capital costs for recycled water distribution (−)
❍ O&M costs for recycled water distribution (−)
❍ Summer supplement potable water purchase costs (−)
❍ Financing costs (−)
Benefits and costs requiring qualitative assessment[a]
(+) Source water protection (phosphorus content TMDL)
(+) Reduced erosion in the Las Vegas wash
(+) Reduced chemical runoff
(+) Reduced public health risk due to less contact with polluted water
(−) Increased administrative costs (e.g., backflow prevention program)
(−) Public information campaign costs (initial + continuing education of users)
Impacts deleted from further analysis: impacts that are relatively small or mitigated
❍ None identified
[a]Place “+” or “−” in parentheses for positive benefits or costs (negative benefits), respectively.

Table 5.16: Template for step 4
Summary screening analysis

Benefits and costs receiving full or partial economic valuation
❍ Reduced water purchase costs from using recycled water instead of potable water (+)
❍ Savings in fertilizer usage and costs (+)
❍ Cost to retrofit golf course to use recycled water (−)
❍ Costs associated with increased salinity of recycled water compared to potable water (−)
Benefits and costs requiring qualitative assessment[a]
( ) None in this partial illustration
Impacts deleted from further analysis: impacts that are relatively small or mitigated
❍ None identified
[a]Place "+" or "–" in parentheses for positive benefits or costs (negative benefits), respectively.

Table 5.17: Template for steps 5 and 6
Detail on benefit value derivation for water reuse project

Benefit category	Annual quantity	Unit value used	Comments
Reduced water purchase costs from using recycled water instead of potable water	Average annual golf course water use in Las Vegas is 980 AF/year per golf course.	Recycled water price was $1.69 per thousand gallons from March 20, 2001, to May 1, 2005, when it was set at $1.85. Recycled water rate to increase to $2.20 likely, spring 2006. Potable water costs January 1, 2000, to September 1, 2003, for Tier 4 was $2.27, after which it was $3.02.	Changes in rate structure provided by LVVWD. For analysis purposes, rate in effect to cover the summer season was considered to apply for the full calendar year. Golf course average annual water use is for water year as opposed to calendar year.
Fertilizer savings	Annual golf course water use averages 980 AF/year per course.	$25 per AF based on value derived for California.	$/AF value comes from value commonly used in analyses for California agencies.

Table 5.18: Template for step 8
Costs and benefits of water reuse project
(2003 US$ per year, PV over 25-year period)

	Dollar amount	Stakeholder accruing cost or benefit
Cost components		
Retrofit costs	$670,000	Hypothetical golf course
Cost of additional water for salt flushing	$1,396,000	Hypothetical golf course
Total costs	***$2,066,000***	
Benefit components		
Savings in water costs	$3,530,000	Hypothetical golf course
Fertilizer cost savings	$397,100	Hypothetical golf course
Total monetized benefits	***$3,927,100***	
Benefits requiring qualitative assessment [a]		
None in this partial illustration		
Monetized net benefits (monetized benefits minus costs)	***$1,861,000***	

[a] + indicates positive benefits anticipated but not monetizable with readily available data, and − indicates costs anticipated but not monetizable with readily available data.

Table 5.19: Template for step 9
Omissions, biases, and uncertainties and their effect on the project

Benefit or cost category	Likely impact on net benefits[a]	Comment
Cost of additional water for salt flushing	+	Not all golf courses follow this suggested salt-flushing practice. To date, it is unclear if any of the golf courses using recycled water are applying additional water to flush salts.
Savings in water costs (future rates uncertain)	U	Prices for recycled water and potable water after 2006 are assumed to stay constant into the future. In reality, both recycled water and potable water prices are expected to rise. Potable water prices are likely to rise faster than recycled water prices.

[a]Direction and magnitude of effect on net benefits:
+ = Likely to increase net benefits relative to quantified estimates.
++ = Likely to increase net benefits significantly.
− = Likely to decrease benefits.
−− = Likely to decrease net benefits significantly.
U = Uncertain; could be + or −.

CONCLUSIONS FROM CASE ILLUSTRATIONS

This chapter has provided a series of case illustrations to help reveal how benefits may arise from some water reuse projects and applications. The information provided in these illustrations has in many instances been simplified or assumed in order to facilitate the discussion and provide a basis for demonstrating a concept; the specific dollar values should not necessarily be construed as robust, case-specific estimates. Rather, the case studies are used here to provide insight on where and how reuse benefits can be estimated and also to reveal some common challenges and potential pitfalls for which analysts need to be alert.

In many instances, it is possible to develop useful empirical estimates of beneficial values. However, at the same time, caveats should be clearly understood and well documented, and sensitivity analyses need to be used to reveal the impact of key assumptions and uncertainties. Further, it is always important to identify and qualitatively describe important benefits (and costs), regardless of whether they are amenable to quantification and monetization.

CHAPTER 6

CONCLUSIONS AND SUGGESTED FUTURE RESEARCH

This report has provided an overview of why an economic analysis is useful for water reuse projects and why such BCAs are different from the traditional financial analyses typically performed. The financial perspective is itself very important but focuses solely on cash flow implications for the utility (i.e., revenues generated compared to cash outlays to cover capital and operating expenses). For water reuse projects, it also often is valuable to consider how the benefits compare to the costs (as opposed to how projected revenues compare to costs), where analysis of the benefits considers a broad social perspective that includes environmental implications and other externalities that provide valuable outcomes to individuals and entities beyond the utility’s ratepayer base.

For water reuse projects, there tend to be important benefits that, although often hard to quantify and value in dollar terms, can be very valuable to the parties impacted. The often important categories of benefits tend to include reliability (drought-proofing), ecosystem improvements (e.g., enhanced stream flows and water quality and wetlands and habitat creation), local control, and cost offsets (postponed or avoided costs for expanded and/or upgraded wastewater treatment and/or water supply purposes). Even where these benefits are hard to quantify, it is very important that they be identified, described qualitatively, and become part of the policymaking and stakeholder dialogue. In this manner, the economic analysis can serve as a valuable component of the larger decision support toolkit that local managers and public officials need to use when evaluating water supply issues.

This report also has provided guidance on how to perform a BCA and supplies templates (and a computerized spreadsheet version) to help guide users through the exercise. Illustrative examples also are provided for several water reuse projects. One of the key points raised is that it is challenging to develop empirical estimates of the value of many key benefits of reuse but that it is feasible to do so in some cases, if careful use is made of existing empirical research. However, such “benefits transfers” can also be a source of considerable unintended error, and examples and guidance have been provided to help guide users and alert them to the need for due caution. Ultimately, primary research is preferred to benefits transfer but may not be feasible due to the cost and scheduling requirements of nonmarket valuation research.

Future research that will assist the water reuse community in its efforts to develop more and better economic (benefit–cost) analyses include:

1. Empirical investigations into the value of reliability that reuse provides. Such research should consider the “drought-proofing” aspect of reliability provided by reuse (and desalination) for both residential and commercial customers. It also should consider the other types of reliability (e.g., energy demands and vulnerabilities) and how reuse and desalination may or may not compare favorably to traditional water source options in those reliability contexts.

2. Detailed case studies that provide a robust and focused opportunity to properly investigate the types and magnitudes of benefits (and costs) associated with actual past (or anticipated) water reuse projects. This detailed case study approach could

also examine the distribution of benefits and costs (i.e., who benefits by how much versus who pays how much), to provide some clear empirical examples of the incidence of reuse benefits and costs. It in turn will furnish a robust example for considering a legitimate economic basis for using cost sharing and subsidies to reflect the real externalities created by reuse programs.

3. Investigations of what happens if reuse is not available in several typical community water supply situations. They will provide a better and clearer sense of the proper "baseline" for evaluating water reuse projects. They could address issues such as the perceived and measurable benefits and costs of accommodating (or managing) growth, for example. They also can explore issues such as where the next increments of water supply are derived and at what marginal costs if reuse is not considered part of the community's overall water supply portfolio.

REFERENCES

Arizona Game and Fish Department. Heritage Data Management System. Animal Abstract. http://www.azgfd.gov/pdfs/w_c/hdms/Birds/Rallloyu.fi.pdf (accessed Dec 6, 2005).

Asabere, P. K; Huffman, F. E. Negative and positive impacts of golf proximity on home prices. *Appraisal J.* **1996**, *64*, 351–355.

Bardecki, M. J. *Wetlands and Economics: An Annotated Review of the Literature, 1988–1998*; Environment Canada: Ottawa, Ontario, Canada, 1998.

Bergstrom, J. C.; Cordell, H. K. An analysis of the demand for and value of outdoor recreation in the United States. *J. Leis. Res.* **1991**, *23*, 67–86.

Berrens, R. P.; Ganderton, P.; Silva, C. L. Valuing the protection of minimum in-stream flows in New Mexico. *J. Agric. Resour. Econ.* **1996**, *21*, 294–309.

Bible, D. S.; Hsieh, C. Gated communities and residential property values. *Appraisal J.* **2001**, *69*, 140–145.

Boyle, K. *Meta-Analysis of Sport Fishing Values*; U.S. Fish and Wildlife Service: Washington, DC, 1997.

Boyle, K.; Reiling, S.; Teisel, M.; Phillips, M. *A Study of the Impact of Game and Nongame Species on Maine's Economy*; Department of Agriculture and Resource Economics, University of Maine: Orono, 1990.

Boyle, K. J.; Bishop, R. C. Valuing wildlife in benefit-cost analyses: a case study involving endangered species. *Water Resour. Res.* **1987**, *23*, 943–950.

Boyle, K. J.; Poe, G. L.; Bergstrom, J. C. What do we know about groundwater values? Preliminary implications from a meta analysis of contingent valuation studies. *Am. J. Agric. Econ.* **1994**, *76*, 1055–1061.

Breaux, A.; Farber, S.; Day, J. Using natural coastal wetlands to wastewater treatment: an economic benefit analysis. *J. Environ. Manage.* **1995**, *44*, 285–291.

Brouwer, R.; Langford, I. H.; Bateman, I. J.; Crowards, T. C.; Turner, R. K. *A Meta-Analysis of Wetland Contingent Valuation Studies*, Working Paper GEC97-20; Centre for Social and Economic Research on the Global Environment, University of East Anglia: Norwich, U.K., 1997.

Brox, J. A.; Kumar, R. C.; Stollery, K. R. Estimating willingness to pay for improved water quality in the presence of item nonresponse bias. *Am. J. Agric. Econ.* **2003**, *85*, 414–428.

Burton, M. L.; Hicks, M. J. *Public Parks, Housing Values, and Fiscal Flexibility*, Draft; Center for Business and Economic Research: Huntington, WV, 2003.

Cangelosi, A.; Wiher, R.; Taverna, J.; Cicero, P. Wetlands Restoration in Saginaw Bay. In *Revealing the Economic Value of Protecting the Great Lakes*; National Oceanic and Atmospheric Administration and Northeast-Midwest Institute: Washington, DC, 2001.

Carson, R. T.; Mitchell, R. C. *Economic Value of Reliable Water Supplies for Residential Water Users in the State Water Project Service Area*, SWC Exhibit Number 54; 1987.

CDWR. History of Watermaster Service in West Coast and Central Basins of Los Angeles County. http://wwwdpla.water.ca.gov/sd/watermaster/watermaster_history.html (accessed Sept 16, 2005).

Central Basin and West Basin Municipal Water Districts. Request for Information for the Supply and Delivery of Office Supplies. www.westbasin.org/pdf/Office_Supplies_RFI_111005.pdf.

Christensen, J. D.; Monaco, M. E.; Livingston, R. J.; Woodsum, G., Battista, T. A.; Klein, C. J.; Galeprin, B.; Huang, W. *Potential Impacts of Reduced Freshwater Inflow on Apalachicola Bay, FL Oyster (*Crassostrea virginica*) Populations: Coupling Hydrologic and Biological Models*; National Oceanic and Atmospheric Administration: Silver Spring, MD, 1998.

City of Phoenix. Tres Rios Constructed Wetlands Demonstration Project Research. http://phoenix.gov/TRESRIOS/saltgila.html (accessed Sept 12, 2005).

City of Phoenix. Tres Rios Constructed Wetlands Demonstration Project Articles. http://phoenix.gov/TRESRIOS/anfoard1.html (accessed Sept 12, 2005).

City of Phoenix. Tres Rios Constructed Wetlands Demonstration Project. http://phoenix.gov/TRESRIOS/arte.html (accessed Sept 12, 2005).

Correll, M. R.; Lillydahl, J. H.; Singell, D. L. The effects of greenbelts on residential property values: some findings on the political economy of open space. *Land Econ.* **1978**, *54*, 207–217.

Costanza, R.; Farber, S. C.; Maxwell, J. Valuation and management of wetland ecosystems. *Ecol. Econ.* **1989**, *1*, 335–361.

Croke, K.; Fabian, R.; Brenniman, G. Estimating the value of beach preservation in an urban area. *Environ. Prof.* **1987**, *9*, 42–48.

Cummings, R. G.; Ganderton, P. T.; McGuckin, T. Substitution effects in CVM values. *Am. J. Agric. Econ.* **1994**, *76*, 205–214.

CUWA. The Value of Water Supply Reliability: Results of a Contingent Valuation Survey of Residential Customers. http://www.cuwa.org/library/TheValueofWaterSupplyReliabilityAug94.pdf.

Dalecki, G. M.; Whitehead, J. C.; Blomquist, G. C. Sample non-response bias and aggregate benefits in contingent valuation: an examination of early, late and non-respondents. *J. Environ. Manage.* **1993**, *38*, 133–143.

Darling, A. H. Measuring benefits generated by urban water parks. *Land Econ.* **1973**, *49*, 22–34.

Desvousges, W. H.; Naughton, M. C.; Parsons, G. R. Benefit transfer: conceptual problems in estimating water quality benefits using existing studies. *Water Resour. Res.* **1992**, *28*, 675–683.

Desvousges, W. H.; Smith, V. K.; Fisher, A. Option price estimates for water quality improvements: a contingent valuation study for the Monongahela River. *J. Environ. Econ. Manage.* **1987**, *14*, 248–267.

De Zoysa, A. D. N. A Benefit Evaluation of Programs to Enhance Groundwater Quality, Surface Water Quality and Wetland Habitat in Northwest Ohio. Ph.D. Dissertation, The Ohio State University, Columbus, 1995.

Do, Q. A.; Grudnitski, G. Golf courses and residential house prices: an empirical examination. *J. Real Estate Finance Econ.* **1995**, *10*, 261–270.

Environment Canada. Environmental Valuation Resource Inventory (EVRI). http://www.evri.ca (accessed Mar 10, 2005).

Farber, S.; Griner, B. Using conjoint analysis to value ecosystem change. *Environ. Sci. Technol.* **2000**, *34*, 1407–1412.

Feather, T. D. Valuation of Lake Resources through Hedonic Pricing. Ph.D. Dissertation, University of Florida, Gainesville, 1992.

Firth, W. R. Can golf and housing get along? *Urban Land* **1990**, *1990*, 16–19.

Fisher, A.; Fullerton, D.; Hatch, N.; Reinelt, P. Alternatives for managing drought: a comparative analysis. *J. Environ. Econ. Manage.* **1995**, *29*, 304–320.

Gelt, J. Fountains—Water Wasters or Works of Art? http://ag.arizona.edu/AZWATER/arroyo/073fount.html (accessed Dec 2, 2003).

Griffin, R. C.; Mjelde, J. W. Valuing water supply reliability. *Am. J. Agric. Econ.* **2000**, *82*, 414–426.

Heimlich, R. E. Costs of an agricultural wetland reserve. *Land Econ.* **1994**, *70*, 234–246.

Henglen, S.; Bergstrom, J. C.; Dorfman, J. H. Estimating the benefits of groundwater contamination control. *South. J. Agric. Econ.* **1992**, *24*, 63–71.

Howe, C. W.; Smith, M. G. The value of water supply reliability in urban water systems. *J. Environ. Econ. Manage.* **1994**, *26*, 19–30.

Huang, J.-C.; Haab, T. C.; Whitehead, J. C. Willingness to pay for quality improvements: should revealed and stated preference data be combined? *J. Environ. Econ. Manage.* **1997**, *34*, 240–255.

Industrial Economics. Sportfishing Values Database. http://www.indecon.com/fish/default.asp (accessed February 14, 2005).

Kaoru, Y. Differentiating use and nonuse values for coastal pond water quality improvements. *Environ. Resour. Econ.* **1993**, *3*, 487–494.

Kimmel, M. M. Parks and Property Values: An Empirical Study in Dayton and Columbus, Ohio. M.A. Thesis, Miami University, Oxford, OH, 1985.

Kyler, D. Letter of February 9, 2001, from David Kyler, Executive Director, Center for a Sustainable Coast, to Roy Barnes, Governor of Georgia.

Landry, C. In-Stream Flow Marketing in the Pacific Northwest. Political Economy Research Center. Presented at Pacific Northwest Regional Economic Conference: Conflict and Collaboration: How Government, Business, and Academia Shape the Pacific Northwest Economy, Olympia, WA, May 7–9, 1998.

Lew, D. K.; Larson, D. M.; Suenaga, H.; DeSousa, R. The Beneficial Use Values Database. Department of Agricultural and Resource Economics. http://buvd.ucdavis.edu (accessed Jan 31, 2005).

Loomis, J. Balancing public trust resources of Mono Lake and Los Angeles water rights: an economic approach. *Water Resour. Res.* **1987**, *23*, 1449–1456.

Loomis, J.; Crespi, J. Estimated Effects of Climate Change on Selected Outdoor Recreation Activities in the United States. In *The Impact of Climate Change on the United States*

Economy; Mendelsohn, R., Neumann, J. E., Eds.; Cambridge University Press: Cambridge, U.K., 1999; pp 289–314.

Loomis, J. B.; White, D. S. Economic benefits of rare and endangered species: summary and meta-analysis. *Ecol. Econ.* **1996**, *18*, 197–206.

Mantovani, P.; Asano, T.; Chang, A. C.; Okun, D. A. *Management Practices for Nonpotable Water Reuse*, Project 97-IRM-6; Water Environment Research Foundation: Alexandria, VA, 2001; pp 6:1–6:16.

Mayer, P. W.; DeOreo, W. B.; Opitz, E. B.; Kiefer, J. C.; Davis, W. Y.; Dziegielewski, B.; Nelson, J. O. *Residential End Uses of Water*; AWWA and AWWA Research Foundation: Denver, CO, 1999.

Megdal, S. B. Environmental Restoration Projects in Arizona: The U.S. Army Corps of Engineers' Approach. Final Report. http://ag.arizona.edu/AZWATER/presentations/Megdal_USACE_Final.pdf (accessed Aug 21, 2005).

Michelsen, A. M.; McGuckin, J. T.; Stumpf, D. M. *Effectiveness of Residential Water Conservation Price and Nonprice Programs*; AWWA Research Foundation: Denver, CO, 1998.

Moncur, J. E.; Pollock, R. L. Scarcity rents for water: a valuation and pricing model. *Land Econ.* **1988**, *64*, 62–72.

Nelson, A. C. Using land markets to evaluate urban containment programs. *J. Am. Plann. Assoc.* **1986**, *55*, 156–171.

NPS. *Economic Impacts of Protecting Rivers, Trails, and Greenway Corridors*, 4th ed.; National Park Service: Washington, DC, 1995.

NRC. *Valuing Groundwater: Economic Concepts and Approaches*; National Research Council, National Academy Press: Washington, DC, 1997.

OMB. *Guidelines and Discount Rates for Cost-Benefit Analyses of Federal Programs*; Appendix C to Circular Number A-94; Office of Management and Budget: Washington, DC, 1992.

OWT. *Water Rights Acquisition Summary*; Oregon Water Trust: Portland, 1998.

Owusu-Edusei, K.; Espey, M. Does Proximity to a Golf Course Matter? http://cherokee.agecon.clemson.edu/wp012203.PDF (accessed Dec 21, 2004).

Pinellas County Utilities. Reclaimed Water and Landscaping. http://pubgis.co.pinellas.fl.us/pcuweb_live/water/watersource/conservation.cfm (accessed Sept 6, 2005).

Powell, J. R.; Allee, D. J.; McClintock, C. Groundwater protection benefits and local community planning: Impact of contingent valuation information. *Am. J. Agric. Econ.* **1994**, *76*, 1068–1075.

Quang, D. A.; Grudnitski, G. Golf courses and residential house prices: an empirical examination. *J. Real Estate Finance Econ.* **1995**, *10*, 261–280.

Rand, H. Competing for water: the uncivil war. *Water Resour. IMPACT* **2003**, *5*, 5–7.

Raucher, R. S.; Agras, J.; Mills, D.; Harrod, M.; Chestnut, L.; Burmaster, D.; Crawford-Brown, D.; Cox, T. *Quantifying Public Health Risk Reduction Benefits*; AWWA Research Foundation and AWWA: Denver, CO, 2002.

Raucher, R. S.; Chapman, D.; Henderson, J.; Hagenstad, M. L.; Rice, J.; Goldstein, J.; Huber-Lee, A.; DeOreo, W.; Mayer, P.; Hurd, B.; Linsky, R.; Means, E.; Renwick, M. *The Value of Water: Concepts, Estimates, and Applications for Water Managers*; AWWA Research Foundation: Denver, CO, 2005.

Rea & Parker Research. *San Diego County Water Authority 2004 Telephone Public Opinion and Awareness Survey*; Rea & Parker Research: San Diego, CA, 2004.

Reaves, D. W.; Kramer, R. A.; Holmes, T. P. Does question format matter? Valuing an endangered species. *Environ. Resour. Econ.* **1999**, *14*, 365–383.

Recycled Water Task Force. Economics Work Group Draft White Paper, November 18, 2002. http://www.owue.water.ca.gov/recycle/docs/WorkgroupWhitePapers.htm (accessed Mar 16, 2004).

Richardson, T.; Gross, B.; VanWagoner, B.; Snow, T.; Butler, B.; Bailey, H.; Richardson, T. Use of Recycled Water to Augment Potable Supplies: An Economic Perspective. http://www.watereuse.org/Potable White Paper.htm (accessed Aug 25, 2005).

Rigby, R. *Acquiring Water for Flow Augmentation. Special Report;* U.S. Bureau of Reclamation, Pacific Northwest Region: Boise, ID, 1997.

Rinehart, J.; Pompe, J. Estimating the effect of a view on undeveloped property values. *Appraisal J.* **1999**, *67*, 57.

Rosenberger, R.; Loomis, J. Benefit Transfer of Outdoor Recreation Use Values: A Technical Document Supporting the Forest Service Strategic Plan (2000 Revision). http://www.fs.fed.us/rm/pubs/rmrs_gtr72.html (accessed Jan 30, 2005).

Samples, K. C.; Bishop, R. C. Estimating the value of variations in anglers' success rates: an application of the multiple-site travel cost method. *Mar. Resour. Econ.* **1985**, *2*, 55–74.

Santa Clara Valley Water District. *Water Supply Availability Analysis for the Coyote Valley Specific Plan*; Santa Clara Valley Water District: San Jose, CA, 2005.

Schulze, W. D.; Rowe, R. D.; Breffle, W. S.; Boyce, R.; McClelland, G. *Contingent Valuation of Natural Resource Damages due to Injuries to the Upper Clark Fork River Basin*; RCG/Hagler Bailly: Boulder, CO, 1993.

South Florida Water Management District Water Supply Department. *Draft Upper East Coast Water Supply Plan Planning Document. 2004 Update Final Draft Version*; West Palm Beach, FL, 2004.

Southwest Regional Assessment Group. Preparing for a Changing Climate: The Potential Consequences of Climate Variability and Change. http://www.ispe.arizona.edu/research/swassess/report.html (accessed Dec 2, 2003).

SRI. The Golf Economy Report. http://www.golf2020.com/reports_2002GolfEconomy.asp (accessed Jan 6, 2005).

Stevens, T. H.; Benin, S.; Larson, J. S. Public attitudes and economic values for wetland preservation in New England. *Wetlands* **1995**, *15*, 226–231.

SWFWMD. Water Supply Document. http://www.sfwmd.gov/org/wsd/wsp/uec/pdf/2004update/document/uec_planning_5_04/document_5_04.pdf (accessed June 1, 2005).

SWFWMD. 2004 Annual Agency Reuse Report. Southwest Florida Water Management District. January.

http://www.swfwmd.state.fl.us/documents/reports/annual_agency_reuse_report.pdf (accessed June 1, 2005).

SWFWMD. Annual Alternative Water Supply Report FY2005. Southwest Florida Water Management District. http://www.swfwmd.state.fl.us/documents/reports/annual_alternative_water_supply_report.pdf (accessed June 1, 2005).

TCPS. *Community and Economic Benefits of Texas Rivers, Springs and Bays*; Texas Center for Policy Studies: Austin, 2002.

Thomas, B.; Rodrigo, D. Measuring the Benefits of Non-Traditional Water Resource Investments. In *Proceedings of Conserv 96: Responsible Water Stewardship*; Orlando, FL, 1996; pp 195–199.

U.S. Census Bureau. State and County Quick Facts. http://quickfacts.census.gov/qfd/states/12/12103.html.

U.S. EPA. *Guidelines for Preparing Economic Analyses*; EPA 240-R-00-003; U.S. Environmental Protection Agency: Washington, DC, 2000.

U.S. EPA. Spokane Tribe of Indians Surface Water Quality Standards. Resolution 2003-259. U.S. Environmental Protection Agency. http://www.epa.gov/waterscience/standards/wqslibrary/tribes/spokane.pdf (accessed Dec 2, 2003).

U.S. EPA. Environmental Economic Reports Inventory (EERI). http://yosemite.epa.gov/ee/epa/eed.nsf/webpages/EnvironmentalEconomicsReports.html (accessed Jan 28, 2005).

U.S. EPA. River Corridor and Wetland Restoration. Tres Rios Demonstration, Constructed Wetlands. http://yosemite.epa.gov/water/restorat.nsf/ (accessed Sept 13, 2005).

U.S. EPA. Urban Rivers Restoration Pilot Fact Sheet Tres Rios, Arizona. http://www.epa.gov/oswer/landrevitalization/download/factsheet_tres-rios.pdf (accessed June 28, 2005).

USFWS and U.S. Census Bureau. 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation: California. http://www.census.gov/prod/2002pubs/fhw01-ca.pdf (accessed June 28, 2005).

Varga, T. G. *The Role of Local Projects to Enhance the Imported Water Supply. Water Supply and Water Reuse: 1991 and Beyond*; AWWA: Denver, CO, 1991.

WateReuse Foundation. *Water Reuse Economic Framework Workshop Report*; WateReuse Foundation: Alexandria, VA, 2004.

Weicher, J. C.; Zerbst, R. H. The externalities of neighborhood parks: an empirical investigation. *Land Econ.* **1973**, *49*, 99–105.

Whitehead, J. C.; Blomquist, G. C. Measuring contingent values for wetlands: effects of information about related environmental goods. *Water Resour. Res.* **1991**, *27*, 2523–2531.

Whitehead, J. C.; Hoban, T. J.; Clifford, W. B. Measurement issues with iterated, continuous/interval contingent valuation data. *J. Environ. Manage.* **1995**, *43*, 129–139.

Woodward, R. T.; Wui, Y.-S. The economic value of wetland services: a meta-analysis. *Ecol. Econ.* **2001**, *37*, 257–270.

APPENDIX A

RECREATION

Introduction

Water reuse projects may contribute to sizable recreational values in a number of ways. Reuse may help keep more source waters instream (by substituting for surface water withdrawals) or improve instream quality (by reducing wastewater discharges). A change in either quantity or quality of water could lead to changes in recreational benefits. For increases in environmental quality, the resource may draw more recreational users, and recreationists might increase their value of the activity, increase frequency of the activity, or both. Conversely, a decrease in value or use of resource might occur with a decrease in water quantity or quality.

For example, swimmers may experience benefits from improved water quality, and fishers, wildlife viewers, and hunters may experience benefits from improved habitat. A significant portion of recreational spending is tied to fish and wildlife, both of which require suitable quantities and quality of water and the habitats they support, such as wetlands, for survival (wildlife to a much lesser extent than fish).

Reuse projects may also enable a range of recreational experiences in the communities where the waters are used. Reuse water often is used to irrigate ball fields and golf courses, urban parks, and green spaces. Reuse waters also are used in some locations to create wetlands. The applications of reuse provide a range of outdoor recreational opportunities, which can hold significant value.

Affected Parties

Recreation will generally affect the societal impact category (see "Distributional Perspectives" in chapter 3), because many recreational beneficiaries may reside in areas outside of the agency's service district. Of course, utility customers may also directly benefit, such as when recreational opportunities are created in the utility's service area. Individuals using wetlands or green space that are created (or greatly enhanced) by reuse waters derive recreational use benefits for the days of outdoor activities that they get to experience (additionally, the quality of their experience is improved, and thus each user day becomes more highly valued, because of reuse-enabled enhancements). Likewise, in downstream locations, swimmers may experience benefits from improved water quality, and fishers, wildlife viewers, and hunters may experience benefits from improved habitat. In addition, recreation-related businesses may experience an increase in revenues.

Qualitative Assessment

It may not be possible or desirable to quantify impacts for a particular category. In those cases, it may be appropriate to qualitatively assess impacts.

If benefits were to be qualitatively assessed, a scaling approach may be used to illustrate general magnitudes of benefits. If a −2-to-+2 scale were applied, with a "−2" equal to "large costs" and a "+2" equal to "large benefits," the following definitions may be used (see Figure A.1):

- −2 = Large costs: Change in water quality or quantity will entail large negative impacts on recreation. Costs of change far outweigh benefits (if any exist). This may arise where wastewater discharges are reduced in streams that are critically reliant on the return flows to support recreational uses.

Figure A.1: Scaling of recreational benefits

Large costs	Small costs	No impact	Small benefits	Large benefits
−2	−1	0	+1	+2

- −1 = Small costs: Change in water quality or quantity will cause minor negative impacts on recreation. Costs of change are slightly greater than benefits (if any exist).
- 0 = No impact: Change in water quality or quantity will not affect water-related recreational activities in any way or will have benefits commensurate with the costs.
- +1 = Small benefits: Change in water quality or quantity will have a small positive impact on at least one or more water-related recreational activities. Benefits will slightly outweigh the costs.
- +2 = Large benefits: Change in water quality or quantity will have a large positive impact on at least one or more water-related recreational activities. Benefits will significantly outweigh the costs.

Quantifying the Outcomes (Identifying Units of Measurement)

Values for recreation activities such as swimming or fishing are most frequently cited in dollars per user activity day. An activity day is the typical amount of time pursuing an activity within a 24-hour period. Values for water-related recreational activities can also be measured per season and per year. Values for fishing can be expressed per fish caught and per fish kept.

These values per specified unit of measurement are then applied to the appropriate quantity. If values are cited in dollars per user activity day, then one needs to apply this value to the geographically appropriate total number of user days.

Monetizing the Outcomes

The total value of recreational activities is often divided into two components: (1) what people actually pay in out-of-pocket expenses to participate in a given sport (e.g., equipment and travel expenditures), and (2) what they would be willing to pay over and above what they currently pay. The first component of value can be represented simply by the expenditures incurred. However, cost is typically an underestimate of value, and thus there is the second component of value. Recreational site visits cost money and time, and recreationists would not undertake visits unless the visits yielded net benefits, known as ***consumer surplus***. Thus, even though there are often no direct markets to "purchase" recreational activities, there are prices, both money and time, that individuals pay to participate in recreational activities.

Those prices can be used to estimate an individual's willingness to pay, and thus demand, for water-related activities.

Once a value (or range of values) per user day has been identified, it needs to be applied to the appropriate number of user days. For example, in 2001, residents of the state of California fished 27,878 days (USFWS and U.S. Census Bureau). If a water quality or quantity change had a positive impact such that user days would increase by 5% (or 1,394 days), then the impact could entail a benefit to the recreational fishing sector of approximately $46,000 (assuming a value of $32.83 per fishing day). Additional benefits may be experienced if fishers increase the value of their fishing day or if existing fishers opt to fish more.

Resources (Where To Look Up Further Information)

See subcategories in the sections below:

- A.1 In-Water Recreation
- A.2 Near-Water Recreation
- A.3 Greenbelts
- A.4 Golf Courses

Also, Appendix E provides a resource guide to several useful recreation valuation databases.

A.1 RECREATION: IN-WATER RECREATION

Introduction

In-water recreational activities for rivers primarily consist of swimming, float boating (e.g., canoeing and river rafting), motorboating, and fishing. In-water recreational activities for lakes and reservoirs can include these activities plus jet-skiing, waterskiing, houseboating, and sailing. For increases in environmental quality, the resource may draw more in-water recreation and existing recreationists might increase their value of the activity. Conversely, a decrease in use or value of a resource for in-water recreation might occur with a decrease in water quantity or quality.

Affected Parties

Recreation will generally affect the societal impact category (see “Distributional Perspectives” in chapter 3). In particular, swimmers, boaters, and skiers may experience benefits from improved water quantity or quality, and fishers may experience benefits from improved habitat. Recreation-related businesses may experience impacts as well. Beneficiaries will often include many individuals who reside beyond the service area boundaries of the utility.

Qualitative Assessment

It may not be possible or desirable to quantify impacts for a particular category. In those cases, it may be appropriate to qualitatively assess impacts.

If benefits were to be qualitatively assessed, a scaling approach may be used to illustrate general magnitudes of benefits. If a −2-to-+2 scale were applied, with a “−2” equal to “large costs” and a “+2” equal to “large benefits,” the following definitions may be used (see Figure A.2):

Figure A.2: Scaling of in-water recreational benefits

Large costs	Small costs	No impact	Small benefits	Large benefits
−2	−1	0	+1	+2

- −2 = Large costs: Change in water quality or quantity will entail large negative impacts on in-water recreation. Costs of change far outweigh benefits (if any exist).
- −1 = Small costs: Change in water quality or quantity will cause minor negative impacts on in-water recreation. Costs of change are slightly greater than benefits (if any exist).
- 0 = No impact: Change in water quality or quantity will not affect in-water recreational activities in any way or will have benefits commensurate with the costs.
- +1 = Small benefits: Change in water quality or quantity will have a small positive impact on at least one or more in-water recreational activities. Benefits will slightly outweigh the costs.
- +2 = Large benefits: Change in water quality or quantity will have a large positive impact on at least one or more in-water recreational activities. Benefits will significantly outweigh the costs.

Quantifying the Outcomes (Identifying Units of Measurement)

Values for recreation activities such as swimming or fishing are most frequently cited in dollars per user activity day. An activity day is the typical amount of time pursuing an activity within a 24-hour period. Values for water-related recreational activities can also be measured per season and per year. Values for fishing can also be measured per fish caught and per fish kept.

Monetizing the Outcomes

The total value of recreational activities is often divided into two components: (1) what people actually pay to participate in a given sport (e.g., equipment expenditures); and (2) what they would be willing to pay over and above what they currently pay. The first component of value can be represented simply by the expenditures incurred. However, cost is typically an underestimate of value, and thus there is the second component of value. Recreational site visits cost money and time, and recreationists would not undertake visits unless the visits yielded net benefits, known as ***consumer surplus***. Thus, even though there often are not direct markets to "purchase" recreational activities, there are prices in both money and time that individuals pay to participate in recreational activities. Those prices can be used to estimate an individual's willingness to pay, and thus demand, for water-related activities.

A meta-analysis of studies estimating recreational benefits (Rosenberger and Loomis) provided the following values, which are stated per person per day of activity (all values stated in June 2004 US$):

- Swimming (13 studies): average $27.09 (low: $2.18; high: $135.73)
- Float boating (river rafting; 15 studies): $37.27 (low: $17.93; high: $314.37)
- Motorboating (15 studies): $38.13 (low: $5.26; high: $202.30).

One study estimated the following recreational benefits for waterskiing and canoeing/kayaking in the United States (Bergstrom and Cordell, 1991; all values stated in June 2004 U.S. dollars):

- Waterskiing: $40.96
- Canoeing/kayaking: $19.28
- Rowing/other boating: $41.67.

The individual values for activities within these categories vary due to a number of factors including geographic location and site quality (e.g., ease of access and quality of experience).

There is a large body of literature supporting values for fishing. Fishing values may vary significantly, depending on aspects of the experience such as species, bodies of water (which may be specified as type of water body such as stream or lake or by type of water such as warm water or cold water), and angling techniques. The database created by Rosenberger and Loomis (2001) reports an average value of $39.14 per fishing day per user, obtained from 118 different studies. Values ranged from $2.06 to $251.49. The lower estimate is for trout and salmon fishing in Wisconsin on Lake Michigan (Samples and Bishop, 1985) and the higher for sportfishing in Maine (Boyle et al., 1990).

Identifying more accurate values for specific species of fish in a given location may be accomplished by using some of the fishing-specific databases (Industrial Economics, 2004;

Boyle, 1997). These databases may contain many of the same studies in the Rosenberger and Loomis database but present study results by more specific attributes such as species, water body type, and location. However, values presented in many databases are not consistent across all studies included in the analysis, so precise conversions will need to be conducted to compare or combine values. Results may be presented in dollar values, which vary by units of time (e.g., hour, day, trip, season, or year), measures of consumer surplus (e.g., marginal or total), or per fish caught or per fish kept.

Table A.1 summarizes some of the available monetary values for in-water recreational activities.

Table A.1: Summary of economic values (willingness to pay) of in-water recreational activities (per user day; June 2004 US$)

Activity	Avg value	Low value	High value	No. of sources
Swimming	$27.09[a]	$2.18	$135.73	13
Float boating	$37.27[a]	$17.93	$314.37	14
Motorboating	$38.13[a]	$5.26	$202.30	15
Fishing	$39.14[a]	$2.06	$251.49	118
Waterskiing	$40.96[b]	na	na	1
Canoeing/ kayaking	$19.28[b]	na	na	1
Rowing/ other boating	$41.67[b]	na	na	1

a. Average values were obtained from the average values reported in 1996 dollars in the meta-analysis conducted by Rosenberger and Loomis and were updated to June 2004 US$, using the appropriate CPI of 0.1923.
b. Values were reported in the Bergstrom and Cordell (1991) in 1987 dollars and were updated to June 2004 US$, using the appropriate CPI of 0.5214. na, not available.

Resources (Where To Look Up Further Information)

Recreation values (e.g., values for swimming, fishing, float boating, and motorboating):

- Environment Canada. Environmental Valuation Resource Inventory (EVRI). http://www.evri.ca.
- Rosenberger, R.; Loomis, J. Benefit Transfer of Outdoor Recreation Use Values: A Technical Document Supporting the Forest Service Strategic Plan (2000 Revision). http://www.fs.fed.us/rm/pubs/rmrs_gtr72.html.
- Lew, D. K.; Larson, D. M.; Suenaga, H.; DeSousa, R. The Beneficial Use Values Database. Department of Agricultural and Resource Economics. http://buvd.ucdavis.edu. See April 2001.
- U.S. EPA. Environmental Economic Reports Inventory (EERI). http://yosemite.epa.gov/ee/epa/eed.nsf/webpages/EnvironmentalEconomicsReports.html.

Additional fishing values:

- Industrial Economics. Sportfishing Values Database. Prepared for the U.S. Fish and Wildlife Service. http://www.indecon.com/fish/default.asp.
- Boyle, K. *Meta-Analysis of Sport Fishing Values*; U.S. Fish and Wildlife Service: Washington, DC, 1997.

Crosswalk to Other Categories

Additional benefits may be experienced by other sectors (discussed in other sections). Some local and regional recreation-related businesses may experience a change in revenues that will have local or regional economic impacts.

A.2 RECREATION: NEAR-WATER RECREATION

Introduction

Near-stream recreational activities may include hiking, picnicking, camping, waterfowl hunting, wildlife viewing, and sightseeing. For increases in environmental quality, the resource may draw more near-water recreation and existing recreationists might increase their value of the activity. Conversely, a decrease in use or value of a resource for near-water recreation might occur with a decrease in water quantity or quality.

Affected Parties

Near-water recreation will generally affect the societal impact category (see "Distributional Perspectives" in chapter 3). In particular, hikers, picnickers, campers, hunters, wildlife viewers, and sightseers may experience benefits from improved water quantity or quality and associated habitat. Recreation-related businesses may experience impacts as well. Beneficiaries are likely to include many people who reside outside the utility service area.

Qualitative Assessment

It may not be possible or desirable to quantify impacts for a particular category. In those cases, it may be appropriate to qualitatively assess impacts.

Figure A.3: Scaling of near-water recreational benefits

Large costs	Small costs	No impact	Small benefits	Large benefits
−2	−1	0	+1	+2

If benefits were to be qualitatively assessed, a scaling approach may be used to illustrate general magnitudes of benefits. If a −2-to-+2 scale were applied, with a "−2" equal to "large costs" and a "+2" equal to "large benefits," the following definitions may be used (see Figure A.3):

- −2 = Large costs: Change in water quality or quantity will entail large negative impacts on near-water recreation. Costs of change far outweigh benefits (if any exist).
- −1 = Small costs: Change in water quality or quantity will cause minor negative impacts on near-water recreation. Costs of change are slightly greater than benefits (if any exist).
- 0 = No impact: Change in water quality or quantity will not affect near-water recreational activities in any way or will have benefits commensurate with the costs.
- +1 = Small benefits: Change in water quality or quantity will have a small positive impact on at least one or more near-water recreational activities. Benefits will slightly outweigh the costs.
- +2 = Large benefits: Change in water quality or quantity will have a large positive impact on at least one or more near-water recreational activities. Benefits will significantly outweigh the costs.

Quantifying the Outcomes (Identifying Units of Measurement)

Values for recreation activities such as swimming or fishing are most frequently cited in dollars per user activity day. An activity day is the typical amount of time pursuing an activity within a 24-hour period. Values for water-related recreational activities can also be measured per season and per year.

Monetizing the Outcomes

The total value of recreational activities is often divided into two components: (1) what people actually pay to participate in a given sport (e.g., equipment expenditures), and (2) what they would be willing to pay over and above what they currently pay. The first component of value can be represented simply by the expenditures incurred. However, cost is typically an underestimate of value, and thus there is the second component of value. Recreational site visits cost money and time, and recreationists would not undertake visits unless the visits yielded net benefits, known as ***consumer surplus***. Thus, even though there are often not direct markets to "purchase" recreational activities, there are prices, both money and time, that individuals pay to participate in recreational activities. Those prices can be used to estimate an individual's willingness to pay, and thus demand, for water related activities.

Table A.2: Summary of economic values (willingness to pay) of near-water recreational activities (per user day; June 2004 US$)

Activity	Avg value[a]	Low value	High value	No. of sources
Hiking	$32.00	$1.86	$260.35	27
Picnicking	$44.02	$13.52	$141.82	10
Camping	$42.10	$2.01	$223.08	40
Waterfowl hunting	$36.20	$2.59	$170.28	58
Wildlife viewing	$37.13	$2.81	$160.82	116

a. Average values were obtained from the average values reported in 1996 dollars in the meta-analysis conducted by Rosenberger and Loomis and were updated to June 2004 US$, using the appropriate CPI of 0.1923.

Table A.2 summarizes some of the values for near-water recreational activities. These values were obtained from a meta-analysis of studies estimating recreational benefits and all values are stated per person per day of activity. Values for these activities vary due to a number of factors including geographic location and site quality (e.g., ease of access and quality of experience).

Resources (Where To Look Up Further Information)

Recreation values:

- Environment Canada. Environmental Valuation Resource Inventory (EVRI). http://www.evri.ca.
- Rosenberger, R.; Loomis, J. Benefit Transfer of Outdoor Recreation Use Values: A Technical Document Supporting the Forest Service Strategic Plan (2000 Revision). http://www.fs.fed.us/rm/pubs/rmrs_gtr72.html.

- Lew, D. K.; Larson, D. M.; Suenaga, H.; DeSousa, R. The Beneficial Use Values Database. Department of Agricultural and Resource Economics. http://buvd.ucdavis.edu. See April 2001.

- U.S. EPA. Environmental Economic Reports Inventory (EERI). http://yosemite.epa.gov/ee/epa/eed.nsf/webpages/EnvironmentalEconomicsReports.html.

Crosswalk to Other Categories

Additional benefits may be experienced by other sectors (discussed in other sections). Some local and regional recreation-related businesses may experience a change in revenues that will have local/regional economic impacts.

A.3 RECREATION: GREENBELTS

Introduction

A greenbelt is a belt of recreational parks, farmland, or uncultivated land surrounding a community. In general, people desire natural landscapes and have a special preference for trees and green, park-like, or pastoral landscapes. This review concentrates on irrigated greenbelt areas such as parks and highway medians.

Affected Parties

Greenbelts will generally affect the societal and customer impact categories (see "Distributional Perspectives" in chapter 3). In particular, impacts to greenbelts may include individuals who value open space, green space, and environmental quality; various local and national environmental groups; property owners whose property values might be impacted with changes in greenbelts; and those who use greenbelts for recreational activities. Beneficiaries may thus include many people from beyond the utility's service area.

Qualitative Assessment

It may not be possible or desirable to quantify impacts for a particular category. In these cases, it may be appropriate to qualitatively assess impacts. If benefits were to be qualitatively assessed, a scaling approach may be used to illustrate general magnitudes of benefits. If a −2-to-+2 scale were applied, with a "−2" equal to "large costs" and a "+2" equal to "large benefits," the following definitions may be used (see Figure A.4):

Figure A.4: Scaling of greenbelts qualitative assessment

Large costs	Small costs	No impact	Small benefits	Large benefits
−2	−1	0	+1	+2

- −2 = Large costs: Change to greenbelts will cause large negative impacts that entail costs that are much greater than benefits (if any exist).
- −1 = Small costs: Change to greenbelts will cause minor negative impacts that entail costs that are slightly greater than benefits (if any exist).
- 0 = No impact: Change will not affect greenbelts in any way or will have benefits commensurate with the costs.
- +1 = Small benefits: Change to greenbelts will have a small impact, which will induce benefits that are slightly greater than the costs.
- +2 = Large benefits: Change to greenbelts will have a large impact, which will induce benefits that are significantly greater than the costs.

Quantifying the Outcomes (Identifying Units of Measurement)

Values for greenbelts are often expressed in how they affect property values, with the presence of greenbelts typically increasing nearby property values. Values for greenbelts are also expressed in willingness to pay (WTP)—what households are willing to pay for changes in greenbelt quality or quantity. These values may be expressed in dollars per person or per household and may be given as a one-time payment or per month or year, or even per unit of change (such as percentage increase in greenbelt space or unit change in some index of greenbelt condition).

These values per specified unit of measurement are then applied to the appropriate quantity. For example, if values are cited in dollars per household per year, then one needs to apply the value(s) to the geographically appropriate total number of years (e.g., $10 per household per year for the state of California for 10 years).

Table A.3: Examples of values for greenbelts

Value (June 2004 US$)	Description
3.34% increase in property value if located near a park	Housing prices were found to be higher if they were located next to a park in West Virginia (Burton and Hicks, 2003).
32% increase in property value	Housing prices were found to be higher if they were located next to a greenbelt buffer in Colorado (Correl et al., 1978).
$1,200 per acre ($/year)	This study found that properties in Salem, Oregon that were adjacent to a greenbelt were approximately $1,200 more per acre than those located 1,000 feet away from the greenbelt (Nelson, 1986).
+$41 million ($/year)	A three-mile greenbelt around Lake Merritt, near the city center of Oakland, California, was found to add $41 million to surrounding property values (Darling, 1973).
16%–48% of homeowners would pay more to live near a greenbelt or park	Denver residents that said they would pay more to live near a greenbelt or park increased from 16% in 1980 to 48% in 1990 (NPS, 1995).
5% of selling price of home	Five percent of the selling price of homes near the Cox Arboretum and park in Dayton, Ohio, was attributable to the proximity to the park (Kimmel, 1985).
50% decrease to 23% increase in property value	Impacts to property value ranges greatly depending on the type of park (small basic, medium attractive, . . .) (Owusu-Edusei and Espey, 2003).
23% increase in home value if facing a city park, but −7% for homes facing recreational facilities such as a baseball diamond or field house (due to congestion and noise).	This study used a dummy variable to measure the effects of adjacency to city parks on home values (Weicher and Zerbst, 1973).

Monetizing the Outcomes

Most studies valuing greenbelts examine greenbelt impacts on property values. Evidence in the literature is mixed concerning the impact on property values of proximity to designated greenbelts. While several studies report a positive relationship between greenbelts and property values, some find the opposite. Weicher and Zerbst (1973) found that parks with recreation facilities such as playground equipment and lighted playing fields lowered the value of adjacent homes (perhaps due to noise, lights, and high use).

Some of the studies that have examined values for greenbelts are summarized in Table A.3.

Resources (Where To Look Up Further Information)

Values for greenbelts:

- Environment Canada. Environmental Valuation Resource Inventory (EVRI). http://www.evri.ca.

- U.S. EPA. Environmental Economic Reports Inventory (EERI). http://yosemite.epa.gov/ee/epa/eed.nsf/webpages/EnvironmentalEconomicsReports.html.

A.4 RECREATION: GOLF COURSES

Introduction

People value golf courses for recreation and for the open space they provide in communities and residential developments. Studies have shown that benefits of proximity to a golf course include view, low population density, and greater privacy by virtue of the open space.

Affected Parties

Golf courses will generally affect the societal and customer impact categories (see “Distributional Perspectives” in chapter 3). In particular, impacts to golf courses may include impacts to individuals who value golf for recreation and/or for open space and to property owners whose property values might be impacted with changes in golf courses. Beneficiaries are likely to include many people from beyond the utility’s service area.

Qualitative Assessment

It may not be possible or desirable to quantify impacts for a particular category. In these cases, it may be appropriate to qualitatively assess impacts. If benefits were to be qualitatively assessed, a scaling approach may be used to illustrate general magnitudes of benefits. If a −2-to-+2 scale were applied, with a “−2” equal to “large costs” and a “+2” equal to “large benefits,” the following definitions may be used (see Figure A.5):

Figure A.5: Scaling of scaling of golf course qualitative assessment

Large costs	Small costs	No impact	Small benefits	Large benefits
−2	−1	0	+1	+2

- −2 = Large costs: Change to golf courses will cause large negative impacts that entail costs that are much greater than benefits (if any exist).
- −1 = Small costs: Change to golf courses will cause minor negative impacts that entail costs that are slightly greater than benefits (if any exist).
- 0 = No impact: Change will not affect golf courses in any way or will have benefits commensurate with the costs.
- +1 = Small benefits: Change to golf courses will have a small impact, which will induce benefits that are slightly greater than the costs.
- +2 = Large benefits: Change to golf courses will have a large impact, which will induce benefits that are significantly greater than the costs.

Quantifying the Outcomes (Identifying Units of Measurement)

Values for recreation activities such as golf are most frequently cited in dollars per user activity day. An activity day is the typical amount of time pursuing an activity within a 24-hour period. Other units of measurement for golfing could be expressed per season and per year.

Table A.4: Examples of values for golfing and for golf courses

Value (June 2004 US$)	Description
$25.34 per day	Average consumer surplus per day of golf (Loomis and Crespi, 1999).
7.6% increase in property value	If property is located on a golf course (Do and Grudnitski, 1995).
27% increase in property value	If property is located on a golf course (Owusu-Edusei and Espey, 2003).
4% to 7% increase in property value	If property is near a golf course (Rinehart and Pompe, 1999; Bible and Hsieh, 2001; Asabere and Huffman, 1996; Quang and Grudnitski, 1995).
10% to 50% increase in property value	If property is in a golf course community (SRI).
$13.78-per-sq.-ft increase in property value	If property is located on a golf course (Firth, 1990).

Monetizing the Outcomes

Values for golf courses may be expressed in how they affect property values, with the presence of golf courses typically increasing nearby property values. Several studies have examined values of golf courses. A summary of the available estimates is provided in Table A.4.

Resources (Where To Look Up Further Information)

Values for golf courses:

- Environment Canada. Environmental Valuation Resource Inventory (EVRI). http://www.evri.ca.
- U.S. EPA. Environmental Economic Reports Inventory (EERI). http://yosemite.epa.gov/ee/epa/eed.nsf/webpages/EnvironmentalEconomicsReports.html.

APPENDIX B

ENVIRONMENTAL VALUES

Introduction

Water reuse projects can alter the quality and/or quantity of water in rivers and streams, be used to create wetlands, and can also enhance aquifers. Improved flows and quality in turn can enhance ecosystems by providing better habitat conditions for aquatic, riparian, or terrestrial species. These ecosystem service improvements can generate benefits that include recreational activities and other benefits associated with resource use. These may also include public health values, for example, where improved resource quality is believed by some users to reduce the risk of adverse health effects.

Ecosystem services also generate what is referred to in economics as passive use or nonuse values, which reflect the value individuals place on preserving or enhancing environmental conditions regardless of whether they use them. These are often described as bequest and stewardship values, namely, to reflect human motives to pass a healthy environment to the next generation and to preserve the environment in general. For the purposes of this economic framework, we refer to these ecosystem-services-related nonuse values as "environmental" values, since this term is more transparent for communicating with laypersons.

An important caveat is that, for some of the subcategories provided below, the monetary values provided for some resources, based on the literature review, may contain several categories or types of benefits. That is, these values may in some cases be "total values" that embody the combined benefits that people associate with the resource (e.g., total values reflect both use and nonuse values combined, such as the sum of recreation values plus bequest values). Readers are therefore cautioned about how they interpret and use these values, so that they avoid potential double counting of benefits.

Affected Parties

Environmental impacts will generally affect utility customers and, in many cases, the broader population (e.g., where improved stream conditions may help preserve an endangered species). In particular, environmental changes may impact statewide and society-wide all individuals who value protecting the environment. Thus, stakeholders may include various local and national environmental groups, property owners whose property values might be impacted with changes in local environmental quality, and recreationists such as wildlife viewers and hunters whose activities are impacted with changes in environmental quality. Thus, not only will water agencies and their customers be affected, but individuals and municipal users downstream also are likely to be beneficially affected.

Qualitative Assessment

It may not be possible or desirable to quantify impacts for a particular category. In these cases, it may be appropriate to qualitatively assess impacts. If benefits were to be qualitatively assessed, a scaling approach may be used to illustrate general magnitudes of benefits. If a −2-to-+2 scale were applied, with a "−2" equal to "large costs" and a "+2" equal to "large benefits," the following definitions could be used (see Figure B.1):

Figure B.1: Scaling of environmental qualitative assessment

Large costs	Small costs	No impact	Small benefits	Large benefits
−2	−1	0	+1	+2

- −2 = Large costs: Environmental change will cause large negative impacts on environmental quality that entail costs that are much greater than benefits (if any exist).

- −1 = Small costs: Environmental change will cause minor negative impacts on environmental quality that entail costs that are slightly greater than benefits (if any exist).

- 0 = No impact: Environmental change will not affect environmental quality in any way or will have benefits commensurate with the costs.

- +1 = Small benefits: Environmental change will have a small impact on environmental quality, which will induce benefits that are slightly greater than the costs.

- +2 = Large benefits: Environmental change will have a large impact on environmental quality, which will induce benefits that are significantly greater than the costs.

Quantifying the Outcomes (Identifying Units of Measurement)

See subcategories in Sections B.1 through B.6 below, which address the following environmental resources and impacts:

- Water Quality (B.1)
- Groundwater (B.2)
- Habitat for Threatened and Endangered Species (B.3)
- Habitat (non-T&E species) (B.4)
- Coastal Ecosystems (B.5)
- Wetlands (B.6)

Monetizing the Outcomes

See subcategories in Sections B.1 through B.6 below.

Resources (Where To Look Up Further Information)

See subcategories in sections B.1 through B.6 below.

B.1 WATER QUALITY

Introduction

Water quantity impacts water quality. Increased quantity of water may help protect water quality by diluting wastewater and purifying water naturally (while the reverse holds true for decreased quantities of water). Reduced groundwater extraction can prevent the need to pump groundwater from lower depths, which hold waters of lower quality.

Adequate quantities of water are essential for diluting fertilizers and pesticides that run off from farm fields and wastewater discharges from treatment plants and pollutants in urban stormwater. This dilution ensures that water bodies are not too toxic to fish and are safe for water-based recreation such as boating.

The Clean Water Act requires point sources of pollutants to obtain a National Pollutant Discharge Elimination System (NPDES) permit before pollutants are discharged into U.S. waters. In part, the requirements of individual NPDES permits are based on streamflow. Therefore, treatment costs could be impacted to adjust to the changes in streamflows.

Natural water purification is provided by streamside vegetation and wetlands. Runoff from city streets and agricultural fields contains various pollutants such as oil, pesticides, and fertilizer as well as excess soil. These pollutants are absorbed by plants and broken down by plants and bacteria to less harmful substances. Pollutants attached to suspended soil particles are filtered out by grasses and other plants and deposited in floodplains. This process helps improve water quality. The vegetation and wetlands providing this service all require certain levels of water quantity and quality.

Water quality may also be affected by changes in treatment plant discharges. Reduced treatment plant discharges may positively affect water quality.

Affected Parties

Water quality will generally affect the societal and customer impact categories (see "Distributional Perspectives" in Chapter 3). In particular, impacts to water quality may include individuals who value the environment, various local and national environmental groups, property owners whose property values might be impacted with changes in water quality, and recreationists such as swimmers, boaters, wildlife viewers, and hunters whose activities are enhanced with improved water quality. Also, water customers may be affected (including industrial and agricultural). Downstream water users may also be affected.

Qualitative Assessment

It may not be possible or desirable to quantify impacts for a particular category. In these cases, it may be appropriate to qualitatively assess impacts. If benefits were to be qualitatively assessed, a scaling approach may be used to illustrate general magnitudes of benefits. If a −2-to-+2 scale were applied, with a "−2" equal to "large costs" and a "+2" equal to "large benefits," the following definitions could be used (see Figure B.2):

Figure B.2: Scaling of water quality qualitative assessment

Large costs	Small costs	No impact	Small benefits	Large benefits
−2	−1	0	+1	+2

- −2 = Large costs: Environmental change will cause large negative impacts on water quality that entail costs that are much greater than benefits (if any exist).
- −1 = Small costs: Environmental change will cause minor negative impacts on water quality that entail costs that are slightly greater than benefits (if any exist).
- 0 = No impact: Environmental change will not affect water quality in any way or will have benefits commensurate with the costs.
- +1 = Small benefits: Environmental change will have a small impact on water quality, which will induce benefits that are slightly greater than the costs.
- +2 = Large benefits: Environmental change will have a large impact on water quality, which will induce benefits that are significantly greater than the costs.

Quantifying the Outcomes (Identifying Units of Measurement)

Values for changes in water quality are typically expressed in WTP—what households are willing to pay for the change in water quality. These values may be expressed in dollars per person or per household and may be given as a one-time payment or as a monthly or yearly payment, or even per unit of change (such as a unit change in trophic level or some other index of environmental condition).

These values per specified unit of measurement are then applied to the appropriate geographic scope and time dimension. For example, if a value is cited in dollars per household per year, then one needs to apply the value to the geographically appropriate total number of years that the change will have impacts (e.g., $10 per household per year for the state of California for 10 years). The geographic scope may be as small as a community project affecting only the surrounding community, or a project impacting several counties, or even a larger area such as a state or group of states. The time dimension may range from a short-term project (one or several months) to several years. Some impacts may be perpetual, with unending economic impacts.

Monetizing the Outcomes

Several studies have conducted surveys asking households what they would be willing to pay to protect water resources. A common method is to use a hypothetical referendum, where households are asked if they would vote in favor of a particular resource protection action if it cost them $X. The amount of $X varies across households, so that a demand curve can be traced. From this demand curve, WTP is calculated. WTP values are commonly reported in dollars per year (or per month or other specified period of time) per household. Some WTP values are stated as a one-time payment.

Several studies have examined values for changes in water quality and are summarized in Table B.1. The studies reveal people’s total values for water quality through their associated values for recreation, protection of human health (through drinking water), and protection of ecological services.

Table B.1: Examples of values for water quality

Value (June 2004 US$)	Description	Source
$97.98 per household per year	This is the amount Ohio residents were willing to pay for increased protection of surface water. This value includes residents' value for improved water quality both for improved ecological services and for protection of drinking water.	De Zoysa, 1995
$4.64–$9.58 per household per month	This is the amount Ontario residents were willing to pay for improved water quality in the Grand River watershed both for improved ecological services and for protection of drinking water.	Brox et al., 2003
$15.22–$105.29 one-time payment	Residents of the Pennsylvania portion of the Monongahela River basin revealed the following range in values: (1) $29 to $57.40 for a decline in quality from boatable to unsuitable for any activity; (2) $15.90 to $36.90 for an improvement in quality from boatable to fishable; (3) $8.70 to $18.80 for an improvement in quality from fishable to swimmable; and (4) $25.10 to $60.20 for an improvement from boatable to swimmable.[a]	Desvousges et al., 1987
$60–$81 per household per year	The study estimated the annual WTP for 5 years to improve stream B, Loyalhanna Creek, from current severely polluted status to moderately polluted status.[b]	Farber and Griner, 2000
$231–$238 one-time payment	The study estimated what North Carolina residents were willing to pay for an improvement in water quality from the 1995 (current) degraded level back to the 1981 level.	Huang et al., 1997
$2,564 per unit of trophic state index	The study finds that each unit increase in the trophic state index (with 0 meaning very good and 100 meaning bad) results in a decrease in the parcel selling price.	Feather, 1992

a. A "water quality ladder" is a water quality rating scale that is commonly used in the economic literature. It reflects the ability of a body of water to support a particular designated use (based on its water quality). In this study, using a water quality ladder, respondents were asked to value four scenarios with changes in water quality: (1) degrading water quality from a level where it is suitable for boating (but not for swimming) to a level that is unsuitable for any water-based activities (including boating), (2) improving water quality from boatable to a level where game fish would survive, (3) improving water quality from fishable to swimmable, and (4) improving water quality from boatable to swimmable.

b. Severely polluted streams are incapable of supporting fish and other organisms, and fishing would be poor to nonexistent; moderately polluted streams support some fish but provide poor reproductive conditions for fish, while unpolluted streams are streams where fish and organisms can thrive.

Resources (Where To Look Up Further Information)

Values for environmental services (e.g., water quality):

- Environment Canada. Environmental Valuation Resource Inventory (EVRI). http://www.evri.ca.
- Lew, D. K.; Larson, D. M.; Suenaga, H.; DeSousa, R. The Beneficial Use Values Database. Department of Agricultural and Resource Economics. http://buvd.ucdavis.edu. See April 2001.
- U.S. EPA. Environmental Economic Reports Inventory (EERI). http://yosemite.epa.gov/ee/epa/eed.nsf/webpages/EnvironmentalEconomicsReports.html.

B.2 GROUNDWATER

Introduction

Groundwater systems provide services that may include but are not necessarily limited to (1) providing safe drinking water to a community; (2) supporting aquatic ecosystems through hydrologic interactions with surface waters such as riparian corridors or wetlands; (3) enabling development of overlying land resources for residential, commercial, or other uses; and (4) generating existence, option, and bequest values as a resource left in its "natural" state and being conserved for potential future use by present or future generations.

Changes to instream flows and/or levels of groundwater extraction affect recharge of groundwater, which may impact potential for future extraction, water quality, and salt water intrusion into fresh water aquifers. A reuse-generated increase in stream flows or groundwater recharge may positively affect these aspects, while a decrease may have a negative impact. For example, an increase in groundwater levels may increase future extraction capabilities, improve water quality, and reduce salt water intrusion.

Affected Parties

Groundwater will generally affect the societal and customer impact categories (see "Distributional Perspectives" in Chapter 3). In particular, beneficiaries of increased groundwater recharge may include water districts or industries that have their needs supplied from groundwater, individuals who value an improved environment, various local and national environmental groups, property owners whose property values might increase with improved environmental quality, and recreationists such as wildlife viewers and hunters whose activities are enhanced with improved water quality.

Qualitative Assessment

It may not be possible or desirable to quantify impacts for a particular category. In these cases, it may be appropriate to qualitatively assess impacts. If benefits were to be qualitatively assessed, a scaling approach may be used to illustrate general magnitudes of benefits. If a −2-to-+2 scale were applied, with a "−2" equal to "large costs" and a "+2" equal to "large benefits," the following definitions could be used (see Figure B.3):

Figure B.3: Scaling of groundwater recharge qualitative assessment

Large costs	Small costs	No impact	Small benefits	Large benefits
−2	−1	0	+1	+2

- −2 = Large costs: Environmental change will cause large negative impacts on groundwater that entail costs that are much greater than benefits (if any exist).
- −1 = Small costs: Environmental change will cause minor negative impacts on groundwater that entail costs that are slightly greater than benefits (if any exist).
- 0 = No impact: Environmental change will not affect groundwater in any way or will have benefits commensurate with the costs.

- +1 = Small benefits: Environmental change will have a small impact on groundwater, which will induce benefits that are slightly greater than the costs.

- +2 = Large benefits: Environmental change will have a large impact on groundwater, which will induce benefits that are significantly greater than the costs.

Quantifying the Outcomes (Identifying Units of Measurement)

Values for changes to groundwater are typically expressed in WTP—what households are willing to pay for the change in groundwater. These values may be expressed in dollars per person or per household and may be given as a one-time payment or per month or year or even per unit of change (such as unit change in trophic level or some other index of environmental condition).

Values for changes to groundwater may also be given in a certain dollar amount per volume of water such as per acre-foot or per gallon (or some number of gallons such as 1,000 gallons).

Table B.2 summarizes key studies and their findings. These values per specified unit of measurement are then applied to the appropriate quantity. For example, if values are cited in dollars per household per year, then one needs to apply the value(s) to the geographically appropriate total number of years (e.g., $10 per household per year for the state of California for 10 years).

Table B.2: Examples of values for groundwater

Value (June 2004 US$)	Description	Source
$0.88–$2.72 per 1,000 gallons	Scarcity present values of groundwater in Hawaii, which may reflect values of recharging groundwater sources.[a]	Moncur and Pollock, 1988
$46–$917 per household, per year	Values for ensuring uncontaminated groundwater supplies for the future.	Low: Powell et al., 1994 High: Henglen et al., 1992
$73–$1,507 annually per household	This meta-analysis (of eight studies) examined household WTP for restoration of contaminated groundwater.	Boyle et al., 1994
$2.70–$3.45 annually per household	Passive use values for restoration of contaminated groundwater in Montana (adjusted from total use values of $3.67–$6.10).	Schulze et al., 1993
$66 annually per household	Value reflecting what Ohio residents were willing to pay for increased protection of groundwater.	De Zoysa, 1995

a. For most natural resources, the existence of scarcity and the extent of the scarcity rent can be determined. That portion of the resource price in excess of extraction costs signals scarcity and defines the value of the resource in situ (Moncur and Pollock, 1988).

Monetizing the Outcomes

Several studies have conducted surveys asking households what they would be willing to pay to protect water resources. A common method is to use a hypothetical referendum, where households are asked if they would vote in favor of a particular resource protection action if it cost them $X. The amount of $X varies across households, so that a demand curve can be traced. From this demand curve, WTP is calculated; this is the contingent valuation method. WTP values are commonly reported in dollars per year (or per month or other specified period of time) per household. Some WTP values are stated as a one-time payment.

Resources (Where To Look Up Further Information)

Values for environmental services:

- Environment Canada. Environmental Valuation Resource Inventory (EVRI). http://www.evri.ca.
- Lew, D. K.; Larson, D. M.; Suenaga, H.; DeSousa, R. The Beneficial Use Values Database. Department of Agricultural and Resource Economics. http://buvd.ucdavis.edu. See April 2001.
- U.S. EPA. Environmental Economic Reports Inventory (EERI). http://yosemite.epa.gov/ee/epa/eed.nsf/webpages/EnvironmentalEconomicsReports.html.

B.3 HABITAT FOR THREATENED AND ENDANGERED SPECIES

Introduction

Changes in water quantity (both surface and ground) may impact habitat for threatened or endangered (T&E) species.

Affected Parties

Protection of T&E species will generally affect the societal impact category (see “Distributional Perspectives” in Chapter 3). In particular, beneficiaries of improved habitat for T&E species may include individuals who value biological diversity and various local and national environmental groups.

Qualitative Assessment

It may not be possible or desirable to quantify impacts for a particular category. In these cases, it may be appropriate to qualitatively assess impacts. If benefits were to be qualitatively assessed, a scaling approach may be used to illustrate general magnitudes of benefits. If a −2-to-+2 scale were applied, with a “−2” equal to “large costs” and a “+2” equal to “large benefits,” the following definitions could be used (see Figure B.4):

Figure B.4: Scaling of habitat for T&E species qualitative assessment

Large costs	Small costs	No impact	Small benefits	Large benefits
−2	−1	0	+1	+2

- −2 = Large costs: Environmental change will cause large negative impacts on T&E species that entail costs that are much greater than benefits (if any exist).
- −1 = Small costs: Environmental change will cause minor negative impacts on T&E species that entail costs that are slightly greater than benefits (if any exist).
- 0 = No impact: Environmental change will not affect T&E species in any way or will have benefits commensurate with the costs.
- +1 = Small benefits: Environmental change will have a small impact on T&E species, which will induce benefits that are slightly greater than the costs.
- +2 = Large benefits: Environmental change will have a large impact on T&E species, which will induce benefits that are significantly greater than the costs.

Quantifying the Outcomes (Identifying Units of Measurement)

All of the values listed in this section for changes to T&E species are expressed in WTP—what households are willing to pay for the change in circumstances affecting T&E species. These values may be expressed in dollars per person or per household and may be given as a one-time payment or per month or year or even per unit of change in an indicator (e.g., some index of condition of habitat and population).

Some values may also exist for protection of habitat per area of habitat such as per acre but are not presented here.

These values per specified unit of measurement are then applied to the appropriate quantity. For example, if values are cited in dollars per household per year, then one needs to apply the value(s) to the geographically appropriate total number of years (e.g., $10 per household per year for the state of California for 10 years).

Monetizing the Outcomes

Several studies have conducted surveys asking households what they would be willing to pay to protect water resources. A common method is to use a hypothetical referendum, where households are asked if they would vote in favor of a particular resource protection action if it cost them $X. The amount of $X varies across households, so that a demand curve can be traced. From this demand curve, WTP is calculated; this is the contingent valuation method. WTP values are commonly reported in dollars per year (or per month or other specified period of time) per household. Some WTP values are slated as a one-time payment.

Table B.3 presents examples of values for some aquatic T&E species. These values are for certain species in specified locations, and using these values for direct transfer for use in BT is discouraged but does reflect the range of values obtained in the literature. Refer to the guidance document on use of BT for further information on the process of applying these values to other species and other locations.

Table B.3: Examples of values for aquatic T&E species

Value (June 2004 US$)	Description	Source
$7.25 per household per year	This study found an average state-wide bid of $6.88 (2002 US$) per household to preserve the striped shiner, a state-listed endangered minnow with no direct use value in Wisconsin (the striped shiner is state listed as an endangered species but not listed federally).	Boyle and Bishop, 1987
$10.79 annually per taxpayer[a]	This study found that taxpayers would be willing to pay an average of $10.24 (2002 US$) annually to preserve the federally listed endangered Colorado squawfish in New Mexico.	Cummings et al., 1994
$40–$112 (average of $80) annually per household	This meta-analysis examined WTP values for the protection of Pacific salmon/steelhead.	Loomis and White, 1996
$9–$10 (average of $10) annually per household	This meta-analysis examined WTP values for protection of Atlantic salmon.	Loomis and White, 1996
$9.77 annually per household	This study estimated WTP for protecting instream flows specifically for the silvery minnow on the middle Rio Grande and to protect minimum instream flows on all major New Mexico rivers to protect 11 total listed fish species.	Berrens et al., 1996

a. More than one taxpayer may reside per household.

Resources (Where To Look Up Further Information)

Values for environmental services:

- Environment Canada. Environmental Valuation Resource Inventory (EVRI). http://www.evri.ca.

- Lew, D. K.; Larson, D. M.; Suenaga, H.; DeSousa, R. The Beneficial Use Values Database. Department of Agricultural and Resource Economics. http://buvd.ucdavis.edu. See April 2001.

- U.S. EPA. Environmental Economic Reports Inventory (EERI). http://yosemite.epa.gov/ee/epa/eed.nsf/webpages/EnvironmentalEconomicsReports.html.

B.4 HABITAT (NON-T&E SPECIES)

Introduction

Changes in water quantity (both surface and ground) may impact habitat for numerous aquatic and riparian species (not necessarily T&E species).

Affected Parties

Beneficiaries of protected or improved habitats may include individuals who value a protected or improved environment, various local and national environmental groups, and recreationists such as wildlife viewers and hunters whose activities are enhanced with improved water quality. Many beneficiaries (perhaps a large majority) may reside outside the water agency's service area.

Qualitative Assessment

It may not be possible or desirable to quantify impacts for a particular category. In these cases, it may be appropriate to qualitatively assess impacts. If benefits were to be qualitatively assessed, a scaling approach may be used to illustrate general magnitudes of benefits. If a −2-to-+2 scale were applied, with a "−2" equal to "large costs" and a "+2" equal to "large benefits," the following definitions could be used (see Figure B.5):

Figure B.5: Scaling of habitat qualitative assessment

Large costs	Small costs	No impact	Small benefits	Large benefits
–2	–1	0	+1	+2

- −2 = Large costs: Environmental change will cause large negative impacts on habitat that entail costs that are much greater than benefits (if any exist).
- −1 = Small costs: Environmental change will cause minor negative impacts on habitat that entail costs that are slightly greater than benefits (if any exist).
- 0 = No impact: Environmental change will not affect habitat in any way or will have benefits commensurate with the costs.
- +1 = Small benefits: Environmental change will have a small impact on habitat, which will induce benefits that are slightly greater than the costs.
- +2 = Large benefits: Environmental change will have a large impact on habitat, which will induce benefits that are significantly greater than the costs.

Quantifying the Outcomes (Identifying Units of Measurement)

Values for changes to habitat are typically expressed in WTP—what households are willing to pay for the change in habitat. These values may be expressed in dollars per person or per household and may be given as a one-time payment or per month or year or even per unit of change (such as unit change in trophic level or some other index of environmental condition).

Values for changes to habitat may also be given in a certain dollar amount per area of habitat such as per acre or per volume of water needed to support habitat such as per acre-foot or per gallon (or some number of gallons such as 1,000 gallons).

These values per specified unit of measurement are then applied to the appropriate quantity. For example, if values are cited in dollars per household per year, then one needs to apply the value(s) to the geographically appropriate total number of years (e.g., $10 per household per year for the state of California for 10 years).

Monetizing the Outcomes

Several studies have conducted surveys asking households what they would be willing to pay to protect water resources. A common method is to use a hypothetical referendum, where households are asked if they would vote in favor of a particular resource protection action if it cost them $X. The amount of $X varies across households, so that a demand curve can be traced. From this demand curve, WTP is calculated; this is the contingent valuation method. WTP values are commonly reported in dollars per year (or per month or other specified period of time) per household. Some WTP values are stated as a one-time payment.

Table B.4 presents a few values observed in the literature for impacts to habitat from changes in water quality or quantity.

Table B.4: Examples of values of water for habitat

Value (June 2004 US$)	Description	Source
$29–$120 per person annually	Value is marginal WTP for improved water quality to protect the estuarine habitat of the Albemarle-Pamlico Estuarine System of North Carolina.	Whitehead et al., 1995
$158–$386 per household annually	Value is what California households would be willing to pay to protect Mono Lake water supply in California by providing water for fish, birds, and other parts of the Mono Lake ecosystem.	Loomis, 1987
$85–$620 per acre foot (average of $221/AF)	This is the average price of a water right purchased for instream uses in the Pacific Northwest to protect habitat and other ecological services.[a]	Low: Rigby, 1997 Average: Landry, 1998 High: OWT, 1998

a. This value is an average sales price and does not reflect the value of the numerous ecological services provided by instream flows; it is believed to be an underestimate of true value.

Resources (Where To Look Up Further Information)

Values for environmental services:

- Environment Canada. Environmental Valuation Resource Inventory (EVRI). http://www.evri.ca.
- Lew, D. K.; Larson, D. M.; Suenaga, H.; DeSousa, R. The Beneficial Use Values Database. Department of Agricultural and Resource Economics. http://buvd.ucdavis.edu. See April 2001.

- U.S. EPA. Environmental Economic Reports Inventory (EERI). http://yosemite.epa.gov/ee/epa/eed.nsf/webpages/EnvironmentalEconomicsReports.html.

B.5 COASTAL ECOSYSTEMS

Introduction

Adequate flows of fresh water are critical to coastal and estuarine resources as well as all of the economic activities associated with these resources. At some point in its life cycle, approximately 95% of marine life "depends on the wide range of salinities and abundant food and shelter provided by bays and estuaries. [T]he health of our bays and marine life in our oceans is intrinsically linked to adequate freshwater flowing from our rivers to the bays" (TCPS, 2002).

Affected Parties

Beneficiaries of protected or improved coastal ecosystems may include individuals who value a protected or improved environment, various local and national environmental groups, and recreationists such as wildlife viewers and hunters whose activities are enhanced with improved coastal ecosystems. Many beneficiaries (perhaps most) will reside outside the water agency's service area.

Qualitative Assessment

It may not be possible or desirable to quantify impacts for a particular category. In these cases, it may be appropriate to qualitatively assess impacts. If benefits were to be qualitatively assessed, a scaling approach may be used to illustrate general magnitudes of benefits. If a −2-to-+2 scale were applied, with a "−2" equal to "large costs" and a "+2" equal to "large benefits," the following definitions could be used (see Figure B.6):

Figure B.6: Scaling of coastal ecosystems qualitative assessment

Large costs	Small costs	No impact	Small benefits	Large benefits
−2	−1	0	+1	+2

- −2 = Large costs: Environmental change will cause large negative impacts on coastal ecosystems that entail costs that are much greater than benefits (if any exist).
- −1 = Small costs: Environmental change will cause minor negative impacts on coastal ecosystems that entail costs that are slightly greater than benefits (if any exist).
- 0 = No impact: Environmental change will not affect coastal ecosystems in any way or will have benefits commensurate with the costs.
- +1 = Small benefits: Environmental change will have a small impact on coastal ecosystems, which will induce benefits that are slightly greater than the costs.
- +2 = Large benefits: Environmental change will have a large impact on coastal ecosystems, which will induce benefits that are significantly greater than the costs.

Quantifying the Outcomes (Identifying Units of Measurement)

Values for changes to coastal ecosystems are typically expressed in WTP—what households are willing to pay for the change in coastal ecosystems. These values may be expressed in dollars per person or per household and may be given as a one-time payment or per month or year or even per unit of change (such as unit change in trophic level or some other index of environmental condition).

Values for changes to coastal ecosystems may also be given in a certain dollar amount per acre or per volume of water needed to support coastal ecosystems services, such as per acre-foot or per gallon (or some number of gallons such as 1,000 gallons).

These values per specified unit of measurement are then applied to the appropriate quantity. For example, if values are cited in dollars per household per year, then one needs to apply the value(s) to the geographically appropriate total number of years (e.g., $10 per household per year for the state of California for 10 years).

Monetizing the Outcomes

Several studies have conducted surveys asking households what they would be willing to pay to protect water resources. Several studies are summarized in Table B.5. A common method is to use a hypothetical referendum, where households are asked if they would vote in favor of a particular resource protection action if it cost them $X. The amount of $X varies across households, so that a demand curve can be traced. From this demand curve, WTP is calculated; this is the contingent valuation method. WTP values are commonly reported in dollars per year (or per month or other specified period of time) per household. Some WTP values are stated as a one-time payment.

Table B.5: Examples of values of coastal ecosystems

Value (June 2004 US$)	Description	Source
$29–$120 per person per year	Value is marginal WTP for improved water quality to protect the estuarine system of the Albemarle-Pamlico Estuarine System of North Carolina.	Whitehead et al., 1995
$17 per household (one-time payment)	Existence (intrinsic) value component of mean household WTP ($33.35) for beach maintenance along the north shore of metropolitan Chicago.	Croke et al., 1987
$111 per household per year	The existence value component of mean household annual WTP to raise the water quality of the coastal ponds in Martha's Vineyard, Massachusetts, so that shellfishing could be done year-round.	Kaoru, 1993

Disrupting freshwater flows into bays and estuaries could have tremendous impacts on the coastal economy, directly affecting commercial and recreational fisheries and other nature-based tourism activities. In Georgia, the Center for a Sustainable Coast has argued that reduced streamflows into coastal and estuarine areas could have significant adverse impacts on "fisheries and nature-based tourism activities, worth at least $1 billion annually, and supporting some 40,000 jobs" (Kyler, 2001). Similar adverse impacts, particularly on the production of oysters, could occur in Apalachicola Bay, Florida, if freshwater inflows are reduced (Christensen et al., 1998).

Resources (Where To Look Up Further Information)

Values for environmental services:

- Environment Canada. Environmental Valuation Resource Inventory (EVRI). http://www.evri.ca/.

- Lew, D. K.; Larson, D. M.; Suenaga, H.; DeSousa, R. The Beneficial Use Values Database. Department of Agricultural and Resource Economics. http://buvd.ucdavis.edu. See April 2001.

- U.S. EPA. Environmental Economic Reports Inventory (EERI). http://yosemite.epa.gov/ee/epa/eed.nsf/webpages/EnvironmentalEconomicsReports.html.

B.6 WETLANDS

Introduction

Changes to instream flows or groundwater levels may affect hydrologically connected wetlands. Changes in wastewater discharges may affect wetlands that are dependent on those discharges, and changes in salt water discharges may affect salt marsh wetlands. In addition, reuse water may be used to create or restore wetlands.

Affected Parties

Impacts to wetlands will generally affect the societal impact category (see “Distributional Perspectives” in Chapter 3). In particular, beneficiaries of protected or improved wetlands may include individuals who value a protected or improved environment, various local and national environmental groups, and recreationists such as wildlife viewers and hunters whose activities are enhanced with improved wetlands. Many beneficiaries will probably reside outside the utility’s service area.

Qualitative Assessment

It may not be possible or desirable to quantify impacts for a particular category. In these cases, it may be appropriate to qualitatively assess impacts. If benefits were to be qualitatively assessed, a scaling approach may be used to illustrate general magnitudes of benefits. If a −2-to-+2 scale were applied, with a “−2” equal to “large costs” and a “+2” equal to “large benefits,” the following definitions could be used (see Figure B.7):

Figure B.7: Scaling of wetlands assessment

Large costs	Small costs	No impact	Small benefits	Large benefits
−2	−1	0	+1	+2

- −2 = Large costs: Environmental change will cause large negative impacts on wetlands that entail costs that are much greater than benefits (if any exist).
- −1 = Small costs: Environmental change will cause minor negative impacts on wetlands that entail costs that are slightly greater than benefits (if any exist).
- 0 = No impact: Environmental change will not affect wetlands in any way or will have benefits commensurate with the costs.
- +1 = Small benefits: Environmental change will have a small impact on wetlands, which will induce benefits that are slightly greater than the costs.
- +2 = Large benefits: Environmental change will have a large impact on wetlands, which will induce benefits that are significantly greater than the costs.

Quantifying the Outcomes (Identifying Units of Measurement)

Values for changes to wetlands are typically expressed in WTP—what households are willing to pay for the change occurring to wetlands. These values may be expressed in dollars per person or per household and may be given as a one-time payment or per month or year or even per unit of change (such as a change in some index of wetland condition).

Values for changes to wetlands may also be given in a certain dollar amount per area of wetlands such as per acre or per volume of water needed to support wetlands such as per acre-foot or per gallon (or some number of gallons such as 1,000 gallons).

These values per specified unit of measurement are then applied to the appropriate quantity. For example, if values are cited in dollars per household per year, then one needs to apply the value(s) to the geographically appropriate total number of years (e.g., $10 per household per year for the state of California for 10 years).

Monetizing the Outcomes

Several studies have conducted surveys asking households what they would be willing to pay for protection of water resources. A common method is to use a hypothetical referendum, where households are asked if they would vote in favor of a particular resource protection action if it cost them $X. The amount of $X varies across households, so that a demand curve can be traced. From this demand curve, WTP is calculated; this is the contingent valuation method. WTP values are commonly reported in dollars per year (or per month or other specified period of time) per household. Some WTP values are stated as a one-time payment. Tables B.6 and B.7 present some values observed in the literature for impacts to wetlands from changes in water quality or quantity.

Table B.6: Examples of values of wetlands

Value (June 2004 US$)	Description	Source
$12,496 per wetland acre	Using a discount rate of 3%, this study estimated that present values per wetland acre are commercial fishery = $846; trapping = $401; recreation = $181; storm protection = $7,549; total of these values = $8,977/acre (1983).	Costanza et al., 1989
$66 annually per household	This study examined what Ohio residents were willing to pay for increased protection of wetlands of the Maumee River and Western Lake Erie basins in Ohio.	De Zoysa, 1995
$9–$34 per household per year	This study estimated WTP for wetland preservation benefits in western Kentucky.	Dalecki et al., 1993
$1,238 per acre per year for 30 years ($339,298 per acre over 15 years)	This study estimated economic benefits of wetlands for wastewater treatment use in terms of savings over conventional wastewater treatment methods.	Breaux et al., 1995
$7 and $24 annually per household	This study estimated WTP for preserving the Clear Creek wetland in western Kentucky.	Whitehead and Bloomquist, 1991
$150–$2,391 per acre, lump sum	Values reflect the range of restoring wetlands from croplands by estimating easement costs, restoration costs, and the present discounted value of perpetual crop production.	Heimlich, 1994
$94–$146 annually per respondent	Values reflect what respondents are willing to pay for protection of wetlands in New England.	Stevens et al., 1995
$50 annually per household	This study is a meta-analysis of 30 studies. The largest mean WTP by wetland function was in terms of flood control ($75), with the smallest for water generation ($18).	Brouwer et al., 1997
$585–$10,524 per acre for residents of the drainage basin and from $8,418–$71,507 across the state of Michigan	The study estimated wetland benefits for Saginaw Bay, Michigan.	Cangelosi et al., 2001
$4–$1,670 per acre annually	The predicted values per acre of single-service wetlands range from $4 for presence of amenities to $1,670 for presence of birdwatching opportunities, with most services having predicted values in the $275–$550 range (see Table B.7 for breakdown of all values).	Woodward and Wui, 2001

Table B.7: Per-acre annual values of wetland services

Service	Mean value per acre[a] (June 2004 US$)
Flood	$542
Quality	$575
Quantity	$175
Recreational fishing	$492
Commercial fishing	$1,072
Bird hunting	$96
Bird watching	$1,670
Amenity	$4
Habitat	$422
Storm	$327

a. The predicted values are obtained at the means of year and acre variables. It must be emphasized that the values do not represent marginal values and cannot be summed to obtain the value of multiple-function wetlands. Source: Woodward and Wui, 2001.

Resources (Where To Look Up Further Information)

Values for wetlands:

- Bardecki, M. J. *Wetlands and Economics: An Annotated Review of the Literature, 1988−1998*; Environment Canada: Ottawa, Ontario, Canada, 1998.

- Environment Canada. Environmental Valuation Resource Inventory (EVRI). http://www.evri.ca.

- Lew, D. K.; Larson, D. M.; Suenaga, H.; DeSousa, R. The Beneficial Use Values Database. Department of Agricultural and Resource Economics. http://buvd.ucdavis.edu. See April 2001.

- U.S. EPA. Environmental Economic Reports Inventory (EERI). http://yosemite.epa.gov/ee/epa/eed.nsf/webpages/EnvironmentalEconomicsReports.html.

APPENDIX C

CULTURAL AND AESTHETIC VALUES

Introduction

Water with cultural or aesthetic value has an emotional, spiritual, or sensory appeal. Waters can be used for cultural and religious purposes such as spiritual and ceremonial uses. Water and water features also provide sensory pleasure and psychologically soothing benefits, such as when used for aesthetic water fountains (for both visual and sonic effects), reflecting pools, and other community or art exhibits. Some water sources such as waterways also have historical values that are considered "cultural" as well or become a focal point for a community's identity and activities (e.g., restaurants, shops, theaters, and other attractions are often located in conjunction with a waterway).

Water fountains: Humans have appreciated water fountains for centuries. Water fountains today are designed and installed for a variety of purposes, including to create a pleasing visual and auditory effect, to attract attention, to cool an area, and to mitigate noise.

Spiritual and ceremonial water: Many cultures have spiritual relationships with the natural environment and the use of natural resources, especially water. Water soothes and relaxes, inspires reflection, is a source of beauty, and has spiritual qualities recognized in religion and ritual, from baptism to death (Gelt). Many Native Americans honor rain and other forms of water as a gift bestowed to humans. Some of their ceremonies pay respect to water and use water.

Beneficiaries

Cultural and aesthetic values will generally affect the customers of the water agency (i.e., residents who live or work near areas graced by reuse-enabled water features). However, commuters and other visitors to the area may also benefit. The beneficiaries of water used for cultural purposes include those who experience the appealing attributes of fountains (noise mitigation, cooling effects, and pleasing visual effects) or use the appealing attributes of fountains to attract attention (e.g., for advertising). Other beneficiaries include those who use water for ceremonial or religious purposes.

Qualitative Assessment

It may not be possible or desirable to quantify impacts for a particular category. In those cases, it may be appropriate to qualitatively assess impacts.

If benefits were to be qualitatively assessed, a scaling approach may be used to illustrate general magnitudes of benefits. If a −2-to-+2 scale were applied, with a "−2" equal to "large costs" and a "+2" equal to "large benefits," the following definitions could be used (see Figure C.1):

Figure C.1: Scaling of cultural benefits

Large costs	Small costs	No impact	Small benefits	Large benefits
-2	-1	0	+1	+2

- −2 = Large costs: Change in water quality or quantity will entail large negative cultural impacts. Costs of change far outweigh benefits (if any exist).
- −1 = Small costs: Change in water quality or quantity will cause minor negative cultural impacts. Costs of change are slightly greater than benefits (if any exist).
- 0 = No impact: Change in water quality or quantity will not have any cultural impacts or will have benefits commensurate with the costs.
- +1 = Small benefits: Change in water quality or quantity will have a small positive cultural impact. Benefits will slightly outweigh the costs.
- +2 = Large benefits: Change in water quality or quantity will have a large positive cultural impact. Benefits will significantly outweigh the costs.

Quantifying the Outcomes (Identifying Units of Measurement)

It is especially difficult to quantify the aesthetic, spiritual, and historical attributes associated with water. These water uses do not generally have dollar values associated with them because they are not traded in the marketplace. They are not relatively large uses of water (in terms of volume of water, compared to such sectors as drinking and irrigation) and thus have not been heavily studied. However, units of measurement could be described in terms of changes in temperature for cooling effects and perhaps decibels for increases in noise mitigation.

Monetizing the Outcomes

Estimates of values of water for aesthetic or cultural use have not been identified. However, values could exist for mitigating noise, cooling effect, pleasing visuals (useful in advertising and increasing property values), and religious and ceremonial purposes. Treatment and replacement costs can be examined (e.g., the cost of replacing the water used in these various practices); however, costs are typically underestimates of the true value. For example, one may examine the extra costs incurred by the City of Albuquerque to treat the water to a standard acceptable to the Pueblo (Southwest Regional Assessment Group), but the Pueblo might value its water—used for religious purposes—at amounts far larger than the cost. While it is straightforward to identify the ways in which waters are incorporated into our culture, unfortunately, there is very little empirical research currently available on the monetary value of water for cultural uses.

Resources (Where To Look Up Further Information)

Gelt, J. Fountains—Water Wasters or Works of Art? http://ag.arizona.edu/AZWATER/arroyo/073fount.html.

Southwest Regional Assessment Group. Preparing for a Changing Climate: The Potential Consequences of Climate Variability and Change. Southwest. Prepared for the U.S. Global Change Research Program. http://www.ispe.arizona.edu/research/swassess/report.html.

U.S. EPA. Spokane Tribe of Indians Surface Water Quality Standards. Resolution 2003-259. U.S. Environmental Protection Agency. http://www.epa.gov/waterscience/standards/wqslibrary/tribes/spokane.pdf.

Crosswalk to Other Benefit Categories

Water fountains, ponds, and other water features are attractions that may also exert local economic impacts by increasing business to an area or increasing property values. Large fountains are frequently used to attract attention to residential developments.

APPENDIX D

RELIABILITY

Introduction

Using recycled water instead of surface water or groundwater has implications for the reliability of water supplied to customers. Recycled municipal wastewater is generally considered a "drought-proof" supply. Customers have generally been shown to be willing to pay for decreases of the probability that their water supply will be interrupted in times of drought.

Affected Parties

Reliability will generally affect the societal and customer impact categories (see "Distributional Perspectives" in chapter 3). Residential and commercial/industrial customers seem to value supply reliability quite highly, as indicated by the literature.

Qualitative Assessment

It may not be possible or desirable to quantify impacts for a particular category. In those cases, it may be appropriate to qualitatively assess impacts. If benefits were to be qualitatively assessed, a scaling approach may be used to illustrate general magnitudes of benefits. If a −2-to-+2 scale were applied, with a "−2" equal to "large costs" and a "+2" equal to "large benefits," the following definitions could be used (see Figure D.1):

Figure D.1: Scaling of reliability benefits

Large costs	Small costs	No impact	Small benef its	Large benefits
−2	−1	0	+1	+2

- −2 = Large costs: Change in water quality or quantity will entail large negative impacts on reliability. Costs of change far outweigh benefits (if any exist).
- −1 = Small costs: Change in water quality or quantity will cause minor negative impacts on reliability. Costs of change are slightly greater than benefits (if any exist).
- 0 = No impact: Change in water quality or quantity will not affect reliability in any way or will have benefits commensurate with the costs.
- +1 = Small benefits: Change in water quality or quantity will have a small positive impact on reliability. Benefits will slightly outweigh the costs.
- +2 = Large benefits: Change in water quality or quantity will have a large positive impact on reliability. Benefits will significantly outweigh the costs.

Quantifying the Outcomes (Identifying Units of Measurement)

Values for reliability are often given in dollars per household per year for stated preference studies and in dollars per acre-foot (AF) (or similar measure of water volume) for revealed preference studies. These values per specified unit of measurement should then be applied to the appropriate quantity. If values are cited per household per year, then one needs to apply this value to the geographically appropriate total number of households.

Monetizing the Outcomes

Although interest in water supply reliability is increasing, few studies have directly attempted to quantify its value. The studies that have attempted to quantify the value of reliability used "stated preference" and "revealed preference" methods to examine reliability values for residential customers. Stated preference methods determine estimates for reliability on the analysis of responses to hypothetical choices in surveys. Revealed preference infers the value of reliability from data obtained from choices and decisions made in the marketplace. For example, expenditures made to obtain higher levels of reliability (i.e., to avert potential shortages) sometimes can be used to infer the value of reliability.

Stated Preference Studies

A few studies have determined values of water supply reliability using the stated preference method. Values for reliability are usually defined as WTP to avoid a particular shortfall event. Water supply shortfall events are usually defined in different ways across studies. Factors that may be used to describe a shortfall event include the percentage of water available compared to the amount fully demanded (the shortfall amount), the frequency with which this condition may occur (e.g., once in 10 years), and the probability of a single event. In other studies, respondents are questioned on their WTP to reduce the probability of an event, not avoid it.

- In 1987, a contingent valuation study was conducted for the Metropolitan Water District (MWD) of Southern California in an effort to determine the economic value for changes in the reliability of water supply among residents in Southern and Northern California. A reliable water supply is defined in the paper as "one without the threat of periodic shortages and mandatory rationing" (Carson and Mitchell, 1987, p. 1). In the study, four scenarios of reductions in reliability are investigated and households' WTP to alleviate the threat of those reductions in reliability is determined. Reductions in reliability are defined in terms of magnitude and frequency.

- In 1993, the California Urban Water Agencies (CUWA) hired Barakat and Chamberlin, Inc. to design, conduct, and analyze the results of a contingent valuation survey to estimate the value to residential users of water supply reliability in 10 California water districts. More specifically, they sought to estimate how much residents are willing to pay to avoid water shortages of varying magnitude and frequency. Shortage magnitudes ranged from 10 to 50%, and frequencies ranged from once every 3 years to once every 30 years.

- Griffin and Mjelde (2000) conducted a stated preference study in seven Texas cities. Their first objective was to investigate the value of current water supply shortfalls (existing shortages of known strength and duration). Second, the study attempted to determine the value of future shortfalls, probabilistic shortages of differing strength duration and frequency.

- A study conducted by Howe and Smith (1994) attempts to formulate a framework for determining the optimal level of water supply reliability. The study uses contingent valuation survey methods to measure customers' WTP for improved reliability and willingness to accept (WTA) lower water costs for reduced reliability.

- Michelsen et al. (1998) estimated the annual WTP for avoiding a 5% reduction in water consumption levels for several Southwestern cities. WTP was $321 per household for Albuquerque, $330 per household for El Paso, and $257 per household for Las Cruces.

Table D.1 summarizes the results of these studies. The studies are unique to each location and situation, and it is probably ill advised to use any single value for the transfer of benefits to other situations. However, it appears the majority of households value water supply reliability in excess of $100 per year, and the values given below may help to formulate a range of possible values that could be used to transfer benefits.

Limitations to Stated Preference Studies

While stated preference approaches have been applied to the valuation of nonmarket goods for many years, the method has limitations that need to be acknowledged and considered. For example, Griffin and Mjelde (2000) note that one difficulty with stated preference studies for water reliability is the notion of the "birthright" perspective. It is not uncommon for respondents to view water as an inalienable right. Consequently, while they highly value water reliability, the notion that water should be free can lead to a reduction in their stated WTP for reliability. However, if the limitations are acknowledged and efforts are made to perform the studies in an appropriate manner, stated preference studies can yield informative results.

Drawing Inferences about the Reliability Value for Residential Water[1]

Despite the body of empirical research reviewed in the preceding section regarding water reliability values, there is a general lack of direct empirical evidence about how much residential customers of water utilities value the water they receive on a per-AF (or per-1,000 gallon) basis. This leaves open the key question of "how much are households willing to pay for the water provided by their community water system?" In this section, the research team applies a series of simple assumptions to interpret the available empirical evidence on reliability values in a manner that provides some insight on the more basic issue of the WTP for reliable deliveries of residential water. In addition, the few studies that directly estimate WTP for residential water are reviewed.

1. This text is based on work developed for and provided in an AWWA Research Foundation report on the value of water (Raucher et al., 2005).

Table D.1: Summary table of reliability results from stated preference studies (2003 US$)

Source	Shortfall amount	Frequency	Probability	Annual WTP/ household
Carson and Mitchell, 1987	10% to 15%	1 in 5 yrs	20%	$135
Carson and Mitchell, 1987	10% to 15%	2 in 5 yrs	10%	$248
CUWA	20%	1 in 30 yrs	3.3%	$143
Carson and Mitchell, 1987	30% to 35%	1 in 5 yrs	20%	$186
Carson and Mitchell, 1987	30% to 35%	2 in 5 yrs	10%	$421
CUWA	50%	1 in 10 yrs	5%	$253
Griffin and Mjelde, 2000	Na[a]	Na	Na	$109
Griffin and Mjelde, 2000	Na	Na	Na	$125
Howe and Smith, 1994[b]	0.16% to 9.2%[c]	Na	Na	$80[d]
Howe and Smith, 1994	0.23% to 12.2%[c]	Na	Na	$92[e]

a. Na = not applicable.

b. Howe and Smith (1994) also estimated WTA values for decreases in reliability. Mean annual WTA results per household for approximately a 0.7% to 11% decrease in reliability, depending on the city, ranged from $68 to $166. Mean annual WTA results for approximately a 1.7% to 40% decrease in reliability, depending on the city, ranged from $81 to $241.

c. This percentage range does not represent the magnitude of the shortfall, as is the case in the other studies. Rather, this range represents the increased probability over the base probabilities of the SASE. The actual percentage increase is dependent on the city. The associated dollar values are the annual WTP per respondent for an increase over their current reliability.

d. Value represents the average of the WTP range given in the study ($70 to $90 per year). If "no" respondents for this increased probability range are included in the data set (respondents' WTP = $0), the WTP range is from $16/year to $28/year per respondent.

e. Value represents the average of the WTP range given in the study ($64 to $119 per year). If "no" respondents for this increased probability range are included in the data set, the WTP range is from $15/year to $29/year per respondent.

For example, Griffin and Mjelde (2000) evaluated a "current shortfall" scenario of 20% lasting for 3 weeks. To estimate how much water is at stake in this scenario, consider that the average U.S. household uses approximately 0.5 AF per year (172 gallons per capita per day [based on Mayer et al., 1999], times 2.6 persons per household, times 365 days per year, which equals over 163,000 gallons per household per year or about 50% of the 325,850 gallons in an AF). The shortfall scenario used by Griffin and Mjelde thus may amount to about 0.0058 AF of water (3 weeks out of 52 weeks being 5.77% of the year, times a 20% shortfall, times 0.5 AF per year, which equals 0.0058 AF). Given the estimated WTP to avoid such a shortfall was $32.04 per household per year, the implied value per at-risk AF is $5,553 ($32.04 divided by 0.00577 AF).

Several caveats are required in evaluating a value estimate derived from this process. First, the assumptions applied to estimate the volume of water at stake might be in error. For example, if the water shortfall occurred in summer (which is likely), and the water use in summer is 2.4 times higher than in winter (the ratio of typical total use to indoor use only, as per Mayer et al., 1999), then the implied quantity of the water shortfall is understated. If the outdoor water use season in California (the study location) is assumed to be roughly one-half the year, then the 0.5 AF used per home per year comprises roughly 0.15 AF used in the winter months and 0.35 AF per household used in the six months in which outdoor irrigation occurs. The 3-week shortfall of 20% is thus equivalent to 0.008 AF (3 of 26 weeks of the outdoor watering season, times 20%, times 0.35 AF). Then the implied residential customer WTP is $4,005 per AF ($32.04 divided by 0.008 AF).

Second, the reliability-based WTP values obtained by the original researchers reflect not just the value of the water per se but also some degree of the residential customers' aversion to risk and uncertainty. In other words, the WTP values from the reliability studies undoubtedly embody some risk avoidance premium as well as the value held for the quantity of water at risk. This implies that the inferred WTP estimate would overstate the value of the water alone. This may be particularly true for the studies that value eliminating the risk of shortfalls rather than reducing their likelihood or severity.

Third, the WTP estimates reflect values at the margin for the households' lowest valued current uses of the water (e.g., a portion of their outdoor irrigation). As more and more water is withheld from the households, the water uses that would be affected would be of increasing importance and value to the residential customers. Therefore, the WTP estimates inferred above might be understated compared to the WTP for water used for more highly valued purposes in the home (e.g., drinking and cleaning).

Finally, the reliability estimates we are interpreting are based on stated preference surveys of households. Given the hypothetical nature of some of the survey questions and the difficulty some respondents may have had with probability-based scenarios of water shortfalls and reliability, it may be the case that the results from the original research are skewed in one direction or the other.

Based on the above caveats, the values derived here need to be interpreted with considerable caution. There are reasons why the estimates may be under- or overstated relative to the true WTP of households for utility-supplied water. With these caveats in mind, by applying the general assumptions and procedures described above to the applicable reliability value estimates, the following illustrative WTP estimates for reliability of residential water are inferred:

- Griffin and Mjelde (2000)'s current shortfall scenario implies a WTP for residential water on the order of $4,005 per AF.
- Carson and Mitchell (1987)'s scenarios for the MWD imply a possible WTP for residential water of between $4,675 and $7,714 per AF.
- The Barakat and Chamberlin study for CUWA implies a possible WTP of over $14,500 per AF.

As noted, these value estimates may be overstated for water use at the margin (i.e., for modest cutbacks in current outdoor uses) for reasons described above. In particular, the results based on Carson and Mitchell (1987) and CUWA may be overstated because they are based on certainty equivalents of eliminating future shortfalls. However, these estimates may be on target, or possibly understated, for more essential water uses.

Revealed Preference and Cost-Based Studies

A few studies have used the revealed preference method to determine values for water supply reliability.

- Fisher et al. (1995) explored how price can be used as a tool to reduce demand during a drought. By using estimated price elasticities for residential customers, the loss of surplus was computed with a price-induced cutback of 25% in consumption in California's East Bay Municipal Utility District (EBMUD) service area.

- In 2002, the California Recycled Water Task Force was established to investigate specific recycled water issues. The economic group of the task force was charged with identifying economic impediments to enhancing water recycling statewide. The report uses a case study of the Ground Water Replenishment System (GWRS) in Orange County as an illustration for the importance of economic feasibility analysis. The GWRS was designed to recycle an estimated 70,000 AF of effluent per year and inject it into the Orange County Aquifer.

- Varga (1991) investigated the role of local projects and programs in the City of San Diego to enhance imported water supply and improve reliability. The MWD provides water to San Diego from the Colorado River and Northern California, based on availability. To encourage the use of existing local reservoir capacities and improve the reliability and yield of the imported water system, the MWD and California introduced water rate credits for serviced cities.

- Thomas and Rodrigo (1996) measured the benefits of nontraditional water resource investments. The focus of the study was on the MWD and its member agencies. They investigated the benefits (expected yields and cost savings) of developing additional resources in the region through several alternatives: increased imported supplies (base case), the addition of significant conjunctive storage of local groundwater basins (groundwater case), and the implementation of recycled water and groundwater recovery projects (preferred case). To determine the value of recycled water and conjunctive use storage, the savings attributable to each of these resources were compared to the yield associated with the resource.

An overview of the value of reliability inferred from results of revealed preference and cost-based approaches is provided in Table D.2.

Table D.2: Water supply reliability values inferred from revealed preference or cost and price differential results (2003 US$/AF)

Source	Value ($/AF)	Basis
Fisher et al., 1995	$51 to $230	Welfare loss per AF due to a price-induced reduction in water consumption of 25%
Recycled Water Task Force, 2002	$179 to $256	The value (AF/year) of drought proofing based on drought penalties and rate increases for customer
NRC, 1997	$331	The difference in cost of local groundwater supplies versus the MWD noninterruptible rate (AF/year)
Varga, 1991	$60	The rate per AF that MWD credits to local water retailers to store imported water in the local reservoir in order to increase reliability of imported supplies (AF/year)
Varga, 1991	$111	The rate per AF that MWD credits local water retailers to seasonally store imported water to increase capacity and yield of imported water system (AF/year)
Thomas and Rodrigo, 1996	$353	The benefit per AF of conjunctive use storage to ensure greater reliability

Resources (Where To Look Up Further Information)

Reliability values:

- Environment Canada. Environmental Valuation Resource Inventory (EVRI). http://www.evri.ca/.

- Lew, D. K.; Larson, D. M.; Suenaga, H.; DeSousa, R. The Beneficial Use Values Database. Department of Agricultural and Resource Economics. April. http://buvd.ucdavis.edu/ (accessed Jan 31, 2005). See April 2001.

Caveat: Commercial Values for Reliability Also May Be Significant

Note that the reliability values above pertain essentially to residential customers. Commercial, industrial, and institutional customers (CII) may also place a high value on reliable supplies. Businesses that rely on water as a key part of their production process do not want to have their production levels curtailed, disrupted, or subjected to uncertainty because of potential limits on water use. While no empirical estimates are available at this time on CII reliability values for water supply, reuse may provide appreciable value in this manner to a utility's CII customers. This in turn can have associated beneficial impacts in terms of retaining or attracting businesses to the region, with attendant local economic impacts such as stability or growth in income, employment, and tax revenues.

APPENDIX E

A SOURCEBOOK ON VALUES OF WATER RESOURCES

This document briefly summarizes and identifies the location of a number of sources where values of water resources may be obtained. Several databases are summarized that contain primarily nonmarket, but some market, values in meta-analysis format that can be used for benefits transfer in a wide variety of applications.

1. EVRI DATABASE

The Environmental Valuation Resource Inventory (EVRI) database is an Environment Canada database located on the web. It includes nonmarket (e.g., contingent valuation) and market (e.g., commercial fishing) values alike for a wide range of resource categories, including air, land, water, and artificial structures. Studies included in the database were conducted from 1960 to the present but focus on the late 1980s and early 1990s.

At present, entries in the EVRI are concentrated in the area of water valuation studies. This is a consequence of initial focus on water valuation in the Americas during the testing phases of the development of the infobase. The scope of the EVRI is being broadened to include valuation studies for many types of natural capital from all parts of the world. The EVRI is intended primarily as a tool to assist policy analysts using the benefits transfer approach in estimating economic values for changes in environmental goods and services or human health. For the benefits transfer approach, the results of the previous studies held within the EVRI can be used (transferred) to estimate the economic value of changes stemming from current programs or policies.

The main challenge faced in conducting an economic valuation with a benefits transfer approach is in finding the most appropriate studies to use in the transfer exercise. Choosing an appropriate set of studies involves matching the context of the previous economic study(ies), termed study sites, with the context of the current program or policy, termed the policy site. The EVRI has been designed specifically to help analysts evaluate the quality of the information about the study site(s) and to match the studies with current policy sites. The EVRI's Searching Module helps the user define the good or service to be valued and identifies studies with potential for transfer. The Screening Module helps the user assess the suitability of the studies identified in the search according to criteria outlined in the benefits transfer literature.

Using the EVRI and the benefits transfer approach appropriately will yield significant time and cost savings compared to the time- and resource-intensive process of designing, testing, and implementing a new valuation study. Beyond its role in facilitating defensible benefits transfers, the EVRI can assist in the design of new valuation studies since it contains concise, detailed, and easily accessed information about the methods and approaches taken in existing valuation studies. In the long run, the EVRI will illustrate the gaps in the body of valuation research with respect to environmental goods and services and different parts of the world.

The EVRI's abstracts of valuation studies outline the pertinent valuation issues and results necessary for a researcher to identify the best candidate studies for a potential benefits transfer. There are six main categories of information, contained in more than 30 fields:

- Study reference—basic bibliographic information
- Study area and population characteristics—information about the location of the study along with population and site data
- Environmental focus of the study—fields that describe the environmental asset being valued, the stressors on the environment, and the specific purpose of the study
- Study methods—technical information on the actual study, along with the specific techniques that were used to arrive at the results
- Estimated values—the monetary values that are presented in the study as well as the specific units of measure
- Alternative language summary—an abstract of the study available in English, French, and Spanish.

The EVRI database and its searching modules are located at the following website: http://www.evri.ca.

This is a subscription (i.e., fee-based) database (see fee rates in Canadian dollars below).

- C$900 per 12-month subscription or per 100 log-ons to the EVRI site, whichever comes first
- C$600 per 6-month subscription or per 50 log-ons to the EVRI site, whichever comes first
- C$200 per 1-month subscription or per 20 log-ons to the EVRI site, whichever comes first.

2. JOHN LOOMIS RECREATION META-ANALYSIS DATABASE

John Loomis is a nonmarket valuation economics professor at Colorado State University. The Loomis Recreation Meta-Analysis database is a comprehensive collection of 701 recreational nonmarket valuation studies from 1970 through 1998 but focuses on the late 1980s and 1990s. The file is in Excel format. Individual study values are reported, and a useful summary sheet reporting national averages and the means over five regions is included (values reported in 1996 dollars). The categories likely to be most useful to water resources include fishing, swimming, float-boating, motorboating, picnicking, waterfowl hunting, and camping. Results from the database are presented in a report entitled “Benefit Transfer of Outdoor Recreation Use Values” (Rosenberger and Loomis), located on the Internet at http://www.fs.fed.us/rm/pubs/rmrs_gtr72.html.

3. SPORTFISHING VALUES DATABASE BY IEc

Prepared by Industrial Economics, Inc. (IEc) under contract to the U.S. Fish and Wildlife Service, the Sportfishing Values database provides a detailed account of the contents of numerous recent nonmarket valuation studies. Included in the database is information from over 100 travel cost and contingent valuation studies of sportfishing activity. To the extent possible, the database describes the resource and the change that provide the basis for the reported value, including species and resource quality characteristics. In addition, the database describes the associated study characteristics (including respondent sample information), the valuation methodology, and other study-specific conditions. The database is located at http://www.indecon.com/fish/default.asp.

4. BUVD

The purpose of the Beneficial Use Values (BUVD) database is to provide an educational and informational tool to the general public and interested specialists, documenting the economic values for beneficial uses of water identified by the California State Water Resources Control Board (SWRCB). It is envisioned that the BUVD be a companion to the Water Quality Standards Inventory Database (WQSID), which currently provides information to the public on water quality standards for, and beneficial uses of, water bodies throughout California but gives no information on the value of those beneficial uses.

In preparing this alpha version of the database, the literature on economic values of water was consulted widely but not exhaustively, so in its current form the BUVD should be considered the following:

- A representation of many, though not necessarily all, economic values for beneficial uses of water available in the current literature.

- A template that can be added to as more studies are identified as suitable for inclusion in the database over time.

- The current version has a basic front-end search engine that simplifies the use of the database for persons less familiar with Microsoft Access, relational databases, and query building. It is expected that the web-based version of the database to be implemented later will have a more powerful search engine that will allow users to do more complicated data searches.

Basic Structure and Contents of the BUVD

The Beneficial Use Values database is a Microsoft Access relational database with nine underlying tables. These tables contain the beneficial use values that will appear in the web-based version and the documents in which they were reported. The nine tables are linked. Currently, there are over 2,000 values for a diverse set of amenities, including values for water for recreation, habitat, municipal, and industrial uses.

The database design centers on the Documents table, which contains reference information (pubyear, title, and refinfo), a field describing the type of publication (pubtype), and general information specific to each document (amenity, sitedesc, and comments). Documents were classified as one of the following publication types:

- Journal article
- Book/book chapter
- Report
- Unpublished/working paper
- Other.

Of the 131 studies included in the edited database, there were 8 books or book chapters, 101 journal articles, 17 reports, and 5 working or unpublished papers. Because six of the book chapters were separate chapters in three books, there are actually 128 distinctly different studies reported in the database. The vast majority of the studies were conducted in the last 25 years, which reflects the relative paucity of studies valuing water and its uses in the literature before the 1970s.

Valuation Methods Used in Reported Studies

Market valuation methods: When market data are available, market price and quantity information can be used to estimate demand, supply, or production relationships. These relationships provide a means for directly measuring economic value.

Contingent valuation methods: Use survey questions to obtain direct estimates of WTP. These methods are frequently used to value goods for which there is little or no behavioral (market) data. These are also the only methods that can obtain estimates of nonuse values.

Conjoint analysis methods: A survey-based approach in which people are asked to rate or rank several different scenarios, each with different levels of attributes taken from a common set. Statistical methods are then used to estimate the WTP of individual attributes.

Damage function approach methods: These methods seek to determine a “dose–response” relationship between an environmental quality change and some physical effect and then use market values for the estimated marginal effect to determine a monetary value for the overall effect.

Hedonic methods: Hedonic methods assume that the price of a good is a function of its attributes. Thus, the price of a good is regressed on its characteristics to find the marginal value of the characteristics.

Averting behavior approaches: Averting behavior approaches infer the value people place on an amenity by what they spend to prevent its removal or degradation.

Optimization models: Optimization models are mathematical representations of an economic problem and include mathematical programming, calculus of variations, and optimal control models.

Opportunity cost methods: This approach views the opportunity cost associated with using an amenity for one use as the value of the amenity used in its next best alternative use.

Simulation models: Simulation models used in valuation of beneficial uses are typically used to determine the biological or physical response to economic stimuli.

Travel cost methods: Although there are many variants of this approach, all travel cost method studies use expenditure and trip visitation data for visitors to a natural resource to extrapolate the associated value of a resource.

Replacement cost methods: The replacement cost methods use the monetary cost of replacing or restoring an amenity as a measure of the value of the amenity.

Other methods: Valuation methods falling into this category represent a variety of approaches to valuing beneficial uses that include three cost-based valuation techniques, an energy analysis approach, and an agricultural yield comparison approach.

The website is located with the University of California—Davis at http://buvd.ucdavis.edu. More information about the BUVD can be found in Lew et al.

5. EPA'S EERI

At the EPA Environmental Economic Report Inventory (EERI) website, over 200 downloadable reports are available, although the site contains no fields or spreadsheets to summarize values or other study information. The search capabilities are advanced: you can search for reports under author, title, subject, or geography, among others. This inventory also contains downloadable working papers and some EPA data sets. The website is located at www.epa.gov/economics.

6. WETLANDS AND ECONOMICS: AN ANNOTATED REVIEW OF THE LITERATURE

This bibliography provides a comprehensive review of recent wetland valuation studies. The main portion consists of an annotated bibliography of published and unpublished literature. The annotations focus on those studies of particular relevance for the Great Lakes basin and in particular on the monetized aspects of the studies. In total, 277 papers are included in the bibliography.

On a geographical basis, over half of the studies are of U.S. wetlands (representing 22 states). Thirty papers provide insight into the economics of Canadian wetlands, from six provinces. Relatively few (11) studies address the value of wetlands in the Great Lakes basin specifically. In addition, case studies from 24 other countries are included, the largest number of them European.

The greatest number of studies refer to freshwater marshes, although a significant number of studies are of coastal (saltwater) marshes, especially in the Eastern United States. Also notable are the 18 papers on mangroves. Recreation represents the focus of the largest number of studies in the bibliography (including those papers specifically valuing the use of wetlands for hunting and fishing). Of those papers assessing the value of the production or support of commercial products by wetlands, those dealing with commercial fisheries are most numerous. In addition, 19 papers deal with the values of wetlands for water control/supply, and 29 are on their values for enhancing water quality. The large number of studies on existence/option/bequest values corresponds to the interest in contingent valuation studies, especially in the United States, where recent legal developments have sparked an increased interest in this methodology. While legal issues most likely contribute to the number of papers on property appraisals of wetlands as property, the interest in rehabilitation and construction of wetlands also contributes to the number of papers on project financial accounting.

Although case studies predominate numerically in the references, the significant number of papers on methodological issues points to the continuing debate over and development of methods appropriate for the determination of wetland values. It is currently located at http://www.cciw.ca/glimr/data/wetland-valuation/intro.html.

7. META-ANALYSIS OF SPORTFISHING VALUES

This database contains sportfishing studies only. It was compiled by Kevin Boyle at the University of Maine and others to provide the U.S. Fish and Wildlife Service a means to systematically explore variation in sportfishing value estimates across studies. A total of 161 studies are reviewed in detail, producing 3,104 valuation estimates. The file is in Excel format and can be analyzed by any of a large number of study variables, including location.

An accompanying report entitled "A Meta Analysis of Sport Fishing Values" is available; it subjects the data to statistical analysis. A subset of 1,002 value estimates from 70 studies is used to conduct meta-analyses and regressions to verify hypothesized determinants of value, such as water type, methodology, and species. The Excel file can be used without the report, although the report provides some insight and aid in using the data in the spreadsheet.

APPENDIX F

SPREADSHEET VERSION OF WATER REUSE PROJECT ECONOMIC EVALUATION FRAMEWORK

The software tool for the economic framework is designed as a series of steps to lead users through the process of identifying and documenting the full range of benefits and costs associated with a water reuse project.

The user should follow the worksheets in order from step 1 to step 8 in the process. As the user proceeds through the steps, the tool will set up information for later steps based on information entered by the user. Green cells on each worksheet page are places for the user to enter information. Yellow cells on each worksheet represent spaces where the tool is expected to fill in information based on user input from previous steps.

Note that the "steps" in the electronic spreadsheet version do not always correspond directly with the framework steps (e.g., Figure 4.1) in order to take advantage of the spreadsheet capabilities.

Step 1 is a place to record information regarding the water reuse project to be evaluated. This includes information on the type of project (e.g., indirect nonpotable, indirect potable), the type and number of customers associated with a project, other entities associated with the project, key project dates, and key project stakeholders.

Step 2 is a worksheet for defining and recording baseline information. This is primarily cost information for the case without the project, which is the avoided costs with the project.

Step 3 (B and C) helps users with the identification of benefits and costs (step 3) and also initiates the screening analysis (step 4) for project benefits (B) and costs (C). In each step, for each benefit or cost, the user is asked to determine if the item can be quantified in dollar terms, should instead be given a qualitative assessment, or is so small that it can be eliminated from further consideration in the analysis. Also, for each benefit or cost category, the user can identify key customers or stakeholders associated with that benefit or cost category. If multiple customers or stakeholders are affected, then multiple entities can be identified in columns to the right.

Step 4 shows a summary of the screening analysis, separated into benefits and costs for the quantitative assessment, benefits and costs for requiring the qualitative assessment, and impacts that exist but are deleted from further analysis.

Steps 5 and 6 (B and C) provide space to quantify dollar benefits or costs identified in steps 3 and 4. For each benefit or cost category identified for quantitative assessment in the screening steps, the tool will set up a section for valuation of that item over time. The user can enter the quantity associated with that benefit (e.g., acre-feet of water) and the range of $/unit values associated with that item. Projection of the units and $/unit values over time can be used to calculate total benefit or cost over time. Once the total has been calculated, a net present value is given according to the discount rate specified by the user.

Step 7 lists the qualitative benefits and costs identified in steps 3 and 4. The user can then rate the likely impact on net benefits (the monetized benefits minus the monetized costs for the project) using a five-point scale, with +2 showing a very positive impact on net benefits, −2 showing a very negative impact on net benefits, and 0 showing a neutral impact on net benefits. Users can also insert a +1 or –1 for modest positive or negative impacts on net benefits, respectively. Explanation of the values can be recorded to the right of the ratings.

Step 8 is a summary of all the benefit and cost findings, including both quantified and qualitative information on all the benefits and costs of significance associated with the project. This page shows a summary of net benefits for the project along with the qualitative assessments developed in previous steps.

Step 9 is a listing of omissions, biases, and uncertainties associated with all values in the analysis, both quantitative and qualitative.

Step 10 in the spreadsheet tool provides text with guidance for conducting and reporting the results of sensitivity analyses. The text is not repeated here, but the tracking and reporting of sensitivity analyses can be done by using the offline paper template provided.

Step 1 – Reuse project information and agency information

Name of agency		
Name of person conducting analysis		
Phone number		
E-mail		
Reuse project information		
Project name		
Project location		
Direct potable, indirect potable, or non-potable water production		
Project operational date		
Does the project operate year-round or seasonally?		
Annual volume of reclaimed water produced (by year, if available)		
Annual volume of water distributed (by year, if available)		
Type and number of customers	Number	Customer names
Agriculture		
Golf course		
Industrial/commercial		
Public/parks		
Residential		
Other		
Other nonregulatory entity involved in reuse project	Entity type	Role
Key project dates (existing or planned)		
Beginning of planning		
Beginning of permitting		
Funding application		
Beginning of construction		
Beginning of operation		
Listing of key stakeholders		

Step 2 – Baseline (without project) information

Is this a regional project or "go it alone"?	
Projected demand (by year, if available)	
Projected conservation (by year, if available)	
Is your conservation broken out from your demand forecast?	
Existing supply (by year, if available)	
In the absence of this project, would another project have been built?	
YES	
What potable project?	
Avoided capital and/or O&M costs of water supply development	
Avoided capital and/or O&M costs of water supply treatment	
Avoided capital and/or O&M costs of water transmission	
Avoided capital and/or O&M costs of water distribution	
What wastewater treatment project?	
Avoided capital and/or O&M costs of wastewater treatment and disposal	
What other reuse project?	
Avoided capital and/or O&M costs of reuse supply development	
NO	
Avoided O&M costs of water supply treatment	
Avoided O&M costs of water transmission	
Avoided O&M costs of water distribution	
Avoided O&M costs of wastewater treatment and disposal	

Step 3B – Reuse project benefit identification

Benefits				
Check one	*Check one*	*Check one*	(categories not checked assumed to be not applicable)	
Quantitatively	**Qualitatively**	**Very small or mitigated – no analysis**	**Direct benefits (agency or customer)**	**Entity accruing benefit**
			Avoided capital costs of water supply development/purchase	Choose one
			Avoided O&M costs of water supply development/purchase	Choose one
			Avoided capital costs of water supply treatment	Choose one
			Avoided O&M costs of water supply treatment	Choose one
			Avoided capital costs of water transmission	Choose one
			Avoided O&M costs of water transmission	Choose one
			Avoided capital costs of water distribution	Choose one
			Avoided O&M costs for water distribution	Choose one
			Avoided capital costs of wastewater treatment and disposal	Choose one
			Avoided O&M costs for wastewater treatment and disposal	Choose one
			Reclaimed water sales revenues	Choose one
x			Increased supply flexibility	Choose one
			Avoided penalties from exceeding water quality mandated goals	Choose one
		X	Avoided penalties from exceeding wastewater discharge volume goals	Choose one
			Avoided increased groundwater pumping costs with declining groundwater levels	Choose one
x			Increased supply reliability (customer perspective)	Choose one
	x		Increased supply quality reliability (customer perspective)	Choose one
			Other (specify):	Choose one
			Other (specify):	Choose one
			Other (specify):	Choose one
			Indirect benefits (societal)	
			Environment	
			Source water protection	Choose one
			Enhanced downstream habitats	Choose one
			Reduced seawater intrusion	Choose one
			Reduce declining groundwater levels (less subsidence risk)	Choose one
			Environmental restoration	Choose one
			Threatened or endangered species	Choose one
			Coastal ecosystems	Choose one
			Other (specify):	Choose one
			Recreation	
			Instream recreation	Choose one
			Near-stream recreation	Choose one
			Flatwater recreation	Choose one
			Creation of green belts for recreational use (golf courses or parks)	Choose one
			Other (specify):	Choose one
			Human health	
			Reduced public health risk due to less contact with polluted water	Choose one
			Other (specify):	Choose one
			Economic and social	
			Increased growth	Choose one
			Water projects leveraging other community projects	Choose one
			Local control over water resources (not relying on imported water)	Choose one
			Increased property values (e.g., golf development)	Choose one
			Cultural values	Choose one
			Aesthetic values	Choose one
			Lower treatment costs for downstream users	Choose one
			Energy savings from avoided pumping costs for importing water	Choose one
			Farm benefits: increased farm production or lower water costs	Choose one
			Savings in fertilizer usage	Choose one
			Other (specify):	Choose one

Step 3C – Reuse project cost identification

Costs				
Check one	*Check one*	*Check one*	(categories not checked assumed to be not applicable)	
Quantitatively	**Qualitatively**	**Very small or mitigated – no analysis**	**Direct costs (agency or customer)**	**Entity incurring cost**
			Capital O&M costs for reclamation treatment	Choose one
			O&M costs for reclamation treatment	Choose one
			Capital costs for recycled water distribution	Choose one
x			O&M costs for recycled water distribution	Local wastewater agency
	x		Capital costs for customer retrofits & training	Choose one
	x		O&M costs for customer retrofits	Choose one
			Capital costs for storage	Choose one
			O&M costs for storage	Choose one
			Capital costs for sludge disposal	Choose one
			O&M costs for sludge disposal	Choose one
			Loss of potable water sales	Choose one
x			Water purchase costs	Choose one
			Increased admin costs	Choose one
			Public information campaign costs	Choose one
			Other (specify):	Choose one
			Other (specify):	Choose one
			Other (specify):	Choose one
			Indirect costs (societal)	
			Environment	
	x		Reduced effluent flows into bays and rivers	Choose one
			Loss of marsh habitat due to increased salinity	Choose one
			Other (specify):	Choose one
			Human health	
		x	Increased public health risk due to increased contact with reuse water	Choose one
			Other (specify):	Choose one
			Economic and social	
			Increased growth (congestion and other negative impacts)	Choose one
			Plant location (odor and traffic)	Choose one
			Air pollution increases	Choose one
			Resource access/social justice	Choose one
			Other (specify):	Choose one
			Salinity impacts from landscape irrigation on grass and plants	Choose one
			Increase in groundwater salinity over time	Choose one

Step 4 – Summary screening analysis

Benefits and costs for quantitative assessment

- Increased supply flexibility
- Increased supply reliability (customer perspective)
- O&M costs for recycled water distribution
- Water purchase costs
-
-
-
-
-
-
-
-

Benefits and costs requiring qualitative assessment

( ) Increased supply quality reliability (customer perspective)
( ) Capital costs for customer retrofits & training
( ) O&M costs for customer retrofits
( ) Reduced effluent flows into bays and rivers
( )
( )
( )
( )
( )
( )
( )
( )

Impacts that exist but are deleted from further analysis

- Avoided penalties from exceeding wastewater discharge volume goals
- Increased public health risk due to increased contact with reuse water
-
-
-
-
-
-
-
-

Steps 5 and 6B – Benefits calculation

What discount rate should be used for this analysis?								
Increased supply flexibility								
			Years	1	2	3	4	5
	Amount		Low					
Increased supply flexibility	Unit		Med					
			High					
	$/unit values		Low					
			Med					
			High					
	Total value		Low					
			Med					
			High					
	Net present value		Low	$0				
			Med	$0				
			High	$0				
	Comment:							
Increased supply reliability (customer perspective)								
			Years	1	2	3	4	5
	Amount		Low					
Increased supply flexibility	Unit		Med					
			High					
	$/unit values		Low					
			Med					
			High					
	Total value		Low					
			Med					
			High					
	Net present value		Low	$0				
			Med	$0				
			High	$0				
	Comment:							

Steps 5 and 6C – Costs calculation

O&M costs for recycled water distribution

			Years	1	2	3	4	5
	Amount		Low					
Increased supply flexibility	Unit		Med					
			High					
	$/unit values		Low					
			Med					
			High					
	Total value		Low					
			Med					
			High					
	Net present value		Low	$0				
			Med	$0				
			High	$0				
	Comment:							

Water purchase costs

			Years	1	2	3	4	5
	Amount		Low					
Increased supply flexibility	Unit		Med					
			High					
	$/unit values		Low					
			Med					
			High					
	Total value		Low					
			Med					
			High					
	Net present value		Low	$0				
			Med	$0				
			High	$0				
	Comment:							

Step 7 – Qualitative benefits and costs

Five-point scale:

5 very positive value
4 positive value
3 neutral value
2 negative value
1 very negative value

Category	Impact (1–5)	Comment/explanation
Increased supply quality reliability (customer perspective)		
Capital costs for customer retrofits and training		
O&M costs for customer retrofits		
Reduced effluent flows into bays and rivers		

Step 8 – Summary of benefits and costs

Costs	Dollar amount Small	Dollar amount Large	Stakeholder accruing cost or benefit
Increased supply flexibility			Choose one
Increased supply reliability (customer perspective)			Choose one

Benefits	Dollar amount Small	Dollar amount Large	Stakeholder accruing cost or benefit
O&M costs for recycled water distribution			Local wastewater agency
Water purchase costs			Choose one

Benefits or costs requiring qualitative assessment	Likely impact	Stakeholder accruing cost or benefit
Increased supply quality reliability (customer perspective)		
Capital costs for customer retrofits and training		
O&M costs for customer retrofits		
Reduced effluent flows into bays and rivers		

Monetized net benefits	Low	High
(monetized benefits minus costs)	$0	$0

Step 9 – Omissions, biases, and uncertainties

Benefit or cost category	Likely impact on net benefits	Comment

Step 10 – Sensitivity analysis applied to discount rate (thousands of dollars)

Variable/ scenario	Monetized benefit	Cost	Monetized net benefit

Advancing the Science of Water Reuse and Desalination



WATEREUSE FOUNDATION

1199 North Fairfax Street, Suite 410
Alexandria, VA 22314 USA
(703) 548-0880
Fax (703) 548-5085
E-mail: Foundation@WateReuse.org
www.WateReuse.org/Foundation