Guidelines for Preparing Economic Analysis for Water Recycling Projects

Prepared for the State Water Resources Control Board

By the

Economic Analysis Task Force for Water Recycling in California

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Executive Summary

ES-1. Introduction

This document provides guidance for conducting economic and financial analyses of water recycling projects. Proponents of a water recycling project may benefit from the methods described in this document in applying for state and federal grants and loans, as well as for internal evaluations of the desirability and feasibility of recycling projects.

The present guidance is the product of the Economic Analysis Task Force (EATF) for water recycling in California, a group of technical experts in economic analysis and policy from agencies and academia including:

- California State Water Resources Control Board (State Water Board),
- California Department of Public Health (CDPH),
- California Department of Water Resources (DWR),
- California Public Utilities Commission (CPUC),
- U.S. Bureau of Reclamation (Reclamation), and
- University of California - Davis

The EATF met regularly to formulate and discuss this current guidance as well as direct drafting of this and other products of this effort such as the Beneficiary Pays Analysis report.

Economic and financial analyses are clearly distinguished with respect to analytical perspective, inflation adjustment, interest and discount rates. Economic analysis considers benefits and costs of a project for the society as a whole. A financial analysis is concerned mostly with a project's ability to generate enough revenues to pay back financial costs incurred in facility construction and operation. Discount rates are used in economic analysis to convert benefit and revenue streams to monetary units of a year of reference. Inflation is included in financial analysis, which uses nominal prices. Use of real prices in economic analysis excludes inflationary effects, but accounts for individual price changes.

ES-2 Integrated Water Resources Planning

In this guidance water recycling is considered as part of integrated resources management. In this process, planners, water utilities and local and regional governments should establish a baseline with future projected water demands. The baseline includes forecasts of land use, population and wastewater. Institutional, legal and other requirements should be considered in formulating a baseline. Clear water supply objectives and alternatives should be specified prior to the economic and financial analysis of each water supply alternative or project. Projects for increasing water conservation, augmenting water supply and enhancing water quality are often proposed. Refinement of alternatives may be required following economic and financial analyses and prior to final recommendations on the set of water and wastewater management actions. This is illustrated in Figure ES-1 below.

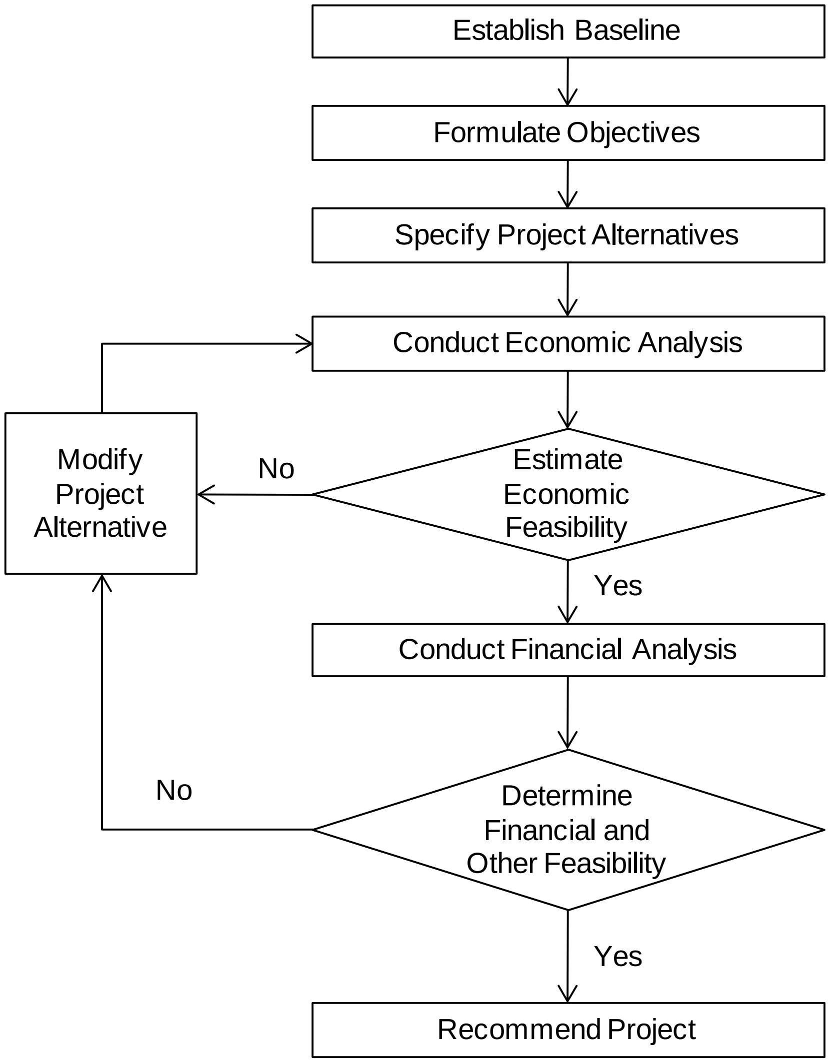

Figure ES-1. Integrated Water Resources Planning Process.

ES-3. Economic Analysis

In economic analysis, the project proponent is interested in quantifying benefits and costs of a project from a broad societal point of view. Often the spatial extent of the analysis covers the region surrounding the proponent's area or the entire state. Figure ES-2 summarizes the economic analysis framework presented in this guidance. An identification of relevant project benefits should initiate the process followed by a quantification of these costs. Time horizon and discount rates for the economic assessment should be selected. Time periods of 50 years and discount rates around 6% are common among most project proposals; however, agencies often have different policies for selecting these two parameters. Common decision criteria include: net present value, expected net present value, benefit-cost ratio, annualized net benefits and internal rates of return. Most commonly, project alternatives with a positive net present value are considered economically feasible.

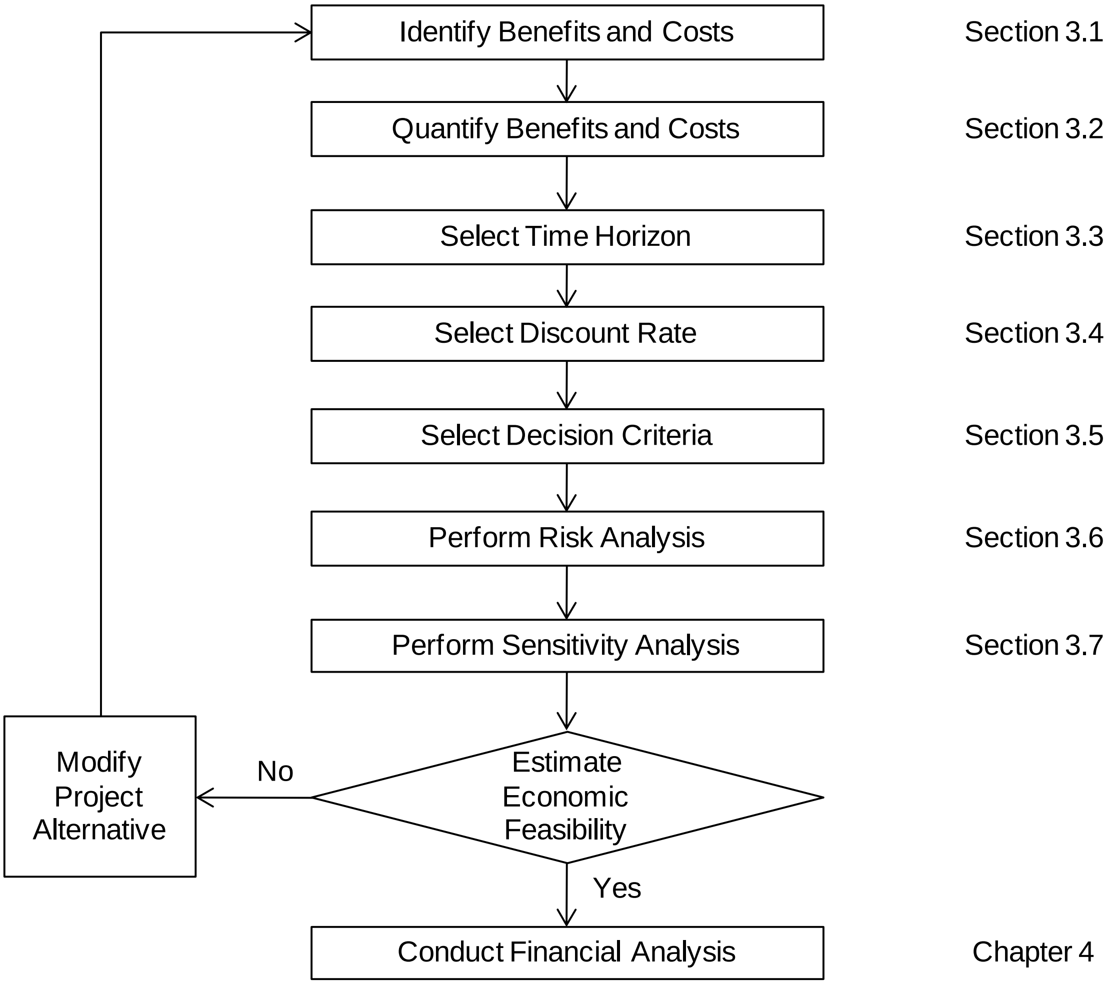

Figure ES-2. Economic Analysis Process for a Project Alternative.

Risk and sensitivity analyses conducted as part of the economic analysis help identify and quantify the magnitude and effect of uncertainties in parameters and events. Common parameters to include in a sensitivity analysis include the discount rate, average recycled water deliveries to users, and periods of analyses. Uncertainty in the water supply portfolio that includes sources such as groundwater or water imports can be part of a risk analysis. Finally, financial analysis should be conducted only for economically desirable alternatives.

ES-4. Financial Analysis

In a financial analysis, a proponent is interested in assessing the project's ability to generate revenue streams sufficiently large to cover financial costs over time. Like in economic analysis, project costs should be identified and quantified. In some cases, costs of a project are allocated among purposes and beneficiaries. A Beneficiary Pays Analysis can be useful in determining cost allocations. Financing mechanisms such as issuing bonds, requesting loans and applying for grants often are required to fund a proposed alternative. This step also aids in estimating debt service amounts given a portfolio of funding sources for a project.

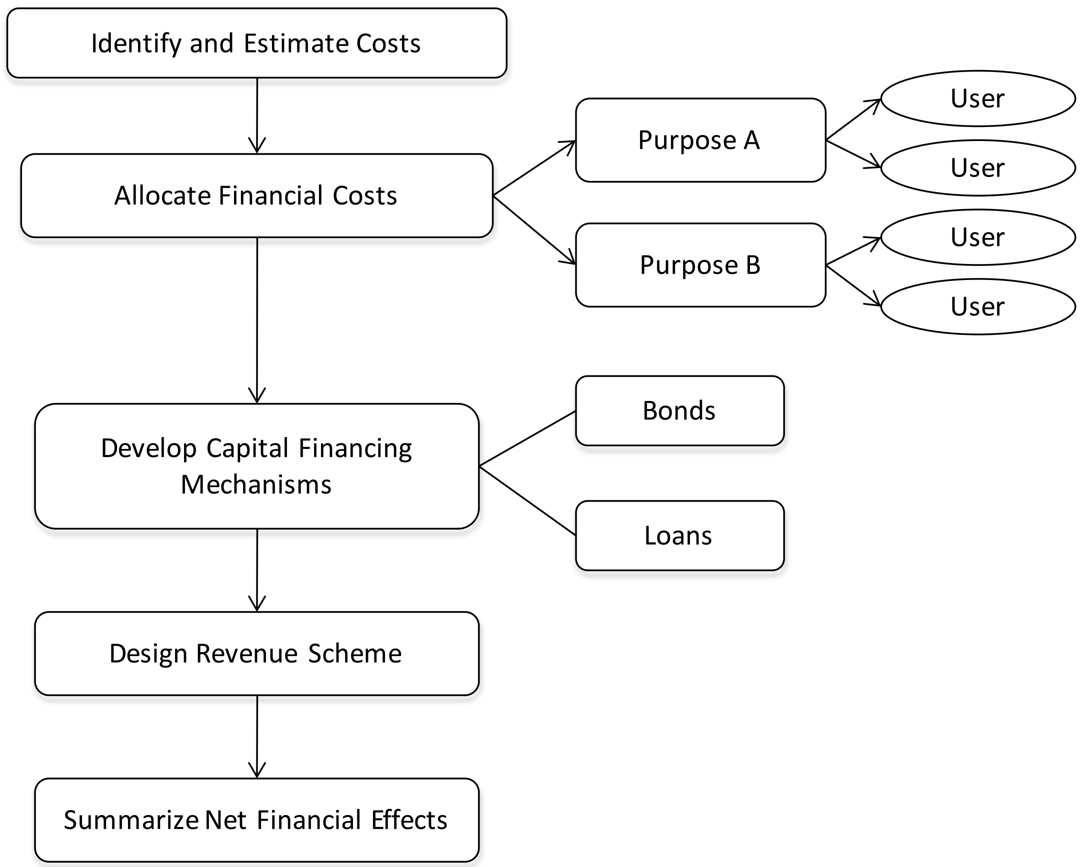

Figure ES-3. Financial Analysis Process of a Project Alternative.

A revenue scheme is required to determine price ranges for recycled water considering the price of fresh water alternatives and the net financial costs per unit of recycled water produced. The net financial assessment results are favorable if all years in the period of analysis have net positive financial benefits. Projects with projected negative financial benefits for one or more years of operation can be regarded as financially unfeasible and may require leverage from additional funding sources or changes in the financial plan.

ES-5. Conclusions

Economic and financial analyses are useful to identify benefits and costs of a project alternative. Conducting these analyses helps in developing a more efficient allocation of scarce resources for infrastructural projects. The present document provides guidance for conducting economic and financial analysis recognizing challenges of integrated resource management with water recycling.

Table of Contents

List of Tables

List of Figures

Appendices

List of Acronyms

CALAG	DWR California Agriculture model
CDPH	California Department of Public Health
CEA	Cost-Effectiveness Analysis
CPUC	California Public Utilities Commission
CWC	California Water Code
CWSRF	Clean Water State Revolving Fund
DWR	California Department of Water Resources
EATF	Economic Analysis Task Force for Water Recycling Projects in California
ENPV	Expected Net Present Value
ENR	Engineering News Record
EQ	Environmental Quality
IMPLAN	Impact Analysis for Planning
IRR	Internal Rate of Return
LBUVC	Lost Beneficial Use Value Calculator (State Water Board)
LCPSIM	DWR Least Cost Planning Simulation Model
MOA	Memorandum of Agreement 1996 between the State Water Board and the CDPH
NCROM	DWR Net Crop Revenue Models
NED	National Economic Development
NPDES	National Pollutant Discharge Elimination System
NPV	Net Present Value
OSE	Other Social Effects
P&G 1983	Economic and Environmental Principles and guidelines for Water and Related Land Resources Implementation Studies
RED	Regional Economic Development
RM D&S FAC-09-03	Representation and Referencing of Cost Estimates in Bureau of Reclamation Documents Used for Planning, Design and Construction
RM D&S Title XVI	Water Reclamation and Reuse Program Feasibility Study Review Process
SCRB	Separable Cost Remaining Benefit Method
SWAP	Statewide Agricultural Production Model
State Water Board	State Water Resources Control Board
USACE	US Army Corps of Engineers
Reclamation	U.S. Bureau of Reclamation
REMI	Regional Economic Models Inc.
RIMS	Regional Input Output Modeling System
USWRC	U.S. Water Resources Council
WRFP	Water Recycling Funding Program
WTP	Willingness to pay

1. INTRODUCTION

An economic analysis is used to determine whether a proposed project will be a worthwhile investment. The analysis takes a perspective beyond that of the proponent and accounts for all benefits and costs regardless of who is affected. Completing an economic analysis allows for fair comparisons to be made between alternatives and demonstrates why a proposed project can be considered the best solution to meet a given objective. The economic analysis differs from a financial analysis in that economic analysis is the primary step used to determine whether to proceed with a project. When observed from society's perspective, does the project generate sufficient benefits in excess of costs to warrant consideration for investment? The financial analysis employs accounting procedures to evaluate funding strategies and cash flows to determine viability and stability of a project or plan.

1.1 Purpose of this Document

This economic analysis guidance document provides an orientation and method for completing economic and financial analyses for water recycling projects in California based on relevant state and federal guidelines. The intended users of this document are personnel in water utilities, consulting engineers responsible for preparing economic and financial analyses of water recycling projects, and state and federal staff responsible for reviewing economic analysis for water recycling projects.

This document was prepared under contract with the State Water Resources Control Board (State Water Board) by the University of California with guidance from the Economic Analysis Task Force (EATF). The work was driven by recommendations from the Governor's 2002 Recycled Water Task Force and the State Water Board's Water Recycling Funding Program (WRFP) 2007-2008 Strategic Plan. Recommendations from the afore-mentioned programs included the formation of the EATF and coordination among state and federal agencies in their funding processes and procedures. The agencies included were the:

- California State Water Resources Control Board (State Water Board),
- California Department of Public Health (CDPH),
- California Department of Water Resources (DWR),
- California Public Utilities Commission (CPUC), and
- U.S. Bureau of Reclamation (Reclamation).

1.1.1 Background on Water Recycling in California

Funding of water recycling in California began in the 1960s with construction of Water Factory 21 in Orange County and a tertiary treatment facility constructed by Contra Costa County Sanitation District. In the following decade, the Clean Water Construction Grant Program of 1972 allotted construction funding for recycling facilities from both federal and state sources totaling 75% and 12.5% of construction costs respectively. Funding decisions were primarily based on the *cost effectiveness* of a project, as this was the method outlined by the Code of Federal Regulations (40CFR35 Appendix A Subpart E revision 2006).

In 1977 the State Water Board adopted the Policy and Action Plan for Water Reclamation in California. The plan promoted recycled water as a water supply source in water-short areas and encouraged DWR to assist in implementing this policy. State Water Board Grants Management Memorandum 9.01 (State Water Board, 1977) provided the mechanism for state funding. Amendments to the 1978 Clean Water Act limited federal funding to the National Pollutant Discharge Elimination System (NPDES) and eliminated funding for water recycling.

Since the 1970s, state bonds provided substantial funding for water recycling projects. The 1978 Bond Law required cost effectiveness criteria for funding; and later in 1984 and 1988, loans required this cost-effectiveness be relative to other water sources. In 1996 and 2000, bond laws permitted the State Water

Board to enter into agreements for water recycling loans and grants. Cost-effectiveness was kept as the preferred criteria to select a project alternative. Most recently, the bond law of 2002 provided grants without specific funding criteria requirements. Loans under the Clean Water State Revolving Fund (CWSRF, since 1988) have provided funds only for recycled water projects that are cost effective.

Title XVI of P.L. 102-575 (Title XVI) directed the Secretary of the Interior to investigate and identify opportunities for water reclamation and reuse. Each project must be authorized individually by Congress. The federal cost-share is generally limited to $20 million per project. The Title XVI Act and amendments give the Secretary the authority to provide up to 25% cost-share to non-federal entities for design and construction of facilities; up to 50% of the cost of feasibility studies; and up to 50% of the cost of demonstration projects.

Reclamation has implemented statutory requirements for Title XVI feasibility studies through internal Directives and Standards. Those directives and Standards list the information that must be addressed prior to any finding by Reclamation that the feasibility study is complete. Once the project has received a Congressional authorization and meets the program requirements, that project is eligible to receive funding.

1.1.2 Uses of Economic Valuation in Water Recycling

In 1979, the State Water Board adopted the Interim Guidelines for Economic and Financial Analyses of Water Reclamation Projects (Ernst and Ernst, 1979). This 83-page document provided abundant detail beyond what applicants would commonly employ. Since 1985, the seven-page Water Reclamation Loan Program Guidelines (1985 and further updates) has been used. In 1993, the external program review panel recommended revision of these cost-effectiveness procedures and suggested changes. Later work groups (2004) removed cost-effectiveness as a funding criterion.

Reclamation follows internal Directives and Standards for Title XVI Projects and has developed final funding criteria for the Title XVI Program. Reclamation does not use the federal *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (Principles and Guidelines) to determine eligibility for Title XVI Projects. However, currently Reclamation incorporates an economic analysis using methods from the Principles and Guidelines as a factor in determining the priority in which projects will be funded. In other words, even though a Title XVI application does not require a detailed economic analysis using the Principles and Guidelines, the review process may award more points to a project as the level of detail in the economic analysis increases.

1.2 Economic Analysis and Financial Analysis

This document outlines the basic method to complete an economic and financial analysis for water recycling projects. Before proceeding, it is important to explain the difference between the two analyses. The economic analysis of a project is concerned with the viability of a project from a societal perspective and answers the questions of whether it is economically rational to proceed with the project. An economic analysis is concerned with the broader benefits and costs of a project. Financial analysis is concerned with the ability of the proponent to raise funds and repay the project costs, or answering the question, “is the project financially feasible?”.

The economic analysis considers all benefits and costs of a project, and determines the project’s overall value to society. A financial analysis is concerned with the ability of a project to generate enough revenue to pay back all the incurred financial costs. Conducting economic and financial analyses have important distinctions. Table 1 provides a comparison of the most important aspects.

Table 1-1. Key Aspects of Economic and Financial Analyses

Aspect	Economic Analysis	Financial Analysis
Analysis perspective	Accounts for all benefits and costs "to whomsoever they shall accrue"	Accounts only for benefits and costs realized by a project proponent.
Inflation adjustment	Uses real prices which exclude general inflationary effects but accounts for individual resource price changes different from the general inflation rate (labor, energy).	Uses nominal prices and revenues which include inflationary effects
Discount rate	Calculates net present value using two real (no inflation) discount rates: 1) the consumption discount rate of 3% and 2) return to private capital of 7%.	Not Applicable
Interest Rate	Not Applicable	Nominal (includes inflation) cost of borrowing money

1.2.1 Accounting Perspective

The accounting perspective identifies who the benefits and costs accrue to when conducting the economic or financial analysis. The fundamental principle of the proper accounting perspective for the economic analysis is to use the widest geographical definition of who will benefit and bear the cost of the project. For water recycling projects, this will probably be the national level if federal funding is involved, or state level if the project is state funded. An international perspective may also be necessary if the project affects international watersheds or river basins.

The economic analysis includes benefits and costs realized within the set perspective. When completing the economic analysis there may be an incentive to narrow the accounting perspective (i.e. to the proponent's perspective) to reduce the costs resulting from the project. This approach is incorrect. The wider perspective should be used to determine the full effects of a proposed project.

1.2.2 Inflation Adjustment

In both the economic and financial analysis, project values need to be adjusted for price changes that match the type of discount or interest rate being used. Real (non-inflated) prices have to be used if real discount or interest rates are used. In the economic analysis, real prices should be used along with a real discount rate with the following adjustment. If the price level of a specific category of costs, such as energy or labor, are projected to be different than the general inflation projections then those adjustments need to be made. One option is to use the Consumer Price Index available at: **http://www.bls.gov/cpi/**. Engineering News Record indices also are commonly used.

In a financial analysis, projected cost and revenue values include inflation and a nominal (with inflation) interest rate is employed to calculate financial feasibility.

1.2.3 Discount Rate

The discount rate is used to determine the present value of a projected stream of current and future benefits and costs. It accounts for the time value of money and can include inflation and risk. The discount rate is important in determining the economic feasibility of a project. Discounting affects the net present value of a project when there is a significant difference in the timing of benefits and costs such as large initial investment costs and long delays in benefits. In an economic analysis, prices and the discount rate are not adjusted for inflation.

The selection of a discount rate is discussed in Chapter 3.

1.2.4 Interest Rate

The interest rate is used in determining the financial feasibility of the project and should reflect the cost of the capital to the proposing agency.

1.3 Who Should Use This Document

This document was designed to aid agencies seeking funding for construction of water recycling projects, in evaluating the economic feasibility of water recycling facilities. The economic evaluation can aid and support internal decision-making and externally in preparing applications for grants and loans.

1.4 Document Organization

Chapter 2 outlines elements of integrated water resources planning. General elements for economic and financial analyses are discussed in Chapters 3 and 4 respectively. Examples of financial and economic analyses appear in Chapter 5. If some components of the analyses (e.g. estimation of some types of benefits) require elaboration beyond this Guidance Document, references are provided in the set of Appendices following Chapter 5

A summary of economic and financial analysis practices for water recycling practices in California among State and Federal agencies is presented in Appendix A. Discount Rate is discussed in Appendix B. To aid the user, a set of miscellaneous items including quality control practices for the applicant, modeling for estimation of costs and benefits and a reference benefits and costs table are in Appendix C. Formulae, Glossary and Additional Resources have been included in Appendices D through F. References to the entire EAGD and Appendices are included in Appendix G.

2. INTEGRATED WATER RESOURCES PLANNING

This chapter provides a context for economic and financial analyses and describes the foundations of both analyses. The basis for both analyses stems from a whole system planning model called Integrated Water Resources Planning (IWRP) with a fair description presented in Asano *et al.* (2007). IWRP takes a system-wide approach to addressing water resources problems (Hanak *et al.*, 2011). A framework for IWRP in water recycling is depicted in Figure 2-1. In Chapter 2, we briefly discuss the first three steps in the process. Economic and financial analyses, undertaken in the fourth step of the framework, are discussed in Chapters 3 and 4 respectively.

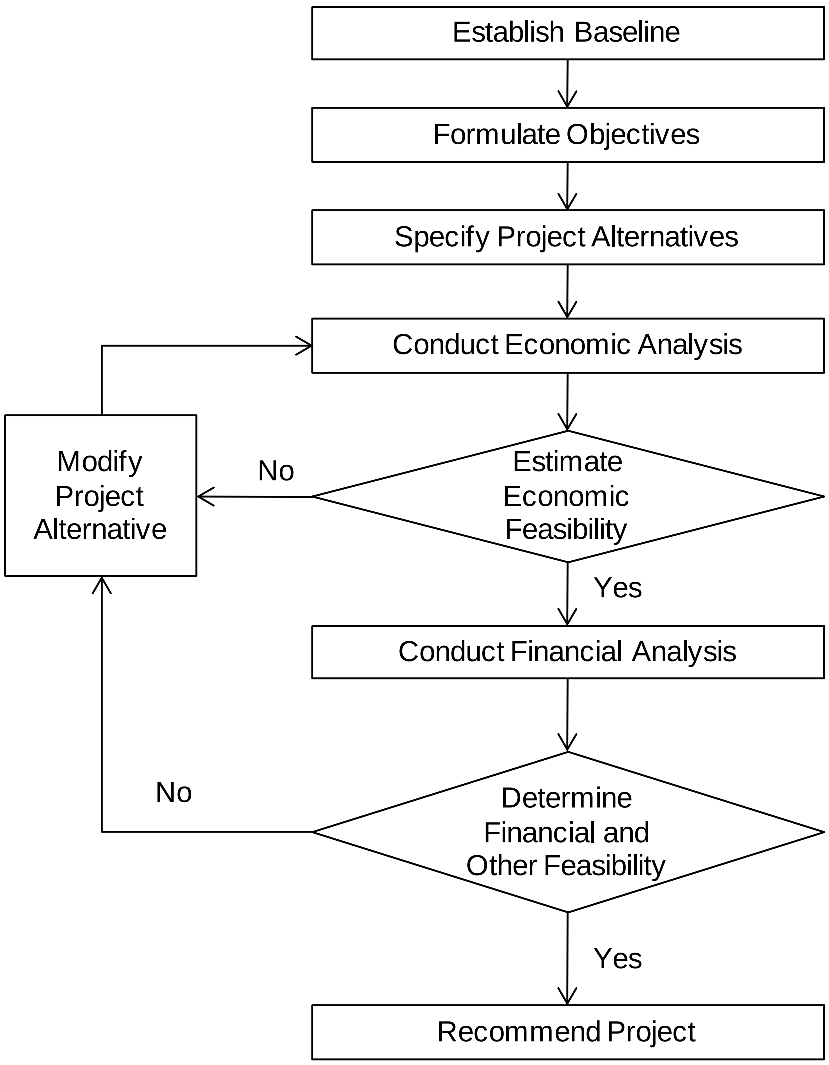

Figure 2-1. Integrated Water Resource Planning Process

The IWRP process establishes a baseline of physical, economic and social parameters to formulate a set of water management objectives and project alternatives. Project alternatives that may or may not include water recycling can meet primary objectives. Water management objectives will vary by agency depending on the resource base and economic and social demands for water. Economic and financial analyses are used to evaluate each project alternative in a systematic and coherent framework.

2.1 Establish Baseline

The baseline describes what would happen in the area without the proposed program, policy or project. It is used as a benchmark to compare project alternatives. A clear definition of the baseline helps describe the issues and therefore how the proposed recycling project may address the issues. The baseline begins by describing the current situation, but then continues to describe how future conditions will affect key parameters over the planning period.

The foundation of economic analysis is a "with versus without" comparison in which the water reuse project is compared to no new project. Establishing the baseline is first step in this comparative analysis since it specifies the "without" condition. The baseline should contain assumptions about the future that is generally understood by the community. For example, one area that may elicit alternative views is projections of population and economic activity that drive water use projections. Achieving reasonable consensus on the baseline assumptions is important in evaluating water reuse projects.

2.1.1 Land Use Plans

Land use planning establishes guidelines for development or conservation in an area to achieve long term objectives and goals. Land use plans provide the basis for projecting future population and infrastructure demands. Land use planning has always been considered a local responsibility and is the dominant parameter in determining future population and economic activity. Defining water problems, formulating objectives and specifying project alternatives should be consistent with local land use plans.

2.1.2 Population Projections

Changes in population, income and employment will impact water demands and wastewater discharge. Population projections for the state, counties and cities can be found through the California Department of Finance web site in the section of reports and research papers (http://www.dof.ca.gov). Assumptions regarding the increase in the population served by the proposed project should be consistent with the Department of Finance population projections.

2.1.3 Wastewater Projections

As population, economic activity, and water use changes, wastewater disposal needs will also change. Wastewater treatment facilities may need to increase capacity or new facilities may need to be constructed. The baseline analysis should include variations in wastewater flows that will result in changes in the volume of recycled water available. Changes in treatment standards also can trigger plant modifications.

2.1.4 Institutional, Legal and Regulatory Requirements

Institutional setting and established regulations should be considered when examining potential solutions for water and wastewater needs. Local, state, and national policies affect the construction of water recycling projects. Institutional agreements and rules affect the construction, operation, and liability of water recycling activities (USEPA 2004). Water quality guidelines and standards affect the treatments needed for specific end uses.

2.1.4.1 Recycled Water Regulations and Standards

The "Purple Book"[1] is used to assist the California Department of Public Health (CDPH) in evaluating water recycling projects and contains excerpts from the Health and Safety Code (2001) and the Water Code (See Appendices A for agency documents and Appendix F for

[1] **http://www.cdph.ca.gov/certlic/drinkingwater/Documents/Lawbook/RWstatutes2011-01-01.pdf**

additional resources). The Health and Safety Code covers guidelines for sanitary districts, housing regulations regarding gray water use, and provisions on augmenting of sources through recycled water and standards for cross connections.

2.1.4.2 Wastewater Regulations and Standards

Sections 13510-13512 of the California Water Code (CWC) promote water recycling to the maximum extent possible to supplement surface and groundwater supplies. Protection of public health is a condition in recycled water use, covered by the CWC sections 13521, 13522 and 13550(a)(3). A report should be filed with the appropriate Regional Water Quality Control Board (Regional Water Board) and the Regional Water Board will determine the necessary requirements for the proposed use. The Regional Water Boards should consult and consider the recommendations of CDPH. The 1996 Memorandum of Agreement between the State Water Board and the CDPH provides a framework for collaboration and delineates areas of responsibility and authority on water recycling and wastewater discharge.

2.1.4.3 Drinking Water Regulations and Standards

The CDPH, in coordination with the State Water Board, oversees the potential effects of water recycling on human health. The drinking water-related statues (often referred as the Blue Book) are a compilation of the Food and Agricultural Code, the Health and Safety Code, the Public Resources Code and the Water code. Drinking water-related Regulations are from Title 17 and Title 22 of the California Code of Regulations.

2.1.4.4 Local Agency Formation Commissions

California requires Local Agency Formation Commissions (LAFCo) at the county level to oversee the orderly formation of local government agencies that affect land use. The objective of the LAFCo is to preserve agricultural and open space, discourage sprawl, and assure efficient local government services. LAFCos are responsible for changes in service area and services provided by special districts.

2.1.4.5 Water Rights

Water rights affect the volume of water released by wastewater treatment plants into receiving waters. If water rights have been established for downstream users, or minimum flows have been established through legislation, a reduction in flows may not be permitted. California law does not allow a change in existing use, including recycling, unless it can be demonstrated that the change would create “no injury” to existing legal water users. It is therefore important to consider these constraints when planning a water recycling facility.

Water rights are usufructuary, or a right to use, but not a right of absolute ownership. California’s system of water rights is a blend of two very different types of water rights: riparian and appropriative. Riparian rights usually come along with owning a parcel of land adjacent to a source of water. A riparian right entitles the land owner to a use a correlative share of the water that would naturally flow in the stream. Appropriative rights follow the principle of “first in time, first in right” and distinguish between senior and junior appropriators. In most of California, overlying land owners may extract percolating ground water and put it to beneficial use without approval from the State Water Board or a court, adjudicated basins in southern California being a major exception. California does not have a permit process for regulating ground water use. In several basins, however, groundwater use is subject to regulation in accordance with court decrees adjudicating ground water rights within the basins.

The California Supreme Court decided in the 1903 case Katz v. Walkinshaw that the “reasonable use” provision that governs other types of water rights also applies to ground water. Prior to this time, the English system of unregulated ground water pumping had dominated but proved to be inappropriate to California's semiarid climate. The Supreme Court case established the concept of overlying rights, in which the rights of others with land overlying the aquifer must be taken into account. Later court decisions established that ground water may be appropriated for use outside the basin, although appropriator's rights are subordinate to those with overlying rights.

2.2 Formulate Management Objectives

The baseline establishes the assumptions on future economic growth, resource systems, and environmental and social conditions. This framework will serve as the basis for formulating water management objectives. DWR through the California Water Plan has developed a set of water resource management objectives that may apply to most regional or local conditions (DWR, 2009). Stated objectives can then be met with alternative management strategies. This framework can be used to formulate the agency water management objectives and strategies that include alternative projects, programs or policies. DWR has derived the following six broad management objectives:

- Reduce water demand
- Improve operation efficiency and transfer of water
- Increase water supply
- Improve water quality
- Practice resource stewardship
- Improve flood management

The second step in the IWRP process is to select the water management objectives that best reflect the agency setting. Management objectives that would probably be of interest to most water agency would be to reduce water demand, increase water supply, and improve water quality.

The next step in the IWRP process is to specify project alternatives that will achieve the stated management objectives.

2.3 Specify Project Alternatives

DWR suggests that resource management strategies be employed to develop project alternatives. In summary, the intent of resource management strategies:

> "…is to prepare plans that are diversified, satisfy regional and state needs; meet multiple economic, environmental, and societal objectives, include public input, address environmental justice, mitigate impacts; protect public trust assets, and are affordable." (DWR, 2009, 1-7)

DWR is charged with developing resource management strategies to meet regional and local water related problems. Participants include representatives from state agencies and organizations representing diverse interests to develop a comprehensive approach to water problems. They are tasked with collecting land use data and developing water use estimates required for statewide and regional water planning. They accomplish this by conducting surveys of agricultural, urban and environmental land uses, collecting weather and other data required to make water use estimates. This information provides a basis for projecting future water supply and demand at regional and local levels. DWR (2009) provides in Table 1-1 potential benefits of alternative strategies that could achieve water management objectives.

2.3.1 Projects to Reduce Water Demand

Improving agricultural and urban water use efficiency is a strategy to reduce water demand. Appendix C provides cost ranges from DWR (2009) and other sources for water demand reductions.

2.3.1.1 Agricultural Water Use Efficiency

Agricultural water use efficiency includes water application and delivery hardware upgrades, efficient water management techniques, and reduction in crop water consumption. A range of values for improving agricultural water use efficiency from the California Water Plan Update 2009 is presented in Appendix C.

2.3.1.2 Improve Urban Water Use Efficiency

Improved urban water use efficiency can be achieved by technological and behavioral improvements that reduce residential, commercial, industrial and institutional water use (DWR, 2009). The California Water Plan 2009 Update provides a range of costs for urban water use efficiency improvements (Appendix C).

2.3.2 Projects to Increase Water Supply

Increasing the available water supply can be accomplished by employing a combination of storage, management, and technology applications.

2.3.2.1 Conjunctive Management and Groundwater Storage

Conjunctive water management use refers to managing surface water and groundwater together rather than separately to maximize total benefits (DWR, 2009). Time and location of availability play important roles in improving the opportunity of use, overall supply reliability and long term sustainability of the resource. Projects to facilitate conjunctive use can include conveyance systems, recharge and extraction facilities. The benefits and costs of the conjunctive management are highly variable due to the wide range of circumstances of a program. The use of recycled water for groundwater recharge makes conjunctive use especially relevant for many water recycling projects.

2.3.2.2 Desalination

Desalination is the physical removal of sufficient salts from a water supply to make it useable for beneficial activities (DWR, 2009). The principal method of desalination is reverse osmosis that removes pollutants as well as salts. Desalination produces a reliable water supply and will become a more important water supply alternative as natural water supplies become stretched to meet competing uses, and costs decline due to improvement in the technology.

The cost of desalination depends mostly on the quality of the water supply. Ranges of cost for desalination of groundwater, wastewater and seawater from the California Water Plan 2009 Update (DWR, 2009) appear in Appendix C. Although technological advances have lowered costs of desalination over time, this water supply technology uses considerable amounts of electricity and requires disposal of saline wastewater.

2.3.2.3 Precipitation Enhancement

Cloud seeding artificially stimulates clouds to produce more rainfall than they normally would produce (DWR, 2009). The procedure is primarily used to improve hydroelectric operations because the benefits of such a procedure are spatially dispersed. The amount of water produced by cloud seeding is difficult to measure.

2.3.2.4 Recycled Municipal Wastewater

Reusing treated municipal wastewater from commercial, industrial, institutional and domestic sources for beneficial uses can be part of a strategy to meet future demand. The process usually results in a decrease in the use of freshwater supplies (DWR, 2009). Benefits of recycling wastewater include reduced supply cost and improved reliability, as well as reduced costs for wastewater disposal. DWR also claims that significant energy saving can be realized when compared with importing additional water supplies. The cost of recycled water depends on treatment and distribution costs, and water quality required by the end user. Some cost estimates from the California Water Plan Update 2009 are presented in Appendix C.

2.3.2.5 Surface Storage

Reservoirs that collect and store water have been the principal method of meeting a constant demand with a variable supply (DWR, 2009) . This alternative includes the construction of new dams and the modification of existing facilities to increase capacity. Reservoirs also provide additional benefits of hydroelectric power, flood management, recreation and operational flexibility. DWR did not provide a cost range of additional surface storage projects due to highly variable nature of regional circumstances and beneficiaries.

2.3.3 Projects to Improve Water Quality

Water quality restricts water supply for specific uses. Therefore improving water quality, by treatment or source protection, expands the useable water supply.

2.3.3.1 Drinking Water Treatment and Distribution

Alternatives for providing drinking water include basic chlorine disinfection, surface water filtration, membrane filtration, ultraviolet light, ozone and dilution with high quality water. Costs of providing drinking water treatment reported by the Metropolitan Water District are presented in Appendix C.

2.3.3.2 Groundwater and Aquifer Remediation

Conjunctive management (use) refers to the coordinated and planned use and management of both surface water and groundwater resources to maximize the availability and reliability of water supplies in a region to meet water supply objectives. Managing both resources together, rather than in isolation, allows water managers to use both resources for maximum benefit. Water is stored in the groundwater basin for later and planned use by intentionally recharging the basin when excess water supply is available. For example, recycled water may be used to supplement surface water supplies or be used to recharge groundwater basins.

2.3.3.3 Matching Water Quality to Use

Matching water “quality to use” is a management strategy that recognizes that not all water uses require the same quality water. A water quality constituent often is only considered a contaminant when that constituent adversely affects the intended use of the water. The California water code governs the water quality standards to minimize the risks to human health, while the State Water Board regulations on wastewater quality aim to minimize the risks to environmental health. Adhering to the regulations under California Title 22, recycled water can be treated to meet a wide range of water quality standards that can be matched to different beneficial uses.

2.3.3.4 Pollution Prevention

The Federal Clean Water Act (CWA) requires each state to adopt a statewide anti-degradation policy and procedures for its implementation. California anti-degradation policy was adopted by the State Water Board as resolution No. 68-16, which establishes the requirement that state water discharges be regulated to achieve the "highest water quality consistent with maximum benefit to the people of the state." The use of recycled water for beneficial use is consistent with the aims of the state anti-degradation policy and provides an economic benefit to the state.

2.3.3.5 Salt and Salinity Management

Beneficial use discussions sometimes leave the impression that water supports one set of uses and then becomes a waste. However, many state communities routinely reuse, reclaim and recycle water multiple times. There is often a high demand for recycled water for landscape and agricultural irrigation, but salt concentrations must be managed to protect the beneficial use or the potential water supply may be lost. The state's Recycled Water Policy, adopted by the State Water Board in May 2009, identifies the need for every groundwater basin/sub-basin to have a salt/nutrient management plan.

Sustainable salt management in any hydrologic region in California protects water resources that may be serving multiple regions in the state. For example, salinity control in the Sacramento Basin may have a relatively small direct benefit in this watershed. However, reducing salt loads in tributary rivers to the Delta could provide a significant benefit to those receiving water through the California Aqueduct (that includes much of southern California) and the Delta-Mendota Canal (much of the San Joaquin Valley). Those benefits include higher drinking water quality, avoided costs, continued ability to produce food and fiber, habitat maintenance, and reduced pre-treatment costs for industries requiring low salinity water supplies.

It's extremely difficult to estimate the cost of sustainable salt management in California. Ideally, salinity control should be incorporated into a broader effort that protects and expands water supplies, optimizes water use, protects fisheries and other habitats, or stores water for future use. Salt management methods vary in effectiveness and cost, depending upon the volume and concentration of salts (expressed as total dissolved solids or TDS – this includes organics, inorganics and colloidal suspensions), type of salt, the desired salt concentration after treatment, and the type of management strategy used.

2.3.3.6 Urban Runoff Management

The primary benefits of urban runoff management are to reduce surface water pollution and improve flood protection. Additional benefits may be to increase water supply through groundwater recharge in areas with suitable soil and geological conditions, and where pollution prevention programs are in place to minimize the impact on groundwater. Groundwater recharge and storm water retention sites can also be designed to provide additional benefits to wildlife habitat, parks and open space.

3. ECONOMIC ANALYSIS

Economic analysis is a systematic approach to finding the optimum use of scarce resources, involving comparison of two or more alternatives in achieving a specific objective under the given assumptions and constraints. It explicitly considers the value of resources employed and attempts to measure the private and social costs and benefits of a project to the community or economy (Howe, 1971).

In contrast to a financial analysis (Chapter 4), the economic analysis takes a broader perspective, including in principle all benefits and costs "to whomsoever they accrue" from the completion of a project (Raucher *et al.*, 2006). Economic analysis is a more comprehensive investigation on the effects of a proposed project. Economic analysis seeks to answer questions such as, will project benefits exceed project costs, and who will benefit and who would pay?

A "full social cost accounting" that identifies and accounts for all benefits and costs of a proposed project is recommended for Economic Analysis (Asano *et al.*, 2007). The process should include benefits and costs that directly affect the proposing agency and the effects of the project on individuals, households and businesses outside of the agency purview. It should also include the benefits and costs that cannot be readily measured using observable market prices and costs.

Economic analysis can be separated into eight major steps outlined in Figure 3-1. While these steps are not comprehensive and represent broad categories in the process, they encompass the most commonly used stages in economic analysis. In the first step, all project benefits and costs are identified regardless of responsibility, timing or location. In the second step, they are quantified or described if they cannot. In the third step, the time horizon or project life is selected. The discount rate is selected in the fourth step, and decision criteria are selected in step five. Steps three, four and five do not have to be performed in order. Step six is an optional risk analysis. The sensitivity analysis is conducted in step seven and the economic feasibility is estimated in step eight.

3.1 Identify Benefits and Costs

The first step of the economic analysis is to identify the costs and benefits of the project. Benefits and costs are of two types: 1) those that directly affect the agency, and 2) those that impact parties outside of the agency. Generally, benefits and costs are identified broadly and inclusively, "to whomsoever they accrue" (federal Flood Control Act 1936). However, sometimes political entities commission economic analysis for a narrower regional or statewide boundary of impacts. For state and federal evaluations of projects, the broad identification of impacts is most suitable.

3.1.1 Direct Benefits and Costs

Direct benefits are an immediate result of project implementation and are generally felt by the agency or customer. Direct costs are out-of-pocket costs to build and operate the water recycling facility and are also borne by the agency or customer.

3.1.1.1 Additional Water Supply

Reclaimed water is an additional water supply that could replace the development of other water sources and should be compared with developing alternate water supply sources or the value of freeing some existing supplies for other uses. Alternatives could include groundwater, surface water, transfers, purchases, desalination, or water conservation (Asano *et al.*, 2007, 1388)

As indicated by the portfolio analysis described in Chapter 2, the additional water supply can also increase the reliability by providing water during droughts. The additional water supply can also improve water quality, increase operational flexibility, reduce flood impacts, decrease energy demand, expand recreational opportunities, and reduce groundwater overdraft.

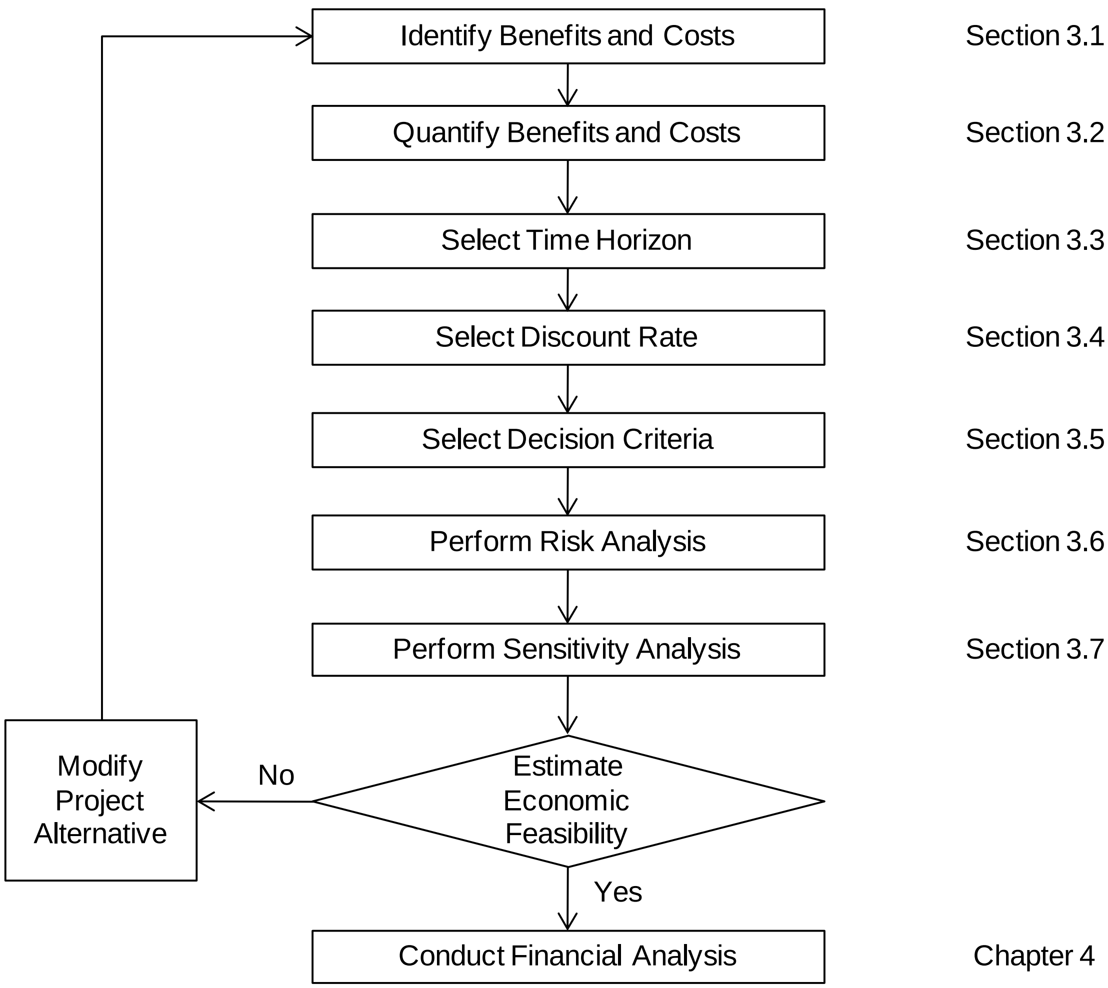

Figure 3-1. Economic Analysis of a Project Alternative

3.1.1.2 Reliability

Reclaimed water improves the reliability of existing water supply systems. Additional reuse water supplies can make the system less sensitive to drought conditions. Increase in water supply reliability reduces the probability of water use restrictions, which has a direct value to industrial, commercial, and residential water users and serves as an attraction for future economic development.

3.1.1.3 Local Control

Water supplies that originate outside of the agency's jurisdiction are often subject to the decisions and policies of other parties. Local water recycling may increase the degree of local control and thereby reduce reliance on outside parties.

3.1.2 Indirect Benefits and Costs

Indirect benefits and costs are realized by parties outside of the proposing agency and they are not considered in the financial analysis of the proposed project. In economics, indirect effects of economic decisions are called "externalities". Externalities occur when the all effects of a transaction are not reflected in the market price of goods and/or resources. In the case of indirect or external benefits, the responsible agency does not receive true worth of the action and produces less of the product than would be optimal. In the case of external costs, the opposite is true. The true cost of the agency's actions is not reflected in the cost and more of the product is produced than is optimal.

In the case of water reuse projects, potential indirect benefits and costs result from changing the existing surface water and groundwater hydrology and changes in water quality.

3.1.2.1 Environmental Changes

Water recycling may reduce surface water diversions resulting in a more naturally occurring flow regime and enhanced water quality for native species. More natural conditions can help native species thrive and aid in the restoration of deteriorating habitats. Benefits are not only for the species but also for users of national parks and other outdoor locations that rely on these environments. Environmental benefits are produced if reclaimed water use will help enhance, develop, or improve a surface water body, habitat or ecosystem (Raucher *et al.*, 2006). Costs can result from reduced flows negatively affecting downstream habitats.

Recent improvements in wastewater treatment have resulted in a higher quality discharge and subsequent improvements to the water quality of receiving waters. The benefits of increased water quality include improved instream flows, and riparian and wetland habitats. This enhances water-based and passive recreational use opportunities.

Water reuse projects can have positive or negative effects on streamflow. Positive effects of water reuse projects include the prevention of critical low-flow conditions by reducing surface water diversions, which results in a more naturally occurring flow regime and enhanced water quality for species. More natural conditions can help native species thrive and aid in the restoration of habitats. Enhancing streamflow affects riparian habitat that supports plants that in turn provide flood control and water quality improvement by filtering contaminants and taking up nutrients. Ecological benefits that include enhanced critical wildlife habitats for threatened or endanger species can have a substantial monetary value. Fishing, boating and other forms of water-based recreation due to enhanced streamflows can also have significant monetary value. Water reuse projects can also negatively affect streamflow by increasing total consumptive use of the existing streamflow. The negative effects on streamflow can be resolved by changes in water rights.

Water reuse projects can be critical in preserving and enhancing wetlands. Wetlands can provide a wide range of benefits. Wetland habitat supports a variety of species of microbes, plants, insects, amphibians, reptiles, birds, fish and mammals. Wetlands provide flood control, improve water quality by filtering contaminants, recharge groundwater, prevent shoreline erosion, and facilitate recreational opportunities.

Water reuse projects have potential to significantly change the hydrology of a region. If water recycling reduces groundwater pumping and overdraft is reduced, economic benefits will result.

Minimizing overdraft may avoid subsidence or reduce the rate of saltwater intrusion to the aquifer which can represent a critical benefit to region (Raucher *et. al*, 2006). Water reuse projects can also be important for conjunctive water management. Benefits would be a reduction in subsidence and avoiding increased pumping costs.

3.1.2.2 Recreation

A water recycling facility may provide water to create or enhance recreational facilities such as sports fields, urban parks or greenbelts. Benefits are accrued to ballplayers, picnickers and other users of recreational facilities irrigated with recycled water. Aesthetic benefits for residents living in the vicinity of these facilities and carbon sequestration benefits may also be significant.

3.1.2.3 Nutrient Value

Benefits may result from the nutritional value provided if reclaimed water is used for agriculture or horticulture and nutrient content acts as a replacement for fertilizer. Reduced fertilizer use can improve underlying groundwater quality by reducing nitrate loading into groundwater. Conversely, higher nutrient content in applied water could also have negative effects on the underlying soil and groundwater.

3.1.3 Economic Impact Analysis and Equity Assessments

An economic impact analysis identifies groups that benefit or are harmed by the project and then measures the magnitude of those changes. These changes are estimated across broadly defined economic sectors that include industry, consumers and governments. The analysis measures direct and indirect impacts. Impacts are measured by changes to gross regional product, income, employment, government revenues and expenditures, and prices. The assessment requires that projected levels of the afore-mentioned variables be compared with baseline levels.

An equity assessment focuses on effects on the income and employment of disadvantaged sub-populations. In an equity assessment, income and employment impacts on small businesses, small government jurisdictions, small not-for-profit organizations, socially disadvantaged populations, and economically disadvantaged populations are estimated.

3.2 Quantify Benefits and Costs

In the second step, benefits and costs are quantified in monetary terms or alternatively qualitatively described. Benefits and costs should be quantified for each category of user or project participant. Project participants to consider are the water supplier, wastewater agencies, customers, and society.

3.2.1 Methods to Value Additional Water Supplies

Water recycling may help avoid or postpone investments in expanding water supply and wastewater capacity. Augmented water supply from sources other than recycling may increase wastewater volumes to treat, requiring different equipment or a greater plant capacity. Possible avoided costs include reduced imports or delayed capital expenditures on acquiring new freshwater sources. Operation and maintenance costs can also be reduced as no additional potable water treatment would be required. In many cases, the value of reuse water can be derived from the marginal cost of new water supplies. The avoided cost of the alternative should be part of the baseline analysis.

In accounting for avoided costs, there is a risk of double counting benefits. It is important when identifying benefits and avoided costs that it is only counted once in the economic analysis. For example, double counting can occur when recycled water is accounted for as a future avoided cost (such as disposal) and the sale of that recycled water is also accounted for as a benefit.

Out-of-pocket life cycle costs to the agency should be used to value the direct project costs. This includes the cost of capital equipment, operational and maintenance costs, water supply acquisition costs, treatment and distribution costs, overhead and administration fees. Cost sharing arrangements and any public subsidies also need to be included.

3.2.2 Methods to Value Water Supply Reliability

Water customers value a water supply that will not be interrupted during drought. Water reuse projects can provide greater water supply reliability. Raucher *et al.* (2006) provides guidance on estimating the value of water supply reliability. Studies have been done to estimate the value of water supply reliability based on customers "stated preferences" and "revealed preferences". Stated preferences are opinions elicited directly from customers. Revealed preferences are derived by observing actual market choices made by the customers. Results from both approaches are presented with the recommendation that the conditions of the estimates be considered before using specific values. Both approaches have strengths and limitations, as discussed by Raucher *et al.* (2006).

3.2.3 Methods to Value Local Control

Placing a monetary value on local control is generally difficult since it depends on the sources and conditions of existing water supplies. The value of reducing the importance of outside rules and policies can probably best be valued by describing what management or operational decisions would be affected and the extent of the increased flexibility a water reuse project would bring. Documenting past experiences that would be different if the water reuse project existed would be helpful to understand the value of improving local control.

3.2.4 Methods to Value Environmental Changes

The literature on valuing environmental changes is extensive and varied but is relatively difficult to employ in this type of analysis. Raucher *et al.* (2006) suggests several practical procedures to value environmental changes and these are summarized here. To facilitate evaluation, environmental changes were organized into the following categories.

- Water quality
- Groundwater
- Endangered species habitat
- Wildlife habitat
- Coastal Ecosystem
- Wetland
- Air Quality

3.2.4.1 Water Quality

Water reuse projects will directly reduce treatment plant discharges which may improve the quality of the receiving water course. Improved water quality increases the extent and the number of the beneficial uses. A good example of the effects of increased water quality is shown in the quality standards required for various water uses. In irrigated agriculture, improvements in water quality result in increased crop yields in addition to a wider variety of crop selection.

The value of improved water quality is typically embedded in the value of the beneficial use which in economics is called a derived value. Direct values of water quality have been estimated by surveying affected populations. Raucher *et al.* has reported results from a number of studies on the willingness to pay for improved water quality (Raucher *et al.*, 2006, p. 123). The following reported values are presented as examples of the values that could be used for valuing water quality improvement for water reuse projects. The total value of improved water quality would depend on the number of households or residents in the project area.

Appendix C of this document presents willingness to pay ranges of values for residents of Ohio, Ontario, Pennsylvania and North Carolina from Raucher *et al.* (2006). If these values are sufficient to warrant further consideration in the case of the proposed project, estimates can be made either by direct survey or transferring values from existing studies.

3.2.4.2 Groundwater

Increases in stream flow that affect the recharge and quality of groundwater is a benefit to the proposed project. Raucher *et al.* (2006) reported results from a number of studies on groundwater quality. Some studies provide willingness to pay for improved groundwater quality, secure uncontaminated groundwater, and restoring contaminated groundwater in different locations. These are presented in Appendix C. Many more studies exist on the value of groundwater, related quality, and alternative methods of estimating the value of specific aquifers.

3.2.4.3 Endangered Species Habitat

Aquatic wildlife habitat is sensitive to changes in water quality. Values for the habitat are derived from the value of the species. Several studies have been done to estimate the willingness to pay for protecting threatened and endangered species (Raucher *et al.*, 2006). A survey of values for preserving endangered species in different locations is provided in Appendix C.

3.2.4.4 Wildlife Habitat

Wildlife diversity and wildlife habitat are important to the general welfare of the region. The value of preserving adequate water quality has been estimated in a number of published studies. Appendix C provides survey responses for protection of water supply in Mono Lake and the Pacific Northwest as examples.

3.2.4.5 Coastal Ecosystems

The ecological health of coastal and estuarine ecosystems is important to individuals, environmental groups and recreationists most of which may not reside in the agency's service area. Coastal ecosystems values for improvement estuaries in North Carolina, shore beach maintenance in Chicago and coastal ponds in Massachusetts are presented in Appendix C.

3.2.4.6 Wetlands

Wetlands are intrinsically linked to surface water and groundwater. Improvements in water quality will directly result in economic benefits due to the vast array of unique goods and services provided by wetlands. Wetlands are supported by worldwide organizations and environmental groups have begun efforts to preserve and enhance these critical areas (Mitsch and Gossenlink, 2000).

The literature of estimating the value wetlands is substantial with over 200 estimates derived from 80 studies worldwide. Raucher *et al.* (2006) summarize a number of these studies for Ohio, Kentucky and New England. A compilation of these values is presented in Appendix C. Other values are also presented in Ghermandi *et al.* (2008).

3.2.4.7 Greenhouse gases

The California State Water Project is the largest single user of energy in California. In the process of delivering water from the San Francisco Bay-Delta to Southern California, the project uses 2 to 3 percent of all electricity consumed in the state. The State Water Project burns energy pumping water 2,000 feet over the Tehachapi Mountains, the highest lift of any water system in the world.

In both urban and agricultural settings, reusing water is far less energy intensive than any physical source of water other than local surface water. For example, Orange County's water recycling system uses only half the amount of energy required to import the same amount of water from Northern California. Groundwater pumping is more energy intensive in San Diego and the Westlands Water District than water recycling from urban wastewater.

Energy use is intimately linked to the production of greenhouse gases and any initiative that reduces energy use will reduce the commensurate amount of greenhouse gases. Producing and using recycled water locally uses less energy and therefore produces less greenhouse gases than using potable water.

3.2.5 Estimating Economic Impacts and Conducting an Equity Assessments

Water reuse projects can affect the income and employment of the broader population. In most cases these impacts will not be significant, but the potential does exist. Estimating the total economic impacts of potential projects can be estimated using existing models (Table 3-1).

The most robust approach is a Computable General Equilibrium model (CGE). However the expense and time to apply this approach is prohibitive except for cases that have long-term economic impacts and broad geographic significance.

The Regional Economic Models Inc. (REMI) model often possesses the capability of accurately estimating economic impacts for the necessary geographic scale. It is readily available on a timely basis, but it is expensive for this purpose.

The Impact Analysis for Planning (IMPLAN) model is a good alternative to assess direct and indirect economic effects of potential projects. It is readily available at a reasonable cost. Using the model requires some training that is available through the distributor.

The least expensive approach is the Regional Input-Output Model (RIMS) that is available from the United States Department of Commerce. However, it requires a familiarity with input-output analysis and how an analysis should be conducted.

Table 3-1. Economic Impact Models

Model Name	Project Manager	Description
Regional Economic Models Inc. (REMI)	Regional Economic Models Inc.	An integration of multiplier, econometric and general equilibrium models.
Impact Analysis for Planning (IMPLAN)	Minnesota IMPLAN Group	An input-output multiplier model using Social Accounting Matrixes over a particular geographic region to investigate the consequences of projected economic transactions among industry and institutions.

Regional Input Output Modeling System (RIMS)	U.S. Bureau of Economic Analysis	An input-output model for the U.S. showing industry inputs purchased and products sold among 500 sectors.

The United States Environmental Protection Agency (USEPA) recommends completing an "equity assessment" to examine how costs and benefits affect the population and the regional (or national) income and wealth. The assessment suggests a three-step equity assessment: 1) define scope of the equity analysis; 2) define distributional variables, 3) measure equity consequences. The populations to consider are grouped into four categories: individuals, businesses, not-for-profit organizations, or governments. Disadvantaged sub-populations within these groups are of particular interests as they might be under-represented, vulnerable or economically disadvantaged. Equity categories to examine include entity size, minority status, income level, childhood status, gender, type and physical sensitivity. More details on conducting equity assessments can be found in the Guidelines for Preparing Economic Analysis (USEPA, 2010).

3.2.6 Estimation of potential financial burdens to non-participants

In some cases, unintended financial burdens may occur for project non-participants as a result of a water recycling project. However, these costs are not part of the recycling project's proponent financial analysis, and are rather economic costs of the project. Affected non-participants may be the water supplier (either local supplier or wholesaler) or downstream water users. This includes potable water wholesalers and retailers that may lose water sales revenues as the new recycling facility starts operations and takes some market share.

Water recycling also may reduce the water volume available for downstream users. If downstream communities rely on this water for their water supply, reductions in upstream flow will affect the finances of downstream water suppliers. In both these cases, recycled water may affect non-participant freshwater rates. Fresh water prices can increase as estimated water use decreases and fixed costs remain roughly constant, thus increasing financing costs to non-participants. Fresh water demand also can be reduced relative to recycled water, thus reducing the supplier's revenue. The example in Chapter 5 illustrates how the impact to project non-participants could be taken into account in the economic analysis.

3.3 Select Time Horizon

Selecting the time horizon of the economic analysis should be based on stated criteria and not be arbitrary. The time frame should be long enough to cover the expected life of the project's capital investments or when the net benefits of the project are expected to be negligible when discounted to the present.

3.4 Select Discount Rate

Discounting makes benefits and costs that occur in different time periods comparable by expressing their values in present terms. This is done using a discount rate. A discount rate accounts for the opportunity cost of using money now versus in the future. The discount rate reflects that a dollar used now is worth more than a dollar in the future; therefore, benefits and costs that accrue early in the project are worth more than those realized later. The discount rate is not the same as the rate of inflation. When completing an economic analysis, all benefits and costs should be adjusted using the discount rate so that they are recorded in present value dollars or constant dollars, corrected for inflation. The use of constant dollars avoids the need to account for inflation in costs and benefits. As the discount rate increases, the present value of money decreases.

The discount rate used is often constrained by regulations or agency. For example, Reclamation and the United States Army Corps of Engineers (USACE) are subject to federally-established rates. DWR and the State Water Board currently use a 6% discount rate. The USEPA (2000) suggests using the consumption rate of interest for inter-generational discounting when changes in consumption cash flows rather than in capital stock occur in a project. Based on government backed securities these rates are currently around 3 percent. When changes in capital stock are more likely, the rate of interest of private capital is more appropriate. Currently the Office of Management and Budget estimate the opportunity cost of private capital is 7 percent.

Discount and interest rates are commonly controversial in economic and financial analyses. Decisions on millions of dollars rely on this parameter. Therefore, a sensitivity analysis using different discount rates is sometimes appropriate. USEPA (2000) suggests displaying the time paths of benefits and costs projected over the project time horizon without discounting, discounting using the consumptive rate of interest (3 percent) and the rate of return on private capital (7 percent). This defines the extent of the results to the feasible range of discount rates.

3.5 Select Decision Criteria

Various decision criteria are commonly employed in economic analysis. Usually one decision criterion suffices to assess the economic feasibility of a project (Au, 1988). Among the most widely used ones is the Net Present Value (NPV). In this section we describe common decision criteria with additional references.

3.5.1 Net Present Value

The NPV is the difference between the benefits and costs of a project. To ensure fair comparisons, all benefits and costs are adjusted using a discount rate. If the NPV is positive, the benefits of the project exceed its expected costs and the alternative is desirable relative to no action (a common base case). In general, alternatives with the highest NPV per unit budget cost should be funded.

3.5.2 Benefit Cost Ratio

Similar to NPV, the benefit-cost ratio sums total benefits and costs using the discount rate. However, rather than subtracting the costs from benefits, they are presented as a ratio of benefits to costs. A ratio greater than one indicates benefits exceed costs and the project is economically justifiable (DWR, 2008). One drawback of benefit-cost ratios is in accounting for negative costs. Negative costs will lower the sum of costs and artificially inflate the ratio. In NPV the net effect of the negative costs would be the same (Lund, 1992).

3.5.3 Annualized Net Benefits

The Annualized Net Benefits (ANB) criterion is equivalent to the NPV method in its formulation (Sassone and Schaffer, 1978). The difference is that it transforms a fluctuating time stream of net benefits into annualized values.

3.5.4 Internal Rate of Return

The goal of the Internal Rate of Return (IRR) is to determine what discount rate will result in net benefits equaling the net costs. The IRR approach uses the net present value formulation to sum costs and benefits. However, the NPV is set equal to zero and the discount rate that equates benefits and costs is determined. The resulting discount rate can then compared to the discount rates that could be applied. If the computed discount rate is greater than the selected discount rate the project is considered justified (as mentioned above, a higher discount rate lowers the present value).

3.5.5 Expected Net Present Value (ENPV)

By specifying risk in the form of estimated probabilities, NPV becomes Expected Net Present Value (ENPV). The benefit of using ENPV is that it accounts for risk by using probabilities for sets of parameter values (scenarios). Estimating these probabilities may require specialized statistical skills. Using the probabilities estimated for each scenario, a single value for ENPV can be calculated.

3.6 Risk Analysis

For some projects a risk analysis may be required. Risk analysis uses probability distribution functions to show a range of outcomes. As demonstrated with ENPV, probabilities can be incorporated into the calculation. Methods to perform a risk analysis in connection with an economic analysis are out of the scope of this document.

Risk analysis is helpful in estimating the frequency and magnitude of events and potential associated outcomes. Examining a range of outcomes and probabilities provides a snapshot of likely burdens and benefits for each event. In the context of water recycling, flooding events and prolonged droughts, and even longer-term issues such as sea level rise or regulatory changes, may change the payoff of a project. Unforeseen new recycled water uses and shifts in consumer preferences towards more or less recycled water also may affect the initial estimates.

A risk analysis can be qualitative or quantitative. Quantitative risk analysis can be deterministic or stochastic. In deterministic analysis, specific point estimates of an outcome are assumed, whereas in stochastic analysis a range of values and its probability distribution are used. Deterministic risk analysis can include worst case, best case and most likely scenarios as single-point estimates. Stochastic risk analysis provides likelihood of outcomes and its consequences. Small projects might benefit less from costly and time consuming risk analysis. Routine calculations through simple spreadsheets for a range of alternatives can be employed instead. Large investment projects involving large consequences can justify allocating more funds to risk analysis.

A Monte Carlo analysis is considered a risk analysis and establishes a range of values for the parameter considered uncertain, and then analyzes random samples of parameter values from probability distributions. Variables have a probability distribution of different outcomes. Probability distributions are a realistic way to represent uncertainty. A deterministic analysis follows for each set of randomly drawn parameter values. The net present values are then averaged to estimate the expected net present value. This approach requires more elaborate estimation of the statistical and correlated properties of each uncertain parameter.

3.7 Perform Sensitivity Analysis

Uncertainty and risk are present throughout the economic analysis as there are no assurances that predictions are accurate. When doing the analysis, areas which are likely to be sensitive should be clearly identified and addressed (Water Resources Council, 1983). To address risk and uncertainty, sensitivity and risk analyses can be utilized. A sensitivity analysis varies values of key variables, such as the discount rate, to determine the effect on the final outcome.

3.8 Assess Economic Feasibility

Project evaluation compares alternatives over the same period of analysis and using the set discount rate and the chosen decision statistic. Most of the methods mentioned above are similar in the sense a discount rate is used to translate values over time. The difference lies in how costs and benefits are expressed. For the same stream of net benefits the NPV may be lower at higher discount rates, whereas the annual value will be higher or lower depending on the length of time benefits and costs are annualized. NPV is usually more informative for projects requiring immediate investments but Annualized Net Benefits (see. 3.5.3) are useful in comparing different infrastructure with different service life.

4. FINANCIAL ANALYSIS

4.1 Introduction

Financial analysis provides an assessment of a project's monetary desirability (income and expenses) to the sponsoring water utility over the period of analysis. While a necessary consideration, financial feasibility is not a sufficient condition to build a project. It establishes financial actions needed for a project's monetary success; however, it does not account for the wider costs and benefits addressed in economic analysis. Financial analysis should be completed if the economic analysis demonstrates that the project is justified.

A financial analysis is used by the project proponent to estimate funds needed to construct and operate a project over the period of analysis. A project is considered *financially feasible or solvent* if the agency has sufficient capital for construction, can pay for costs over the repayment period, and estimated revenues can cover operations and maintenance costs and debt service payments over the period of analysis (Ernst and Ernst, 1979).

The proponent's perspective is used for the accounting perspective in a financial analysis. This perspective will identify financial shortfalls which may require external funds and will identify each user's stake in the project. Sources of funds can include local bonds, state or federal loans, or private loans and incentives. In some cases, supplemental financial analyses, from non-participant perspectives, may also be needed.

This chapter outlines a framework for financial analyses of water recycling projects. The chapter begins with a summary of the process, with details for elements addressed in subsequent sections. The basic steps for a financial analysis are shown graphically in Figure 4-1.

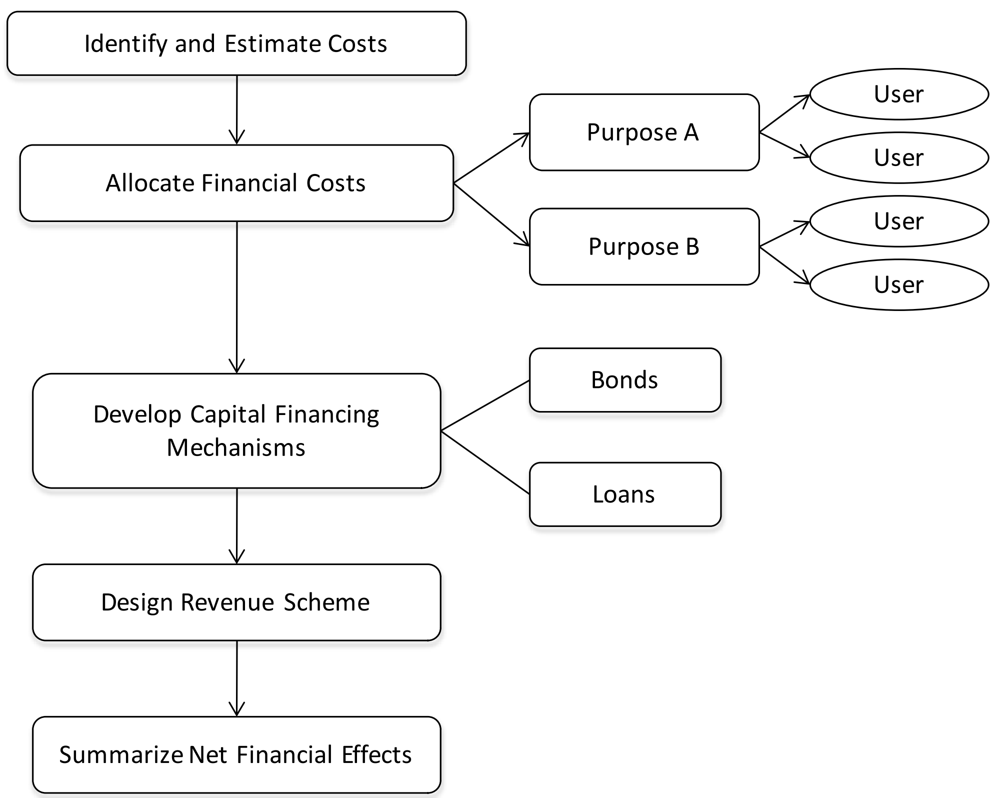

Figure 4-1. Financial Analysis Process.

To summarize the process, project costs are identified and estimated in monetary terms, typically at market prices (Step 1). Costs are then allocated among project purposes and participants (Step 2). In construction and operation of a new project, two main monetary flows are to be considered: a) capital financing and b) revenues. For capital financing (Step 3), potential sources such as bonds and loans are identified and described in terms of the funds available and repayment requirements. The other funding consideration is revenue sources from the project (Step 4). This formulation allows overall financial assessment of the project for the project proponent (Step 5). A detailed description of each step is presented in the following section (Section 4.2). Step by step guidance is presented in Chapter 5.

4.2 Financial Analysis Process

4.2.1 Identification of Financial Costs

Financial costs are actual *out-of-pocket* costs. These include the capital costs from construction, operations and maintenance costs, and debt service repayments. A non-comprehensive list of potential costs is presented in Table 4-1. Costs are estimated based on expected prices of expenditures and are adjusted in time to include inflation. This contrasts to the economic analysis which uses the discount rate to quantify benefits and costs in constant dollars. It is important to note that *sunk costs*, such as existing debt service payments or existing facility operations and maintenance costs, are not included in the financial analysis since these costs would be incurred with or without the project.

Table 4-1. Financial Costs of a Proposed Recycling Project

Cost	Item

Capital Costs	<u>Project Design Costs</u>
	Land purchase
	Planning, design, and engineering
	Materials
	Labor
	Other
	
	<u>Project construction costs</u>
	Materials for recycling facility
	Materials for distribution system
	    Cost to build system
	    Cost to connect users
	
	<u>Labor</u>
	Environmental Mitigation
	Licenses/Fees/Legal
	Retrofitting costs to convert plant to recycled water
	Retrofitting costs for users
	Regulatory Costs
	Administration/Overhead

Table 4-1. Financial Costs of a Proposed Recycling Project

Cost	Item
Operations and Maintenance Costs	Annual Operations Labor Materials Annual Maintenance Labor Materials Training and continuing education Regulatory Costs Cross-connection control and projection
Avoided Costs	Potable water replaced Wastewater disposal costs

4.2.2 Financial Cost Allocation

A project involving water treatment may serve several purposes and users depending on the process and infrastructure. Broad purposes include pollution control and water supply augmentation. Costs can be allocated among users and purposes using the *Separable Costs-Remaining Benefits Method (SCRB).* With the SCRB method, costs are distributed among project purposes by identifying separable costs for each purpose or participant and allocating joint costs or joint savings in proportion to each purpose's remaining benefits (DWR, 2008, p. 48). Sequential steps for the SCRB method are:

1. Estimate benefits for each purpose.
2. Estimate *Alternative Costs*, which is the cost of a single-purpose project for each benefit identified in step 1.
3. Determine the *Justifiable Cost*, which is the lesser of the two items above. The justifiable cost represents the maximum that can be allocated to a specific purpose.
4. Estimate the *Separable Cost* of each purpose by subtracting the project cost with the specified use omitted (given) from the cost of the multipurpose project.
5. Separable cost of each purpose should be deducted from the justifiable costs to determine its remaining justifiable costs.
6. Estimate purpose's percent share of the remaining sum of justifiable costs of all purposes.
7. Deduct the total separable cost from the total project cost to determine the total remaining *Joint Costs*.
8. Distribute the joint costs proportionally for each purpose by weighting them with percent shares estimated in step 6.
9. Cost allocation to each purpose is the sum of the distributed remaining joint cost and the separable cost.

A step-by-step approach to using the SCRB method is presented in Chapter 5. Other less-used methods include the Alternative Justifiable Expenditures, and Proportionate Use of Facilities methods (DWR, 2008).

4.2.3 Capital financing mechanisms

The likelihood of receiving funding depends on the financial standing of the proponent. Therefore, the first step in considering potential financing sources is to assess the proponent's financial standing. A summary of the information needed to assess the financial standing of the proponent is presented in Chapter 5.

In California, water project facilities can be financed through 1) general obligation bonds, 2) tideland oil revenues, 3) revenue bonds, 4) loans and 5) accumulated capital resources. Long term water agency contracts repay most of this debt service. A summary of capital funds, as presented in Table 4-2, will aid financial analysis.

Table 4-2. Hypothetical summary of capital funds (adapted from Ernst and Ernst, 1979).

Source	Projected Amount	Other Information (e.g. repayment period, interest rate)
Grants		
EPA: Clean Water Grant Program		
State: Clean Water Grant Program		
Bonds and Debt		
General Obligation		
Revenue Bond		
General Funds		
Water District Funds		

4.2.4 Revenue-generating tools to repay costs

Revenue sources are needed to cover the financial costs of a recycling project in the long and short term. As such, potential revenue sources should be identified and quantified. A list of potential sources listed in Asano *et al.* (2007):

- Recycled water delivery charges;
- Recycled water user connection fees;
- Wastewater disposal fees/service charges;
- Regional incentive or rebate programs;
- Fees on new development;
- Property taxes on reclaimed water users and/or all properties in the community; and
- Water use surcharges.

Revenues from recycled water sales are a major mechanism to repay project costs of water recycling facilities. The revenue generated from recycled water deliveries depends on the rate structure for recycled water. Recycled water may be priced below potable water cost if the project is driven by wastewater disposal; or the price may be set near or above the potable water cost if reliability of supply is given a high value.

Projections from the revenue sources should consider the use projections established in Chapter 2. For example, the revenue generated depends on demand projections and market assessment for recycled water, established contracted uses, and potential users. The revenue scheme should account for changes in sales with time. New rate schemes may be desired to raise and stabilize revenues for the new project.

4.2.5 Overall Financial Assessment

Once costs have been allocated and revenues estimated, an overall financial assessment of the project is conducted. This assessment produces an overall net cost (or financial balance) for the project. The net cost is used to modify recycled water rates or other charges or as a basis for seeking external financial subsidy.

4.2.6 Financial contingencies and uncertainties

Uncertainty in water recycling is present in many aspects of a project. There is uncertainty in the amount of water recycled as operating conditions change over time, including the level of treatment needed, capital and operation and maintenance (O&M) costs, financial markets for debt repayment, and recycled water demands as consumer preferences and land uses change. Contingencies can be used to accommodate some of the uncertainties in the financial analysis. In addition, contingency plans should be developed for system failures to supply water or to meet standards. Contingency costs may include cross-connection tests, contingency plans for exceeding water quality standards, and a backup treatment system. A prudent financial analysis may include cost of contingencies for such circumstances.

4.3 Conclusions

The financial analysis is used to establish the financial feasibility by accounting for the proposed costs and projected revenues. The analysis takes the proponent's perspective. If the proposed recycling facility could potentially affect a non-participant's finances, a supplemental financial analysis may be needed. To summarize the process, project costs are estimated using market prices. Costs are then allocated among purposes and participants using the *Separable Costs-Remaining Benefits Method*. With the costs clearly itemized and totaled, capital financing sources and revenue schemes are constructed. Finally, with the project costs and revenues outlined, an overall financial assessment can be completed. The financial analysis is completed if the economic analysis demonstrates that the project is justified.

5. ROUTINE ECONOMIC ANALYSIS

5.1 Introduction

This section provides routine economic and financial evaluation methods for water recycling in California. This Economic Analysis Guidance Document is designed to help the reader prepare grant and other funding applications for water recycling projects in California through the California State Water Resources Control Board Division of Financial Assistance. This section should be used as a companion to the provided electronic MS Excel 2010 work books for the economic analysis. Worked examples of the presented routine calculations and the spreadsheets also can be found in this chapter.

It should be noted that table references used in this section follow the table nomenclature used in the workbooks. Thus the first table in this section is Table 2A corresponding to Table 2A in the econ-analysis-final workbook.

5.2 Screening Level Analysis

In a screening level analysis, the objective is to streamline economic and financial feasibility analysis of a proposed project by reducing the information and data requirements to a reasonable minimum. This simplification entails stronger assumptions regarding the economic values of fresh water alternatives and treatment costs, more restrictive (uniform) patterns of recycled water production and quality, and fresh water replacement over the period of analysis. Some elements of the screening level analysis that require user input are:

- Useful Life of Project
    - Minimum value for this category must be the life of the longest loan. However, the value most likely should be based on the longest lifetime of what is being assessed (plant, pipe, etc.). In a combination project that involves treatment and distribution, the user should use the lifetime of the component with the longest life.
- Loan 1,2, and 3:
    - Each loan amount has a corresponding slider bar (with a range of values from $0 to $50,000,000) that should be used to determine which loan values provide an economically favorable response in the screening assessment.
- Interest Rate for Each Loan
- Term For Each Loan
    - Each term has a corresponding slider bar (with values ranging from 0 to 50 years) which should be adjusted to determine the optimal term length for each loan. An optimal term length should result in an economically favorable response in the screening assessment.
- Grant
    - There is a slider bar for the grant amount (with a range of value from $0 to $50,000,000)
- Discount Rate
- Annual Operation and Maintenance Cost (Includes Waste Water Treatment Cost)
    - Confidence in Marginal Cost of Fresh Water ValueUser should use the corresponding slider bar to represent their confidence in the value entered for the Marginal Cost of Fresh Water as a percentage between 0 and 100.
- Marginal Cost of Fresh Water – this is the cost of State Water Project water if it is available or the least cost of fresh water available in $/af

- Potable Water Retail Price this is the customer price of potable water in $/af
- Average Annual Expected Delivery – in af

A brief summary of the meaning of each value in the screening analysis can be seen by selecting the cell that contains the value of interest. It is assumed that fresh versus recycled water replacement factors, recycled water deliveries (sales), and annual operating and maintenance costs are constant. A project is considered potentially economically favorable if the NPV/af of Recycled Water is greater than the NPV/af of fresh water. Furthermore, a project is considered conditionally favorable if the NPV/af of recycled water is less than the NPV/af of fresh water by a small enough margin that the difference could be accounted for by the confidence level of the marginal cost of fresh water. Other alternatives may have a higher NPV, but any positive NPV alternative may be selected when other factors are included. This sheet is mainly used to determine if the user should continue on to perform the more detailed economic analysis. Therefore, regardless of the value of the NPV/af for recycled water, a favorable or conditionally favorable response in the screening assessment informs the user that recycling water is potentially an economically favorable decision and the user should continue on to carry out the full economic analysis. Calculations are shown in a background calculation sheet.

5.3 Economic analysis

Economic analysis compares alternatives that address an identified problem and objective. Projects are valued by quantifying the benefits and costs in monetary terms. The value for each alternative is then compared to the “without project” scenario, the alternatives are ranked, and the best alternative is selected. . Each alternative is analyzed using the same period of analysis and baseline conditions. The table headings presented here and thereafter refer to the tables in the electronic spreadsheets and do not follow the sequence of table captions in this Economic Analysis Guidance Document. In the instructions sheet there is a table of contents with links that will take the user to any page of the workbook. Note that a new workbook must be created for each alternative.

5.3.1 Routine Method & Spreadsheet Templates.

In the provided spreadsheets for economic analysis, the individual tabs require the following information:

- Describe the project information;
- Establish the standard assumptions;
- Establish the baseline conditions and define the without project scenario;
- Identify the benefits and costs;
- Quantify the monetized benefits and costs, and describe the qualitative benefits and costs;
- Select a decision criteria;
- Numerically evaluate the project for the selected decision criteria;
- Complete a sensitivity analysis;
- Summarize the net benefits for the alternatives; and
- Compare alternatives.

This section describes these steps in detail and provides a set of templates to accomplish an economic analysis. This document is designed using the Expected Net Present Value (ENPV) method for the evaluation. Details on the ENPV formulation are provided in Section 3.3.

Step 1: Define the project information

The first step is to provide basic information about the agency (or agencies) considering reuse, the individuals completing the analysis, and the type of project being considered. A statewide accounting perspective is taken for the entire analysis. This information is tabulated on **worksheet 1. Project Information**.

The following information is necessary as it will be used throughout the model:

- Phases of operation (Year). Enter the starting year of phase 1 or start of the operation.
- Name of Alternative. The economic analysis should be performed for each alternative, and each alternative should have a unique name.
- Project Users. This is a list of beneficial use users or categories, such as golf course irrigation, landscape irrigation, misc. commercial use or misc. industrial use.

Step 2: Establishing standard assumptions

Prior to undertaking the economic or financial analysis, the standard assumptions should be described. The assumptions are accounted for in **Table 2A: Standard Assumptions** on **worksheet 2. Std. Assumptions**.

Table 2A: Time and Interest

User Input	**Description of cell values used in the economic analysis**
Useful Life of project	Minimum value (in years) for this category must be the life of the longest loan. However, the value most likely should be based on the longest lifetime of what is being assessed (plant, pipe, etc.). In a combination project that involves treatment and distribution, the user should use the lifetime of the component with the longest life.
Installed Capacity	Capacity of the proposed recycling facility in acre feet (AF).
Recycled Water Market Price	Price to be charged for acre foot of recycled water sold. The price should be based on the market assessment for recycled water.
Potable Water Replacement Factor (for RW)	The proportion of fresh water that is replaced by using recycled water. This is presented as a percentage and assumes that the same replacement factor is applicable for all uses.
Project Design Year Reference Cost Year	The year the design process begins. Represents the base year in the calculations. Inflation effects in this year are 0. Following this year, inflation is accounted for using the established rate.
First Year of Project Construction	The year construction is intended to begin.
Project's First Year of Operation	The intended year the water recycling facility will be functional.
Project's Last Year of Operation	The last year which the project will operate. The last year of operation is equal to the project construction year plus the period of analysis.

Table 2A: Time and Interest

User Input	Description of cell values used in the economic analysis
Financing Period	Set by bond and loan schedules. Represents the time frame over which payments are to be made.
Annual Interest Rate	This will be set by the individual bonds and loans used to finance the project. They will be specific to each bond and loan.
Annual Discount Rate	Discount rate

Step 3: Establish Without Project Conditions

The next step is to describe the "Fresh water supply alternative" scenario using costs. These are tabulated in **Table 3A: Annual Fresh Water alternative cost**on **Worksheet 3.1**Costs considered are:

- Annual avoided operations and maintenance costs of water supply treatment;
- Annual avoided operations and maintenance costs of water transmission;
- Annual avoided operations and maintenance costs of water distribution;
- Annual avoided operations and maintenance costs of wastewater treatment and disposal; and

Annual Fresh Water supply CostThe gray area provides space for the user to enter in other considerations for the annual fresh water alternative cost. The economic analysis results are compared with the cost of fresh water at the end of the workbook.

The next step is to establish the Total Volume of fresh water and total volume of recycled water in acre-ft for the life of the project. The total lifetime fresh water alternative must be equal to or greater than the total lifetime recycled water produced in order to demonstrate that there is fresh water supply throughout the project.

Step 4: Identify benefits and costs and Step 5: Quantify monetized benefits and costs, and describe qualitative benefits and costs

Steps 4 and 5 may be found under worksheets **4.1. Econ Analysis Id & Quant Ben** and **4.2. Id & Quant Costs** respectively. Information for each of these steps is entered into Tables 4A and 4B respectively. These tables should be completed for each category of user that will be impacted for each alternative being considered. The points-of-view to consider are: water supply agency, wastewater agency, regional agencies, customers, or society. As mentioned in Chapter 3, care must be taken to avoid double counting. For example, if each customer is paying a connection fee of $100 to the water supply agency, the water supply agency should not be counting revenue from that $100 as a benefit. Note that the user can enter in additional benefits or costs that are not seen in the drop down menu provided in sheets 4.1 and 4.2.

Table 4A/4B: Identification and Quantification of Benefits/Costs

Column	User Input	Description of cell values used in the economic analysis
A	Item	Number each item – if this is a user input then this column should be shaded.
B	Benefit/Cost	Select a benefit/cost type from the drop down list. (The full list is provided below the excel table).
C	Comments	If this is user input then these cells should be shaded
D	Quantifiable	Is the benefit/cost quantifiable? Select "YES" or "NO" from the drop down list.
E	Confidence in Estimates	The probability associated with each monetized value. The probabilities are included to account for uncertainty in the estimated values. For example, if the benefit from improved water quality is estimated to be $1200 annually, but the range on this estimate is from $500 to $1500, the likelihood or probability of each estimate should be included. The probabilities of the estimates must equal one. To continue with the example, the probability of the benefit being $1200 may be 0.6, $500 may be 0.3, and $1500 may be 0.1. If there is no uncertainty in the value, the probability would be one.
F	Expected Value	The expected value for the benefit/cost for each year based on the estimated value and corresponding probability and is summed for each year for each benefit/cost. =(Probability of the Best Estimate*Best Estimate) + (Probability of the High Estimate*High Estimate) + (Probability of the Low Estimate*Low Estimate) Continuing with improved water quality example from above, the expected value for one year would be: =(1200*0.6) + (500*0.3) + (1500*0.1) = $1020
	Estimates	For each quantifiable benefit/cost, a value and associated probability should be included. Values to use are the high estimate, best estimate, and low estimate. For each estimate, the probability or likelihood of that value is included in Column F (see below). Probabilities are mostly a matter of expert judgment.
	Annual Total Benefits/Costs	The annual total for all benefits and costs. =Sum of the Expected Values for each year

<u>Step 6: Numerically Evaluate Project for the Select Decision Criteria</u>

As mentioned above, the evaluation method used for the templates is Expected Net Present Value (ENPV). This formulation has been built into Tables 4A and 4B. The formula for ENPV is:

$$ENPV = \sum_{i=1}^{N} P_i \sum_{t=1}^{T} \sum_{j=1}^{M} (B_{ijt} - C_{ijt})(1+r)^{-t}$$

Where:

P is the probability of an event

B is the value of the benefit

C is the value of the cost

r is the discount rate

t is time (as years since the reference year).

The evaluation of the project is completed in Table **4C: Project Evaluation** on **Worksheet 4.3 Evaluate Project**. Here, the sum of the annual total of benefits and costs from Table 4A and 4B respectively are discounted and then used to calculate the ENPV. The project should be evaluated for each point of view within each alternative being considered.

Table 4C: Project Evaluation

Column	Column Heading	Description of cell values used in the economic analysis
A	Year	
B	Annual Benefits	Annual benefits as totaled in the last row of Table 4A
C	Discounted Benefits	Annual benefits discounted using the discount rate (*d*) identified in Table 2A. = (Annual Total of Benefits)*(1+discount rate)$^{-n}$ =Column B*(1+*d*)$^{-n}$ where *n* equals the years since the first year of operation
D	Annual Costs	Annual costs as totaled in the last row of Table 4B
E	Discounted Costs	Annual costs discounted using the discount rate (*d*) identified in Table 2A. = (Annual Total of Benefits)*(1+discount rate)$^{-n}$ =Column B*(1+*d*)$^{-n}$ where *n* equals the years since the first year of operation.
F	Net Benefits (Discounted)	=Annual Benefits – Annual Costs =Column C – Column E

<u>Step 7: Complete a Sensitivity Analysis</u>

The sensitivity analysis varies variables such as the discount rate or values for key benefits and costs. A sensitivity analysis of the discount rate is automatically performed using data from the previous worksheets. The user should utilize the corresponding drop down menu to alter the incremental change in the discount rate. The discount rate value seen in the middle of the table is the discount rate entered in sheet 2. Standard Assumptions. If the net benefit is not significantly changed from the top and bottom of the range in the discount rate, then the discount rate is not significant. For any other variables that the user wants to perform a sensitivity analysis, there are user input tables available. To complete the sensitivity analysis, the economic analysis should be re-run with changes to key variables and the change in the net benefit should be recorded. The results are tabulated in **Table 4D: Summary of Sensitivity Analysis** on **Worksheet 4.4 Sensitivity Analysis**. The sensitivity analysis should be completed for each alternative being considered.

Table 4D: Summary of Sensitivity Analysis

Column	Column Heading	Description of cell values used in the economic analysis
A	Variable Name and Values	The parameter being altered and the specific values being used to recalculate the net benefit.
B	Total Monetized Benefit Discounted	Value of the discounted benefit as totaled in Table 4C-Column C after using the respective new values.
C	Total Monetized Cost Discounted	Value of the discounted benefit as totaled in Table 4C-Column E after using the respective new values.
D	Total Monetized Net Benefit Discounted	Value of the discounted benefit as totaled in Table 4C-Column F after using the respective new values.

Step 8: Economic Assessment

The steps covered in Tables 4A, 4B, 4C, and 4D should be completed for each project participant, such as the water supply agency, wastewater agency, and customer. The results from each point-of-view are summarized in **Table 4D: Economic Assessment** on **Worksheet 4.5**. The economic assessment provides the Expected NPV for recycled water as well as the expected NPV for the fresh water alternative. The conclusion is described in the box below as either favorable or unfavorable with a brief explanation of why recycled water is favorable or unfavorable.

Supplementary Tables

To aid in quantifying the effect on project non-participants, two supplemental tables are included at the end of the workbook. The first table is to be used when an alternative water supplier exists and sales of recycled water will result in reduced sales for the alternative supplier. For this case the following information is needed: the potable water replacement factor, the alternative supplier's current potable retail price, the potable water price escalation factor, the alternative supplier's marginal cost of water delivery, the cost escalation factor, and the volume of potable sales lost. **Table 4G: Financial Analysis for Alternative Water Supplier Losses** outlines how to total the total revenue losses felt by the alternative water supplier.

Table 4G: Financial Analysis for Alternative Water Supplier Losses

Column	Input Parameters	Description of cell values used in the economic analysis
A	Year	
B	Potable Price	Potable water price adjusted for the potable water escalation factor (PWEF). =(Potable Water Price/Potable Water Replacement Factor)*(1+PWEF)^n n is the time since the first operation year

Table 4G: Financial Analysis for Alternative Water Supplier Losses

Column	Input Parameters	Description of cell values used in the economic analysis
C	Marginal Costs	Marginal cost of the alternative water supplier adjusted for their cost escalation factor (CEF) =(Marginal Cost of Water Delivery)*(1+CEF)^n n is the time since the first operation year
D	Net Lost Revenue	Revenue lost each year =(Total Volume of Losses)*(Adjusted Potable Water Price – Adjusted Marginal Costs) =(Total Volume of Losses)*(Column B – Column C)

The second scenario occurs when additional treatment is required by the user to make the water suitable for use. For this situation the following values are needed: the replacement factor, treatment cost for each unit of volume, the volume of recycled water used per year, and the inflation rate (as indicated in Table 2A). **Table 4H: Financial Analysis for User Requiring Additional Treatment**, describes how the assessment is completed.

Table 4H: Supplementary Financial Analysis for User Requiring Additional Treatment

Column	Input Parameters	Description of cell values used in the economic analysis
A	Year	User input – or ref other econ workbook location – do not reference outside workbook locations.
B	Rate ($/AF)	Treatment costs adjusted for inflation. =(Treatment Cost/Replacement Factor)*(1+i)^n n is the time since the first operation year i is the interest rate from Table 2A
C	User C incurred cost	The cost incurred given the treatment costs and volume of water consumed annually. = Adjusted Treatment Cost * Recycled Water Used = Column B * Recycled Water Used

It is important to note that only one alternative can be assessed per workbook. So in order to conduct economic analysis for multiple alternatives, a new workbook must be created for each alternative.

5.4 Conclusions

The above sections describe how to work through an economic analysis for a water recycling facility. The templates provided represent a simplified schematic for the process and can be elaborated upon with additional details.