Evaluating Water Recycling in California

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ABSTRACT

This document describes how to complete an economic analysis, financial analysis, and cost allocation for a water recycling project. Water recycling is gaining importance in California because of scarcity, rising wastewater treatment costs, uncertainty in traditional supply sources, and incentives for conservation. To ensure the most efficient use of resources, it is important to evaluate whether water recycling makes economic sense. This is done using an economic analysis. The economic analysis compares alternatives by looking at all direct benefits and costs from the project and evaluating them in terms of overall expected net present value. Identification and calculation of net benefits identifies desirable projects. It also assists in designing a cost allocation based on a Beneficiary Pays Principle. The financial analysis is used to determine the financial feasibility of the project. An application of economic analysis is used to compare alternatives for water recycling at a southern California location where discharge from the inland wastewater treatment facility helps recharge the downstream coastal aquifer. Alternatives included the base case where neither community recycles, recycling at the coastal location only, recycling at the inland location only, and recycling at both locations. Results from the analysis suggest that water recycling is infeasible in all scenarios with net benefits less than zero. The most economically desirable alternative was for both locations to recycle.

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1.0 INTRODUCTION

Use of recycled water is becoming a more socially accepted means of augmenting current water supplies. This is due to a slow increase in use which has raised its profile. Currently in California, it is largely due to the increased scarcity of traditional supplies. Although use of recycled water sounds good in theory, careful analysis is needed to ensure that its use is the wisest course of action.

Economic analysis evaluates the net benefits of recycled water use. An Economic Analysis identifies and compares alternatives that address a specific objective in a systematic and organized way. A large benefit of the economic analysis is that it looks beyond the typical financial costs by taking a broader perspective that encompasses wider benefits and costs to society. This also better estimates the opportunity costs of water in the system.

Despite its benefits, economic analysis is not widely used. One reason is that the process can be cumbersome. The information required for a detailed economic analysis exceeds that for a financial analysis. Whereas economic analysis looks at the broad effects of a project, the financial analysis only considers fiscal effects of the project proponent (i.e. the water utility or district), assessing the costs to build the project and revenues gained from the project.

This document describes how to evaluate whether to proceed with a recycled water project. The process begins with identifying the issue, defining the objective, establishing the baseline conditions, and then identifying possible alternatives to meet the objective. Only after these steps is the economic analysis done. Completing an economic analysis is used to determine whether it "makes sense." These steps are described in Section 4.0. If the project is economically feasible, the next step is to complete a financial analysis to determine financially feasibility. Financial analysis identifies whether the project is financially viable or external funding sources are needed. Finally, given that water recycling projects involve multiple participants, the last step is to determine allocation of costs among participants. This is done through a beneficiary pays cost allocation scheme. The above process is depicted in Figure 1-1. Prior to discussing the monetary aspects of water recycling projects, a brief background on water recycling in California and wastewater treatment technologies is presented.

The document is organized into six chapters. It begins with a background on funding water recycling in California and why it is important for future water management. The next chapter gives a brief background to wastewater treatment. Following chapters discuss the process of completing an economic and financial analysis. Chapter six describes methods of allocating costs between project participants. Chapter seven provides a case study, comparing inland versus coastal water recycling in southern California. The final two chapters discuss the findings and present conclusions.

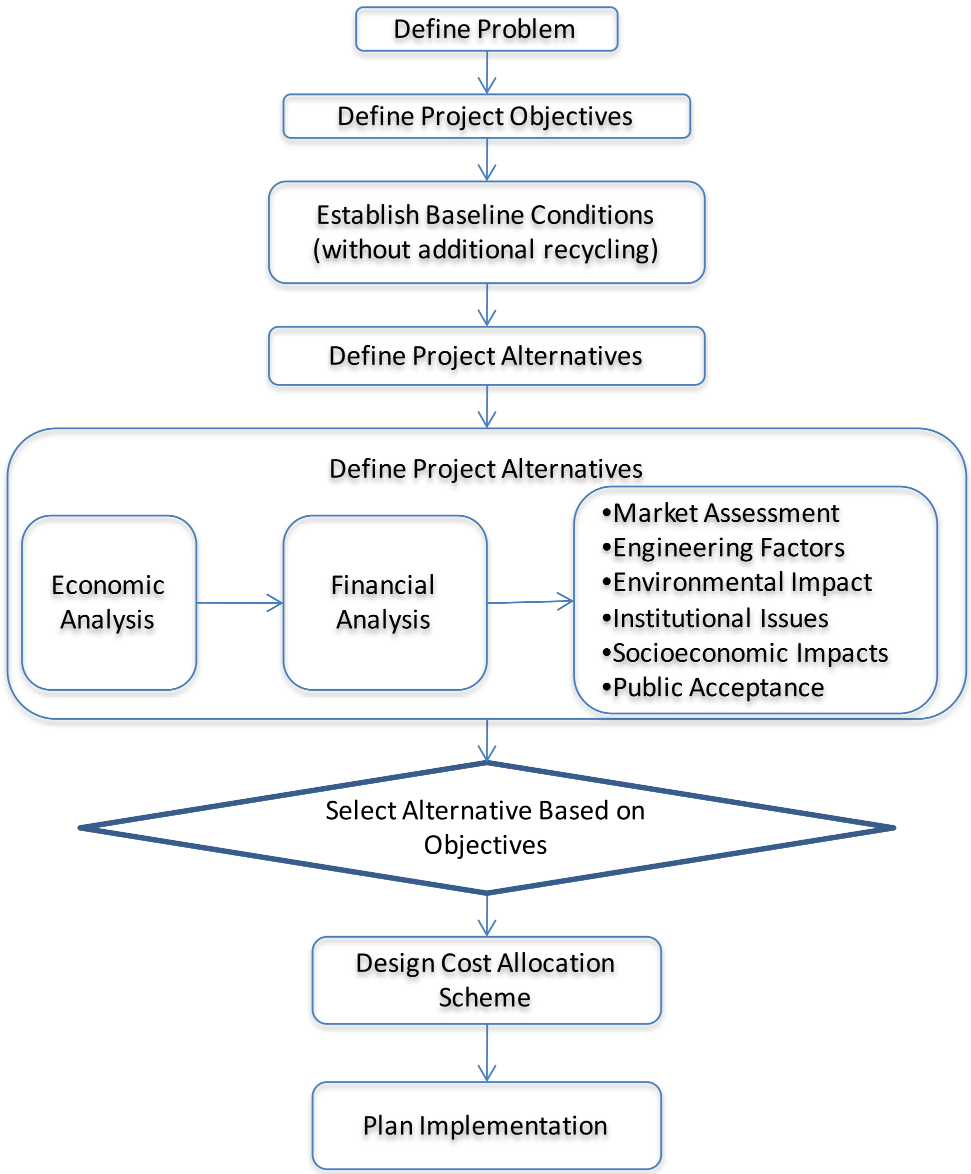

Figure 1-1 A framework for integrated resources planning (adapted from Asano et al, 2007)

2.0 BACKGROUND

2.1 History of Funding for 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, totalling 75% and 12.5% of construction costs respectively (Office of the Federal Register, 2006). In 1977 the SWRCB 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. SWRCB Grants Management Memorandum 9.01 (SWRCB 1977) provided the mechanism for state funding. Since the 1970s, state bonds have played a key role in funding water recycling projects, and since 1988, loans have been provided via the State Revolving Fund (SRF).

2.2 Current Drivers for Water Recycling in California

2.2.1 Water Scarcity

Increased water scarcity is raising the value of water in California. Scarcity is a result of California's growing population, migration from rural to urban areas, and large demands from agriculture and environmental use as well as urban demands (Hanak et al, 2011). The challenge is that the most inexpensive water sources have already been developed. To mitigate the effects of scarcity on the population and economy, the underlying system needs to be managed efficiently. In conjunction with water conservation and improved efficiency measures, recycling water can help augment supplies and reduce pressures on traditional water sources.

2.2.2 Wastewater Disposal

Wastewater treatment costs have been rising. Increased pressure to remove organics and trace contaminants has pushed wastewater treatment plants disposing effluent to the ocean to pursue advanced treatment such as reverse osmosis and ultraviolet light (Santa Ana Region RWQCB, 2004). Rising treatment costs and improved effluent water quality make water recycling more feasible.

2.2.3 Uncertainty in Delta Exports

In California, the Sacramento-San Joaquin Delta cannot be viewed as a long-term unrestricted means to transport water. Environmental constraints and its physical stability threaten its current function (Lund et al, 2010). Throughout California increased attention on the environment has raised the profile of maintaining the Delta in a more natural state. This could result in less water being exported from the Delta. In addition, the Delta levees are at risk of collapsing as they are not structurally sound and vulnerable to failure from flooding and earthquakes. Water quality will be affected by potential climate change effects such as a rising sea level, warmer atmospheric temperatures, and intrusion of invasive species (Hanak et al, 2011). The uncertainty in exports through the Delta has raised the need for supply sources which are not reliant on the Delta. Recycled water is considered a reliable water supply source and could help dampen the effects of changes in the Delta.

2.2.4 20 x *2020*

In 2008, the State of California released its 20 x 2020 Conservation Plan (DWR et al, 2010). The objective of the document was to describe the objective of reducing per capita daily water use by 20% by the year 2020. Many reasons were given for establishing the goal, including: reduced stress on the environment and reduced water-related energy demands. The recommendations for meeting this goal included: reducing the amount of water wasted, providing financial incentives for conservation, making implementation of conservation a condition for receiving state financial assistance, and increased use of water recycling.

2.2.5 Monetary Incentives

Given the scarcity of water and the goal to reduce water user by 2020, incentives have been provided by state and federal governments as well as regional agencies. State incentives are provided via that State Revolving Fund (SRF). The SRF offers to subsidize up to 25% of capital costs (to a maximum of $5 million) for water recycling projects (SWRCB, 2008). Federal monetary incentives come from the US Bureau of Reclamation (Reclamation) through Title XVI (US DoI, 1992). Funds from Title XVI are for the lesser of 25% or $20 million for the planning, design, and construction of water recycling facilities. Finally, in southern California, the Metropolitan Water District provides incentives of up to $250/AF for its member agencies to reduce their water demands (IEUA, 2007).

3.0 WASTEWATER TREATMENT TECHNOLOGY

Water recycling is the use of the effluent from wastewater treatment as a water supply source. Therefore, an initial step in understanding the use of recycled water is understanding the processes involved in wastewater treatment. The goal of wastewater treatment is to remove organic content and constituents that are harmful to humans and the environment. Treatment can involve a number of processes depending on the wastewater characteristics, receiving water body and location. Processes are often categorized as: preliminary treatment, primary treatment, secondary treatment, secondary treatment with nutrient removal, tertiary treatment, and advanced treatment. The treatment levels and associated purposes are summarized below in Table 3-1.

Table 3-1 Wastewater Treatment Processes (Asano et al, 2007)

Treatment Level	Purpose
Preliminary	Remove a large debris and grease
Primary Treatment	Remove a portion of suspended solids and organic matter
Secondary Treatment	Remove biodegradable organics and suspended solids, and typically includes disinfection
Secondary Treatment with nutrient removal	Removal of nitrogen and phosphorous
Tertiary Treatment	Remove residual suspended solids using granular medium filtration, surface filtration, or membranes. Typically includes nutrient removal and disinfection (Cl or UV)
Advanced Treatment	Removes total dissolved solids (TDS) and/or trace constituents for specific applications

Regarding recycled water, removal of constituents from anthropogenic sources is a major concern (NRC, 1998). Inorganic compounds of concern include nitrogen and phosphorous. For example, if the end use of recycled water is for irrigation it is important that phosphorous concentrations are low to minimize the risks of biofouling of irrigation equipment (Asano et al, 2007). A more prominent issue is removal of pathogens due to the public health risks. Recent concerns have also been raised over the presence endocrine disrupters and pharmaceuticals in wastewater.

Public health risks from pathogens present in wastewater are an important consideration with using recycled water. Exposure risk to these pathogens is higher with recycled water than with traditional sources, so much care is taken to minimize their presence and to isolate exposure pathways (Dean and Lund, 1981; NRC, 1998). Some infectious agents of concern include: *Salmonella Typhi*, *Pseudomonas Aeruginosa*, *Entamoeba Histolytica*, *Giardia Lamblia*,and *Balantidium* (Jimenez et al, 2002). Most infectious agents originate from faecal matter and can be categorized as viruses, bacteria, protozoa, or helminths. Viruses are the least common microbial agents present, but are highly infectious – less than 10 viral particles can cause an infection. Generally, enteric human viruses will only infect humans. Bacteria are numerous in wastewater, can affect multiple host animals, and majority require a larger dose to cause an infection (greater than one million cells). Like viruses, protozoa are highly infectious but they are not specific to a host. For example, protozoa from cattle can infect humans. Finally, helminths are parasites that do not need an intermediate host and travel via a faecal-oral pathway (Toze, 2006; Jimenez et al, 2002). To eliminate these agents and minimize the public health risks, disinfection of wastewater is needed prior to distribution. Methods of disinfection are discussed in Section 3.5.

Growing concerns in wastewater treatment and water recycling are related to the presence of endocrine disrupters and pharmaceuticals (Toze, 2006; Snyder et al, 2003). Endocrine disrupters have been noted to result in reproductive toxicity to wildlife, including the feminization of fish. The effects on human health are not as well documented but are expected to be less severe do to the different exposure pathways. Pharmaceuticals have been documented in effluent from wastewater treatment plants and represent possible ecological threats; however, less is known about their effects (Snyder et al, 2003). These chemicals-of-concern can be removed through advanced treatment steps such as activated carbon or reverse osmosis and nanofiltration (see Section 3.4).

Given these concerns it is important to adopt the appropriate level of treatment given the wastewater characteristics and end user. The following sections describe guidelines for treatment given end uses and a brief overview of specific wastewater treatment processes.

3.1 Wastewater Treatment and Water Use

The level of wastewater treatment required is guided by the end use of water. For example, food crops must meet more stringent standards than landscape irrigation as ingestion of food is a direct mechanism for ingestion of harmful microbial agents. Guidelines for appropriate end uses for recycled water are described by the California Department of Public Health (CDPH) Title 22 Code of Regulations (CDPH, 2009). A summary of the CDPH guidelines is in Table 3-2.

Table 3-2 CDPH Guidelines for Water Reuse (CDPH, 2009)

Treatment Level/Recycled Water Type	**Definition**	**Appropriate Uses**
Disinfected secondary-2.2 recycled water	Recycled water oxidized and disinfected. Median concentration of total coliform is less than 2.2/100mL. Concentration of coliforman never exceeds 23/100mL in more than one sample within a 30 day period	Surface irrigation for the following uses: • Food crops where RW is not in direct contact with the edible portion • Recycled water impoundments with restricted recreational access Restricted recreational impoundments. Publically accessible impoundments at fish hatcheries
Disinfected secondary-23 recycled water	Recycled water oxidized and disinfected. Median concentration of coliform is less than 23/100mL Concentration of coliforman never exceeds 240/100mL in more than one sample within	Surface irrigation for the following uses: • Cemeteries • Freeway landscaping • Restricted access golf courses • Ornamental nursery stock and sod farms • Pasture animals which produce milk for human consumption • Nonedible vegetation with controlled access

Treatment Level/Recycled Water Type	**Definition**	**Appropriate Uses**
	a 30 day period	Recycled water impoundments used in landscaping. This does not include decorative fountains. Industrial or commercial cooling or air conditioning that does not result in a mist. Other purposes: • Industrial boiler feed • Non-structural fire fighting • Backfill consolidation around nonpotable piping • Soil compaction • Mixing concrete • Dust control on roads and streets • Cleaning outdoor work areas • Industrial process with no contact with workers
Disinfected tertiary recycled water	Recycled water which has been filtered and disinfected. Disinfection can be done using chlorine or a disinfection process that removes 99.999% of plaque-forming units of F-specific bacteriophage MS2 or polio virus. Median concentration of total coliform is less than 2.2/100mL. Concentration of coliform never exceeds 23/100mL in more than one sample within a 30 day period. Total coliform bacteria should always be less than 240/100mL.	Surface irrigation for the following uses: • Food crops where RW is in contact with the edible portion (includes root crops) • Parks and playgrounds • School yards • Residential landscaping • Unrestricted access golf courses Recycled water impoundments with unrestricted access, provided that water has received conventional treatment (ie includes a sedimentation unit process between coagulation and filtration). Industrial or commercial cooling or air conditioning which produces any mist. Other purposes: • Flushing toilets • Priming drain traps • Industrial process water which comes into contact with workers

Treatment Level/Recycled Water Type	**Definition**	**Appropriate Uses**
		• Structural fire fighting • Decorative fountains • Commercial laundries • Consolidation of backfill around potable water pipelines • Artificial snow making for commercial use • Commercial car washes
Undisinfected secondary recycled water	Oxidized wastewater where "the organic matter has been stabilized, nonputrescible, and contains dissolved oxygen"	Surface irrigation for the following uses: • Orchards (no direct contact with RW) • Vineyards (no direct contact with RW) • Non food-bearing trees • Fodder, fibre crops, and pasture for animals not producing milk for human consumption • Seed crops (not consumed by humans) • Food crops which undergo commercial pathogen-destroying processes • Ornamental nursery stock and sod farms provided that no irrigation occurs within 14 days of harvesting or contact with the general public Other uses include flushing of sanitary sewers.

Notes: Coliform concentrations are found using bacteriological results of the last seven days for which analyses were completed

Also mentioned in Title 22 are regulations for groundwater recharge. Regulations for groundwater recharge by surface spreading are site specific (CDPH, 2009). Given the State's goal to increase the volume of recycled water used, the State's plan is to adopt uniform water recycling criteria for indirect potable reuse for groundwater recharge by December 2013 and for surface water augmentation by December 2016. In addition, by 2016, the feasibility of direct potable reuse is to be completed (CDPH, 2011).

3.2 Secondary Treatment

Secondary treatment removes organic matter from wastewater. Primary treatment, through a settling basin, will remove up to 50% of organic material by settling particulate matter. Secondary treatment can remove up to 90% of the organic matter in wastewater by using biological processes (Dean and Lund, 1981; Metcalf and Eddy, 2003). Secondary treatment is designed to reduce the concentration of total suspended solids (TSS) and biological oxygen demand (BOD).

Secondary treatments are categorized as membrane or non-membrane. Non-membrane treatments can be divided into suspended growth or attached growth processes. Suspended growth non-membrane processes keep substrate and cells in suspension through mixing or addition of oxygen. Attached growth processes move water through a media. Passing through the media allows a biofilm to form which results in the oxidation of organic matter.

3.3 Tertiary Treatment

Tertiary treatment removes residual particulate matter from secondary effluent. Removing particulates reduce clogging in irrigation systems and improves disinfection. Filtration can be through depth or surface filtration. Depth filtration moves the wastewater through a sand filter and surface filtration mechanically sieves the wastewater. Alternative methods involve using low pressure membrane systems such as microfiltration (MF) and ultrafiltration (UF). Both screen particles based on the membrane pore size and use a pressure differential to drive flow (Asano et al, 2007).

3.4 Advanced Treatment

Advanced treatment removes dissolved constituents or specific organics and inorganics following primary, secondary, or tertiary treatment. Carbon adsorption is one method of advanced treatment used to remove dissolved organic and inorganic matter. As wastewater passes through the carbon column, constituents in the liquid phase adsorb onto the carbon, transferring it to a solid phase. To be effective, carbon adsorption needs a low TSS concentration. Gas stripping is an advanced unit process whereby compounds in solution are transferred from the liquid phase to the gas phase. In gas stripping, wastewater comes in contact with an air stream and gaseous constituents are removed by transferring them from the liquid wastewater into the air/gas mixture (Metcalf and Eddy, 2003).

Advanced treatment can also be completed through pressure-driven methods of reverse osmosis (RO) and nanofiltration (NF). Similar to microfiltration and ultrafiltration, RO and NF use a pressure gradient to drive fluid across the membrane and overcome the osmotic pressure. The difference between advanced treatment filtration and tertiary treatment filtration is that RO and NF can remove dissolved ions as well as salts, pesticides, and herbicides. MF or UF are required before RO and NF to avoid membrane fouling. RO is capable of removing up to 99% of monovalent ions in solution and is effective in removing dissolved constituents from low TDS water. NF is capable of removing 50-90% of monovalent ions and separating divalent anions from monovalent ions. Non-charged molecules are screened based on their size and shape. The advantage of NF over RO is that a lower operating pressure is needed (Asano et al, 2007).

A less common treatment method is electrodialysis. Electrodialysis runs an electrical current through the water. A series of non-selective membranes are located between anode and cathode terminals. The electrical current between the terminals drives cations and anions to the anode and cathode respectively. As they migrate towards the terminals they are intercepted by the membranes (Asano et al, 2007).

3.5 Disinfection

Disinfection kills bacteria and viruses in wastewater (Asano et al, 2007; Dean and Lund, 1981). Ideally, the disinfectant used is lethal to the microorganisms but safe for larger life forms such as humans and animals. Disinfection methods include chlorine based compounds (i.e. chlorine or chloramines), ozone, or ultra-violet (UV) light. Disinfection by chlorination is the most widely used method in the USA

(EPAa, 1999a). Chlorination works by using chlorine as an oxidizing agent. The oxidation reaction occurs on the cell wall, causing cell lysis. Ozone is used more widely in Europe (Snyder et al, 2003). Similar to chlorination its action mechanism is based on causing an oxidation reaction on the cell wall causing cell lysis. The oxidizing agent is the hydroxyl radical. In addition to causing cell lysis, ozone will also damage nucleic acids. Ozone is more effective than chlorine for removing bacteria and viruses, but it is more costly (EPAb, 1999; Metcalf and Eddy, 2003). UV radiation causes destruction by altering either the DNA or RNA of pathogens. The light penetrates through the cell wall and damages the genetic material so that the cells cannot replicate. Unlike chlorine and ozone, UV treatment is a physical process as opposed to a chemical process. UV treatment is most effective against viruses. A disadvantage associated with UV treatment is that organisms can repair themselves after treatment (EPAc, 1999; Metcalf and Eddy, 2003).

4.0 ECONOMIC ANALYSIS

The goal of an economic analysis is to compare multiple projects which meet the same objective and identify the best project based on the benefits and costs of each proposed alternative. This process also provides a good estimate of the opportunity cost of water in the system. A financial analysis does not determine the true opportunity cost of recycled water as it neglects the wider benefits and costs (Griffin, 2006).

An economic analysis compares alternatives by assessing the positive (benefits) and negative (costs) aspects of a project. It takes a broad perspective, considering more than one point-of-view. The goal is to describe all benefits and costs "to whomsoever they accrue" of a project (Howe, 1971). Direct benefits and costs from the project are accounted for in monetary (dollar) terms. The range over which benefits and costs are estimated extends from immediate users to the regional economy. Completion of an economic analysis not only describes the value of the proposed project, but also enables a comparison of the proposed project to other alternatives (Asano et al, 2007; Young, 2005).

The economic analysis can be roughly divided into eight steps. 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, the problem is identified and the objectives are defined. Next, an accounting perspective is selected, describing how wide of a net is being cast when considering the benefits and costs. The baseline conditions (without water recycling project) are then outlined. With these standards set, project alternatives are identified and then analyzed. This begins with identifying and then quantifying the relevant benefits and costs for each participant within a given alternative. Benefits and costs are evaluated using the established discount rate and evaluation criteria. Results are reanalyzed for sensitivity to major uncertainties.

4.1 Identify Problem and Establish Objectives

The first step in any proposed project is to identify and define the problem faced by the region. This sets the basis for establishing objectives to be addressed with a project through water management alternatives including water recycling. Objectives could be to increase water supplies, increase supply reliability, or meeting wastewater treatment requirements. Objectives should be measurable and concise. The goal of the economic analysis is to consider projects that meet the specified objective(s).

4.2 Accounting Perspective

With the objective defined, the next step is to establish the accounting perspective for the analysis. The accounting perspective sets the extent to which benefits and costs are to be considered. Typical examples are local, regional, state, or national. The local perspective would consider only benefits and costs that accrue to the immediate municipality or district; whereas, the regional perspective could be defined to include a number of municipalities or a watershed. To demonstrate the implications of the accounting perspective, consider potential environmental effects. The local perspective would consider local habitats and the state perspective would consider the effects on upstream habitats. In theory, a broader perspective is ideal as it encompasses a larger range of benefits and costs (Griffin, 2006). However, a narrower perspective is more practical for local or regional governmental decision-making.

4.3 Define Baseline Conditions

The baseline describes what would happen without the proposed water recycling project. It is used as a benchmark to compare project alternatives. A clear definition of the baseline helps describe the issues at hand and therefore how the proposed alternatives may address the issues. It is important to note that the baseline begins by describing the current situation, but then continues to describe future projections which will in turn affect all proposed alternatives. For example, the same population growth rates and changes in demand should be used for all proposed alternatives. The baseline establishes the future projections and helps define the costs without a project. Fundamental components for the baseline include:

- Population Projections (Section 4.3.1),
- Water Use Projections (Section 4.3.2),
- Wastewater Needs and Projections (Section 4.3.3), and
- Water Supply Portfolio Analysis (Section 4.3.4).

In addition, specific conditions related to water recycling should be addressed. These include:

- A Recycled Water Market Assessment (Section 4.3.5), and
- Optimal Recycled Water Facility Size (Section 4.3.6).

4.3.1 Population Projections

Increases in population will increase water demands as well as wastewater discharge. Population growth also changes land uses, which will change sector (i.e.: municipal versus agricultural) demands for water.

4.3.2 Water Demand Projections

Water demand projections describe how water demands will potentially change in the future. Projections are needed for both urban and agricultural demands. Urban demands can be divided into residential, commercial, industrial, and institutional sectors. Demand for each of these uses will be governed by local land use planning and urban water management. Agricultural demands depend on the projected land use changes and on the type of crop, the specific crop water demands, and changes in cropping patterns. Agricultural demands for water can be more challenging to predict as cropping choices are driven by the market forces.

In theory, with increased water scarcity and cost, water use should decrease. This represents movement along the demand curve. However, population growth, change in population composition, and municipal growth strategies, such as encouraging industrial and commercial development, increase water demands by shifting the demand curve out (Griffin, 2006).

4.3.3 Wastewater Needs and Projections

As demands change in time, wastewater disposal needs will also change. Urban population increases will increase wastewater flows and urban water conservation activities will reduce wastewater flows. Wastewater treatment facilities may need to increase capacity or new facilities may need to be constructed. Variations in wastewater flows will result in changes in the volume of recycled water available. Changes in treatment standards will require plant modifications. Changes in wastewater volumes and standards need to be carefully considered.

4.3.4 Water Supply Portfolio Analysis

Water Supply	Most urban water supply planning employs a portfolio approach involving a mix of water and water demand management activities. In considering the current situation and planning for future changes, current and future water supply sources need to be addressed. Supply sources can include groundwater, local surface water, imported surface water, water transfers, or desalinated

	water. In addition to direct sources of water, water also can be provided indirectly from reductions in water use.
Water Supply Variations	Variations in each supply source should be considered. Supplies may be affected by local or regional droughts or floods. Imports from northern California will be affected by changes in the Delta. And groundwater supplies will be affected by the pumping rates and estimated yields. Potential variations to the supply portfolio defined above can assist planning efforts.

4.3.5 Recycled Water Market Assessment

Well-planned water recycling projects examine current and future recycled water demands. Many recycling projects are under-utilized due to inadequate demand for recycled water. Capable and willing users of recycled water need to be identified early in the project. Identifying potential users requires a market assessment, which involves gathering constraints applicable to each water use and data on each potential user. Information collected should include use, location of users, current and projected water uses, schedule of use, quality and pressure needs, potential connection and distribution costs, competing water sources and other user preferences.

Agencies should base the planned current and future recycled water demands on well founded growth projections reinforced through either a local mandatory use ordinance (MUO) or other commitments from potential recycled water users. Among desirable provisions in the water recycling user contracts are contract duration, recycled water characteristics (source, quality and pressure), quantity of recycled water to be supplied, schedule of use, pricing schedule, operation and maintenance, contingency plans and liability provisions.

4.3.6 Optimal Recycled Water Facility Sizing

Optimal facility sizing can be estimated through a marginal cost analysis. For the scale and size to be optimal, the marginal benefits should exceed the marginal costs (and theoretically be equal), and the total benefits should exceed the total costs (Figure 4-1) (Asano et al, 2007). Along with sizing, the level of treatment and costs need to be considered. Different treatment and redistribution facility designs will result in different supply costs. It is important to consider the variations in the cost of supply when assessing optimal sizing.

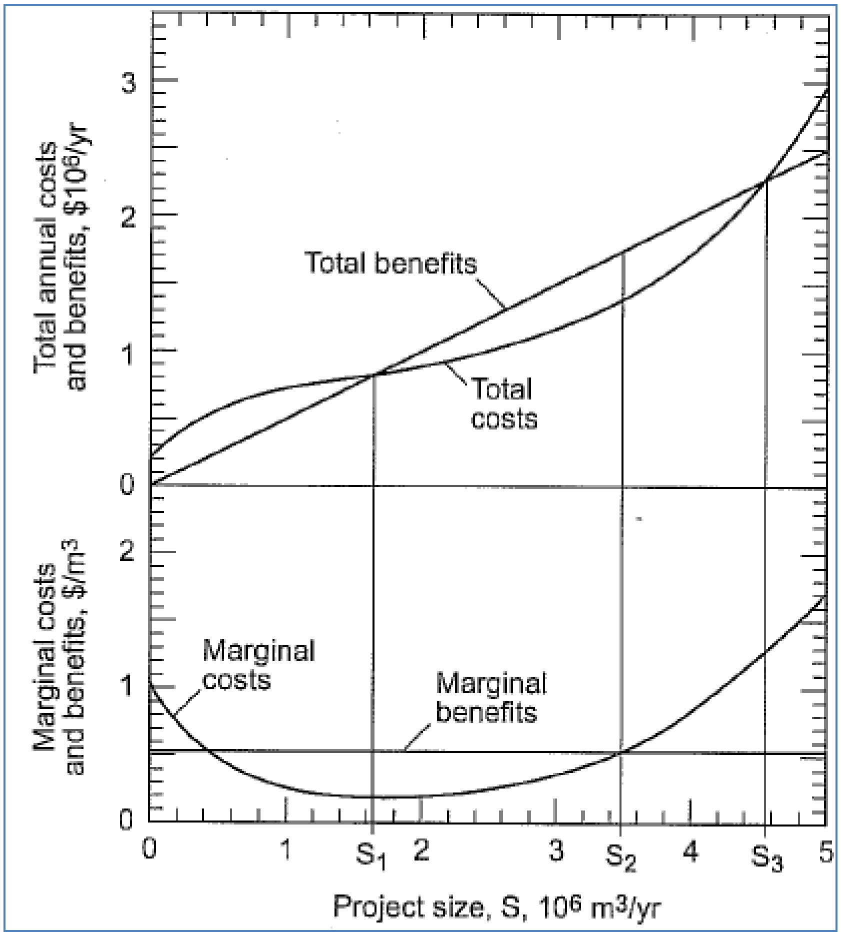

Figure 4-1 Marginal Costs Analysis for Optimal Sizing (Asano et al, 2007)

4.4 Identify Project Alternatives

The objective helps in identifying promising project alternatives. Project alternatives need to address the project's primary and secondary objectives. If the objective is to increase water supplies, alternatives may include augmenting current supplies with conservation or additional imports, or pursuing different sources, such as desalination. If the objective is to make beneficial use of current wastewater treatment capacity, alternatives may include different sizing options. In addition to identifying possible alternatives, it is also necessary to identify relevant points-of-view to be considered, which enables the economic analysis to describe the wider effects of a project.

4.5 Identify Relevant Benefits and Costs

The next step identifies the costs and benefits of each alternative. Benefits and costs can be direct and indirect, monetary and non-monetary. Benefits and costs should be identified for all relevant point-of-view for each alternative. Assessing multiple perspectives shows the costs and benefits which accrue to relevant agencies, institutions, and stakeholders. For water recycling projects this may include more than one water supplier or wastewater treatment agency, the customer, the general society, and non-participants such as a water wholesaler.

To demonstrate how benefits and costs are accounted for in different points-of-view, consider the following scenario. A community in Southern California proposes a water recycling project. The water supplier and wastewater agency are working in concert to supply water to the area. Current supplies are imported via a water wholesaler. Costs to upgrade the wastewater treatment system and distribution system will be borne by both agencies. Some costs will be transferred to the ratepayer through their service fees. In using recycled water to meet some of the demands, less surface water imports are needed which become a monetary savings to the local utility and will potentially improve the upstream and State environment. No communities downstream rely on this for their water supply. How these benefits and costs would be accounted in the various stances is presented below in Table 4-1.

Table 4-1 Example of benefits and costs for different points-of-view

	Description of Benefit/Cost			
Perspective	**Revenue from Sales**	**Upgrades to the system**	**Reduced Freshwater Imports**	**Improved water quality (upstream and downstream)**
Local Utility	Benefit	Cost	Benefit	
Ratepayer/Consumer	Cost	Cost		
Local Perspective				Benefit
State Perspective			Benefit	Benefit
Water Wholesaler			Cost	

In the above example, the water wholesaler would be a project non-participant. Considering the potential effects to non-participants is an important part of the economic analysis. Affected non-participants may be the water supplier (either local supplier or wholesaler) or downstream water users. In the first scenario, where water supply and wastewater treatment are separate entities, recycled water supplied by the wastewater agency may reduce revenue to the water supplier or reduce downstream flows. In the second scenario, water recycling 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 scenarios, recycled water may affect non-participant freshwater rates. Fresh water prices can increase as estimated consumption decreases and fixed costs remain roughly constant, thus increasing financial costs to non-participants. Fresh water demand also can be reduced relative to recycled water, thus reducing the supplier's revenue.

A challenge in addressing more than one point-of-view lies in double counting. Double counting occurs when a benefit or cost is included more than once in the economic analysis. There are two main ways by which this happens. The first is by counting one benefit under two categories within the same point-of-view. For example, consider the value provided by increased greening from municipal irrigation. The greening of the landscape provides an aesthetic benefit which can be quantified from increased property values. Another benefit category would be higher property values. Including both benefits, which are derived from the same information, would be double counting. The second type of double counting stems from including the same benefit for more than one point-of-view. For example, consider the value of increased reliability of supply. The water supplier and customers both benefit from improved reliability. The value of the improved reliability either needs to be separated among the two groups, or accounted for as one cumulative value within one point-of-view.

4.5.1 Direct Benefits

Direct benefits are an immediate result of project implementation and are generally felt by the agency or customer. Direct benefits also include avoided costs. A water recycling project may help avoid or postpone investments in expanding water supply and wastewater 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 could be required. A short list of direct benefits is provided in Table 4-2.

Table 4-2 Direct Benefits

Benefit	Description
Water supply quantity	Reclaimed water represents an additional water supply source. Alternate supplies could be groundwater, surface water, transfers, purchases, desalination, or water conservation (Asano et al, 2007; Raucher, 2006).
Reliability	Reclaimed water is viewed as being more reliable than traditional water sources as it is less sensitive to drought or disruption, such as from upstream endangered species concerns. Consequently additional value is provided through reliability.
Wastewater disposal	Water recycling involves both treating wastewater and using of treated water as a supply. Both represent direct benefits. In the economic analysis, the benefits from treating wastewater should be separated from the benefits of water recycling. The primary beneficiaries of wastewater treatment are those delivering the water to the treatment plant. Use of the treatment plant as a means of pollution control is a benefit in itself as it meets pollution requirements (Ernst and Ernst, 1979). The revenue from the sale of reclaimed water represents an additional benefit
Avoided Costs	Avoided capital costs of wastewater treatment and disposal Avoided capital costs of water distribution Avoided capital costs of water supply treatment Avoided capital costs of water transmission Avoided costs of water supply development/purchase (potable water) Avoided costs of water supply development/purchase (recharge water) Avoided increased groundwater pumping costs with declining groundwater levels Avoided O&M costs for wastewater treatment and disposal Avoided O&M costs for water distribution Avoided O&M costs of water supply treatment Avoided O&M costs of water transmission Avoided penalties from exceeding wastewater discharge volume goals Avoided penalties from exceeding water quality mandated goals
Salvage Value	Value of infrastructure at the end of the period of analysis
Water Sales Revenues	Revenue gained from sales of recycled water (see Section 5.3)

4.5.2 Direct costs

Direct costs are generally considered to be out of pocket costs to build and operate the water recycling facility. As with direct benefits, they are generally borne by the agency or customer. A list of direct costs is provided in Table 4-3.

Table 4-3 Direct Costs

Cost	Description
Distributions and control systems	Connection of the water recycling facility to the new users has costs for both utility and recycled water users

Water quality	Recycled water quality may be subject to specific requirements depending on its final use, or may have the utility or the users incur additional treatment costs to protect distribution and storage systems.
Disposal costs	In some cases, the utility may face disposal costs of recycled water if it compensates its users for taking this water that otherwise would pay a disposal charge.
Revenue losses from water sales	Freshwater operations may be downsized as recycled water increases its share in the local water supply portfolio. As a result revenue losses would enter in the cost side of the equation.

4.5.3 Environmental Impacts

Environmental benefits are produced if reclaimed water use will help enhance, develop, or improve a habitat or ecosystem (Asano et al, 2007). Costs can result from reduced flows negatively affecting downstream habitats. Benefits and costs to the environment are discussed in Table 4-4.

Table 4-4 Environmental Impacts

Environmental Impact	**Description**
Downstream Habitats	From the treatment perspective, use of reclaimed water may reduce the volume of water released from the treatment plant into the environment. This could improve or harm downstream water quality.
Environmental Restoration	Water recycling may reduce surface water diversions resulting in a more naturally occurring flow regime and enhanced water quality for species. More natural conditions can help natural species thrive and aid in the restoration of deteriorating habitats. Benefits are not only for the species but also from users of national parks and other outdoor locations that rely on these environments. A framework for estimating or describing these benefits is discussed in Raucher (2006).
Groundwater Balance and Quality	If water recycling reduces the reliance on groundwater, there is a benefit associated with reducing overdraft. Minimizing overdraft may avoid subsidence or minimize the rate of saltwater intrusion (Raucher, 2006).
Recreation	A water recycling facility may 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 nearby of these facilities and carbon sequestration benefits may also be significant. Guidelines for accounting recreational benefits is provided in (Raucher, 2006).
Source Water Protection	Reduced demand on groundwater and surface water sources may help reduce treatment costs and enhance quality of these traditional water sources overtime. Reduced saline intrusion in aquifers and improved water quality overall help protect drinking water sources. Beneficiaries range from urban and agricultural water users of these sources, to species that rely on the habitat provided by naturally occurring streamflows.
Nutrient Value	Benefits may result from the nutritional value provided if reclaimed water is used for agriculture and nutrient content acts as a fertilizer. Reduced fertilizer use can improve underlying groundwater quality

4.5.4 Non-Quantifiable Benefits and Costs

Other benefits and costs, which cannot be monetized, can be categorized as incommensurable or intangible. Incommensurable benefits and costs are not easily measured using common techniques. Intangibles cannot be economically valued. Examples of incommensurables include the aesthetic value of cleaner water in natural water bodies. An example of an intangible benefit would be increased species diversity in a stream resulting from consistent flows (Griffin, 2006). Accounting for non-monetized benefits and costs is discussed in Section 4.6.3.

4.5.5 Multiplier Effects

When completing the economic analysis, secondary or indirect costs are not included. Indirect costs are those that accrue to non-primary beneficiaries (DWR2008; OMB 2002). Secondary economic effects are generally neglected since multipliers on benefits and costs are generally similar, and equivalent to multiplying all costs and benefits by the same constant (Griffin, 2006).

4.6 Quantify Benefits and Costs

Benefits and costs are quantified in monetary terms or described qualitatively. The breakdown of the categories of benefits and costs and how they are measured is presented in Figure 4-2. Within a different accounting perspective, costs and benefits may have different values, reflecting different preferences.

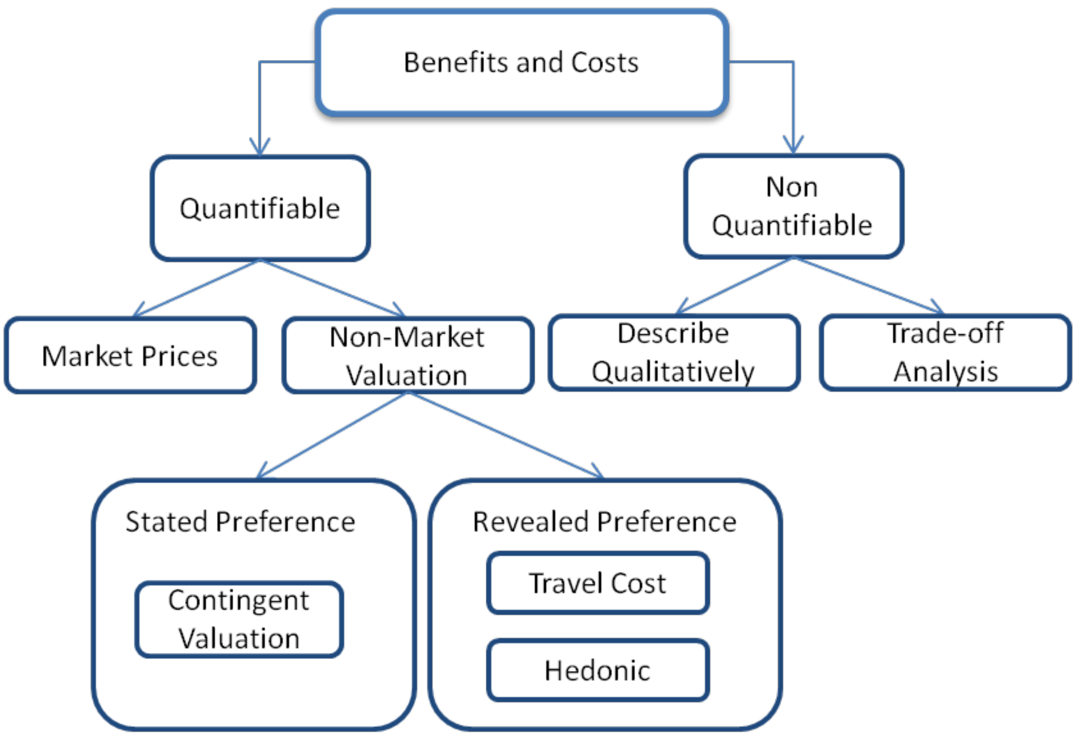

Figure 4-2 Categorization of Benefits and Costs

4.6.1 Market Prices and Willingness-to-Pay (WTP)

Benefits and costs that can be expressed in dollar amounts should ideally be quantified using market prices. For example, costs of building the distribution system can be quantified using market prices for labor and materials. Items which can be monetized are described below in Table 4-5.

Table 4-5 Benefits and Costs with Market Prices

Benefit/Cost	Method to Quantify
Water Supply	Purchase of alternative supplies
Reliability	Least Cost Planning Model Willingness-to-pay to avoid a shortage
Distribution system and Facility Construction	Market prices for labor and materials
Groundwater Protection	Cost of imports to avoid groundwater overdraft. Imputed WTP based on value of water to crop production (Ernst & Ernst, 1979).
Nutrient Value	Avoided fertilizer costs

4.6.2 Nonmarket Valuation

For items without direct prices, such as environmental benefits and costs, non-market valuation methods can be employed. Non-market valuation is defined as the study of economic behavior when market prices are absent or distorted (Young 2005). As described in Figure 4-2, non-market valuation techniques can be broken into stated preference and revealed preference methods. Stated preference includes contingent valuation and revealed preference includes hedonic pricing, travel cost method, and benefit transfers. Each is described below.

Contingent Valuation — Contingent valuation assigns monetary values based on surveys in which users are asked to state how much they are willing to pay for a given good or service. Although the data is derived directly from users, the data is less reliable than other methods because of the hypothetical nature – there is a discrepancy between what individuals state and what they will actually pay (Griffin, 2006; Young, 2005).

Hedonic Pricing — Hedonic pricing is a revealed preference approach with values inferred from another input (Young 2005). For example, the potential use of water-based recreational services influences the demand for related marketed commodities. By analyzing purchasing behavior of the marketed good it is possible to infer WTP for the environmental amenity. Hedonic methods are sensitive to other inputs and it is important to describe what variables were accounted for when establishing the relationship (Griffin, 2006).

Travel Cost Method — The travel cost method (TCM) is a revealed preference technique. It infers the value of water from individuals' cost to visit a specific area. Challenges associated with TCM are accounting for seasonal variations in travel and ensuring that water is an important consideration in travel decisions (Griffin, 2006). For example, the value of water for camping in Yosemite might be larger than the value of camping at a different location; however, it would be challenging to account for this difference.

Benefit Transfer — Benefit transfer is a valuation method in which benefits of a project or policy proposal in one site are employed to assign benefits or value to another site or policy proposal (Young 2005). A common example is the use of price-elasticity of water demand, which is the water user response to marginal changes in water price. Another example is the use of operating costs.

4.6.3 Non-Monetized Benefits and Costs

Non-monetized costs and benefits are often controversial and hard to incorporate in economic analysis. Exclusion of non-monetized benefits may undervalue the benefit to each participant and may lead to disputes over how much each user should contribute. Non-monetized costs can be described qualitatively and included as part of the justification at the end of the benefit cost analysis. It is also possible to combine non-monetized values with monetized ones using a weighted analysis in a project's economic analysis.

In a weighted analysis, monetized as well as non-monetized benefits and costs are ranked using user-defined weights. The monetized and non-monetized items are then normalized, making all values unit-less. The normalized values are multiplied by the weights to give a final value for each. The normalized and weighted values are used to rank alternatives.

To demonstrate how a weighted analysis works consider the following example. A proposed recycling project will reduce demand from natural water sources and will therefore increase natural stream flows. Less disturbed stream flows will improve the quality of aquatic and riparian habitats and is anticipated to improve the biodiversity in the stream. Each alternative preserves a different area with varying diversities. The benefits from diversity cannot be quantified monetarily, but can be quantified using the number of native species populations that are improved. The contribution of diversity to the monetized net benefits is presented in Table 4-6.

In the example, the monetized net benefits are given a weight of 0.8 while the benefits from increased stream biodiversity are given a weight of 0.2. For both the monetized and non-monetized parameters, values are normalized using the highest actual value. For net benefits, values are normalized by dividing by a value of 1000, and for biodiversity, values are normalized by dividing by 12. The normalized value is then multiplied by the weighting factor to give the normalized and weighted value for monetized and non-monetized benefits for each alternative. The sum of these represents the *weighted product* for each alternative and is used to rank and select the best alternative. In the example, the best alternative is option C.

Table 4-6 Weighted Analysis

	Net Benefits ($)	**Biodiversity (# species)**	**Weighted Product**	**Ranking**
Weighting Factor	**0.8**	**0.2**	**1.0**	
Alternative				
A				
Actual Value	500	6		
Normalized Value	0.50 (=500/1000)	0.50 (=6/12)		
Normalized and Weighted	0.40 (=0.5*0.8)	0.10 (=0.50*0.2)	0.50 (=0.40 + 0.10)	3
B				
Actual Value	800	12		
Normalized Value	0.80	1.00		
Normalized and Weighted	0.64	0.20	0.84	2
C				
Actual Value	1000	8		
Normalized Value	1.00	0.67		
Normalized and Weighted	0.80	0.13	0.93	1

4.7 Evaluate Proposed Project

Project evaluation compares alternatives over the same period of analysis and using the set discount rate and the chosen evaluation or performance statistic. The Expected Net Present Value (ENPV) is a strong method for evaluating projects (Gollier, 2010; Weitzman, 1998). The formulation for ENPV is:

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

Where: P is the probability of an event occurring

B is the monetized benefit

C is the monetized cost

d is the discount rate

t is the year, relative to the reference year

i is the event or scenario; and

j is the type of benefit or cost.

ENPV is the difference between the discounted benefits and costs of a project. To ensure fair comparisons across time, all benefits and costs are adjusted using a discount rate, *d*. If the ENPV is positive, the expected benefits of the project exceed its expected costs and the alternative is desirable. In general, alternatives with the highest ENPV per unit budget cost should be funded. The discount rate used will affect the final ENPV value and as such can be a contentious parameter.

ENPV has two main benefits. First, it avoids misrepresenting the value of avoided costs. In the benefit-cost ratio formulation, recording a parameter as a benefit or negative cost skews the final value. With ENPV, regardless of how they are inputted, avoided costs result in the same value (Lund, 1992). The second benefit is that ENPV accounts for uncertainty by using probabilities for sets of parameter values (scenarios). Estimating these probabilities may require specialized statistical skills or may be subjectively assessed. However, using the probabilities estimated for each scenario gives a range of ENPVs inform decision-making.

4.7.1 Discount Rate

A discount rate accounts for the opportunity cost of using money over time, reflecting 1) the productivity of investments and for 2) preference for immediate consumption (Hufschmidt et al., 1961). When completing an economic analysis, values for future benefits and costs are adjusted to *present value* dollars or *constant* dollars using a discount rate (OMB 2002). Using constant dollars allows a fair comparison of benefits and costs over the period of analysis. The formula for calculating present worth is:

Present Worth/Discount Factor = $\frac{1}{(1+d)^n}$

(where *d* is the discount rate and *n* is the number of years over which the discounting will occur).

A higher discount rate decreases the present value of a future impact. A dollar now is worth more than a dollar in the future. Therefore, benefits and costs early in a project are worth more than those felt later.

Inflation also can affect the value of the discount rate. If inflation is not removed from the discount rate, the rate is termed the “nominal” discount rate. If inflation effects are removed, it is a “real” discount rate. When using a real discount rate, benefits and costs should be recorded as real values which have been adjusted for inflation, i.e., constant dollars.

The rate chosen for the economic analysis can affect whether the project is economically feasible and the magnitude of the net benefits. It is therefore important, if not regulated by a funding agency, to choose the most appropriate rate.

4.8 Analyze sensitivity of Results to Major Uncertainties

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 need to be clearly identified and addressed (Water Resources Council, 1983). To address risk and uncertainty, sensitivity and probability analyses can be utilized. A sensitivity analysis varies values of key paramters, such as the discount rate, to determine the effect on the final outcome.

Probability analysis uses probability distribution functions to show a range of values. As demonstrated with expected net present value, the probability can be incorporated into the calculation. Other means to account for risk and uncertainty include Monte Carlo and Risk analysis (DWR 2008).

4.8.1 Monte Carlo Analysis

A Monte Carlo analysis 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 that defines the likelihood that different outcomes occur. Probability distributions are deemed a realistic way of representing 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.

4.8.2 Risk Analysis

Risk analysis is helpful in estimating the frequency and magnitude of events and the potential associate 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, events such flooding and prolonged droughts, and even longer-term issues such as sea level rise, may change the payoff scheme of a project. Unforeseen new recycled water uses and shifts in consumer preferences towards more or less recycled water may also affect the initial estimates.

5.0 FINANCIAL ANALYSIS

Financial analysis provides an assessment of a project's financial feasibility from the proponent's perspective. Generally, the financial analysis process is well understood by project proponents because it follows well-established cash-flow projections. Because of this, and because it is the financial analysis that shows the overall bottom line or profits of the project, proposing agencies generally care more about the results of the financial analysis. However, while a necessary consideration, financial feasibility is not a sufficient condition to build the best project overall. Although the financial analysis assesses whether the project will generate profits, it is important to emphasize that the financial analysis should not be completed unless the economic analysis demonstrates the project is viable. It is the sequential combination of a successful economic and financial analysis that demonstrates whether to proceed with a project.

Financial analysis is used by the 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 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.

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 5-1.

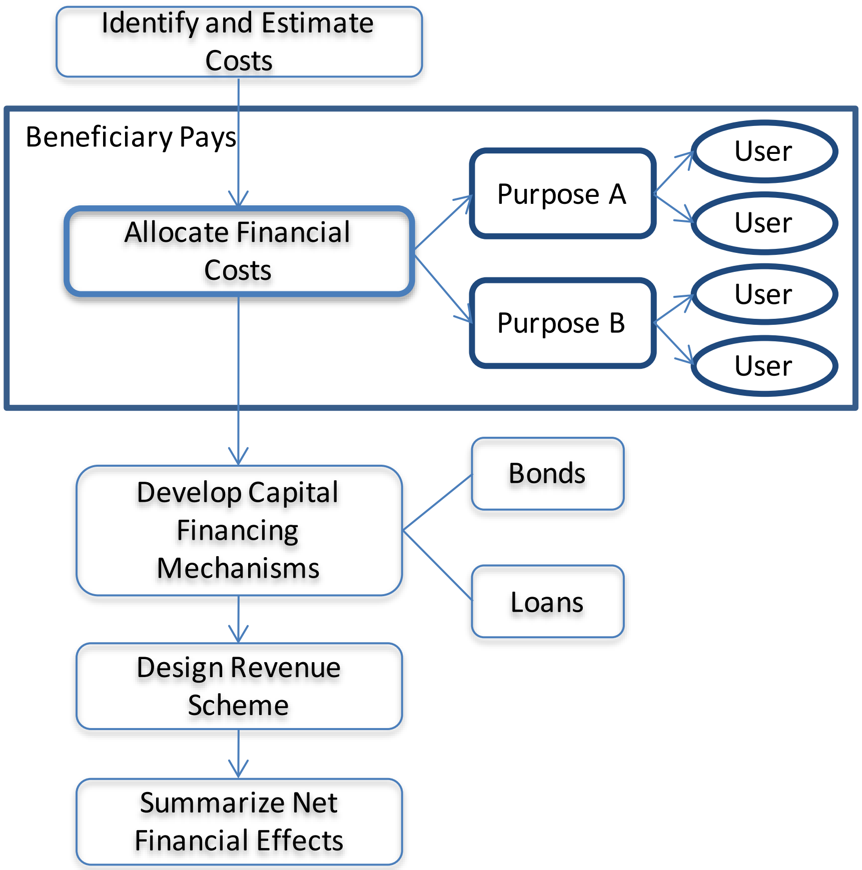

Figure 5-1 Financial Analysis Process (adapted from Asano and Ebrary Inc, 2007)

To summarize the process, project costs are identified and estimated in monetary terms, typically at market prices. Costs are then allocated among project purposes and participants. This step is a process unto itself and is described in detail in Section 6.0. With costs identified, means to construct and operate the project are addressed. Two main monetary flows considered are: a) capital financing and b) revenues. For capital financing, 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. This formulation allows overall financial assessment of the project for the project proponent. The steps above are described in the following sections.

5.1 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 5-1. Costs are estimated based on expected prices of expenditures and are adjusted in time to include inflation. This contrasts with 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 5-1 Financial Costs of a Proposed Recycling Project

Capital Costs	Project Design Costs Land purchase Planning, design, and engineering Materials Labor Other Project construction Materials for recycling facility Materials for distribution system Costs to build system Costs to connect users Labor Environmental Mitigation Licenses/Fees/Legal Retrofitting costs to convert plant to recycled water Retrofitting costs for users Regulatory Costs Administration/Overhead
Operations and Maintenance Costs	Annual Operations Labor Materials Annual Maintenance Labor Materials Regulatory Costs Cross-connection tests
Avoided Costs	Potable water replaced Wastewater disposal costs Freshwater alternative costs

The debt service for the project is used to determine annual payments to recover capital costs. The annual payments are based on the total capital costs, the period of analysis, and the likely interest rate. The formulation is:

Annual Debt Service = Capital Recovery Factor x Loan Principle

Where:

Capital Recovery Factor $= \frac{r(1+1)^n}{(1+r)^n - 1}$

r = interest rate

n = period of analysis (year)

Loan Principle = total capital costs

The project debt service, annual O&M costs, and annual avoided costs are used to determine the annual cost to operate the project over the entire period of analysis.

When summing costs, uncertainty should be accounted for. There is uncertainty in the amount of water recycled as operating conditions change over time, including the level of treatment needed, 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. Costs may include cross-connection tests, exceeding water quality standards, and a backup treatment system. A prudent financial analysis will include contingency accounts for such circumstances.

5.2 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. The next step is to consider possible financing sources. In California, water project facilities are generally financed through general obligation bonds, revenue bonds, loans and accumulated capital resources. Long term water agency contracts repay most of this debt service.

5.3 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. A list of potential sources includes (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 the baseline. 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.

5.3.1 Water Pricing

Pricing of retailed recycled water is the primary means of recovering costs. How to price recycled water, as with any good, depends on the underlying objective. Possible objectives are to: provide sufficient revenue, create economic efficiency, be equitable to the population, be simplistic enough for users to understand the scheme, or meet legal obligations. If based on providing sufficient revenue, the price will be based on the average cost to supply water. This method does not account for the change in costs from changes in the volume provided and results in economic inefficiency. For economic efficiency, the price should be based on the marginal cost, which adjusts the cost based on each additional unit supplied (Griffin, 2006). Rate structures commonly used are a single price either set at the average cost or marginal cost, or block rates. Increasing block rates charge more to those who consume more. It is advantageous to use this method if encouraging conservation or if high consumption users are relatively wealthy. Decreasing block rates charge less to those who consume more. This is based on the marginal cost and economies of scale associated with higher deliveries (Griffin, 2006).

5.4 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. The overall assessment indicates how long it takes the project to begin generating a positive cash flow balance and what the projected profit margin will be at the end of the period of analysis.

5.5 Summary of Financial Analysis

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. To summarize the process, project costs are estimated using market prices. 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 desirable. A challenge in financial analysis is cost allocation. The ideal approach is based on the beneficiaries of the project paying their portion of the project costs. The process and theory behind beneficiary pays is presented in Chapter 6.0.

6.0 BENEFICIARY PAYS

Beneficiary pays is based on the concept that those who benefit from a project should fund that project. With multiple project participants, and the potential need for state and federal funding, it is important to use the benefits received to allocate costs to ensure that contributions are equitable. The beneficiary pays principle (BPP) is similar in logic to plans where polluters pay for much of a cleanup. The difference between beneficiary pays versus polluter pays is that the threat of payment for pollution becomes an incentive for better practices. Beneficiary pays is not a means to incentivize payment. In many cases, participants may try to reduce their benefits to minimize their cost share.

6.1 Allocation Mechanisms

The goal of minimizing costs creates a “prisoner’s dilemma.” Ideally, participants would like to not contribute to the joint costs of a project but partake in the benefits from the multipurpose project. Each additional participant helps improve the benefits resulting from economies of scale. Without them, the total benefits are less and the cost to each remaining participant will increase. Unless an agreement is reached to allocate costs among all participants, the project may not proceed and all will lose (Madani, 2010). A variety of methods have been proposed for allocating costs of public projects among beneficiaries (Giglio and Wrightington, 1972). Several methods are summarized below.

6.1.1 Separable Cost Remaining Benefits (SCRB)

The Separable Cost – Remaining Benefits (SCRB) method is a commonly used approach used by State and Federal funding agencies in allocating project costs. The method is detailed in James and Lee (1971) and was first recommended to the US Inter-Agency Committee on Water Resources in 1950. In this method, the cost allocation is based on the economic benefits accrued for each purpose and user (USDOI 2001). The separable cost, which is the added cost for each participant, and proportion of benefits, is used to determine the proportion of joint costs allocated to each user. Detailed steps for the SCRB approach are described in Section 6.3 and in Figure 6-1.

6.1.2 Alternative Justifiable Expenditure (AJE)

The Alternative Justifiable Expenditure (AJE) approach is simplified version of the SCRB method. Rather than using the separable cost for each purpose, it only uses the alternative cost to construct a project which meets the same objective. (Ernst and Ernst, 1979).

AJE begins with identifying the *total project cost*, as defined in the financial analysis, and the *benefits* for each purpose, as defined in the economic analysis. For each purpose, the *cost of an alternative* project resulting in the same benefit is also calculated. The lowest of the *benefits* and *cost of alternative*, is selected and used as the *justifiable cost*. The *justifiable cost* represents the minimum value each participant should contribute to the multi-purpose project. The *specific cost* for each purpose is then defined. This value represents the cost of each purpose in the multi-purpose project. By subtracting the sum of the *specific costs* from the *total project cost*, the *total joint cost* is defined. The *remaining justifiable cost* is then calculated as the difference between the *justifiable cost* and the *specific cost*. The sum of all the *remaining justifiable costs* represents the *total remaining justifiable cost*. The proportion of the *remaining justifiable cost* to the *total remaining justifiable costs* then represents the present distribution for joint costs. Therefore, by multiplying the *total joint cost* by the representative proportion of *remaining justifiable costs, joint costs* are distributed among project participants. The total contribution by each party is equal to the *specific cost* and their proportion of the *joint costs.*

6.1.3 Subsidies

A common approach to funding projects having State or Federal interests is to subsidize the total cost. Subsidies are used to encourage projects with larger net benefits that may not be encompassed within the individual purposes or user groups. For multipurpose projects, such as water recycling, non-governmental agencies may also subsidize other participants to participate in the project by paying a portion of their separable costs. The SWB has provided subsidies for water recycling through the Clean Water State Revolving Fund. Subsidies amounted up to 25% of construction costs to a maximum value of $5 million (SWRCB, 2008).

Subsidies act as an incentive so that one party's interests are met even if another's could be met through a different project with lower costs. Providing the subsidy may keep more participants involved in the multipurpose project. The drawback of providing a subsidy is that, if applied broadly, users may not know the full opportunity cost of the project which may lead to inefficiencies (Kemper et al, 2003)

6.1.4 Cost sharing

Cost sharing is when overhead costs are distributed among users and all participants contribute (USDOI 2001). The distribution of costs is not based on the benefits received, but is sometimes a negotiated or mandated formula among agencies for many projects. Cost sharing is not the ideal cost allocation mechanism as it neglects the benefits from economies of scale from having joint-use facilities and is not suited to accept single-purpose project facilities that may get added later in the project (USDOI 2001).

6.1.5 Cost allocation based on physical (non-monetary) measures

Cost allocation can be based on non-monetary benefits such as physical benefits or costs caused by each participant. Under this methodology, a volumetric recycled water allocation may determine the cost allocation scheme. Those using 30% of the recycled water pay 30% of the cost. A disadvantage of this approach is that the economic benefit per unit of recycled water may differ across users, introducing a bias on efficient resource allocation.

6.2 Preliminary Steps

6.2.1 Baseline Conditions and Standard Assumptions

Prior to any analysis, baseline conditions and standard assumptions need to be set. The baseline describes the status in the area without the proposed water recycling project. A clear definition of the baseline helps describe the issues at hand and how the proposed recycling project may address these issues. In terms of the economic analysis of water recycling, the baseline condition consists of the fresh water and wastewater disposal alternatives without the proposed water recycling project. The baseline conditions aid in addressing how the current system would affect the multi-purpose project users and how the proposed project would therefore benefit them. Because of the implications, it is important that project participants agree on the baseline conditions established by an authority.

The standard assumptions used in economic and financial analysis calculations need to be agreed on or established authoritatively. These include the discount rate, inflation rate, interest rate, period of analysis, and whether rates used are real or nominal and subsequent costs are real or nominal.

6.2.2 Information from Economic and Financial Analyses

Information from the baseline conditions and previously undertaken financial and economic analysis are used to conduct a cost allocation. Information relevant to the cost allocation schemes are the specific benefits and costs incurred by each user and purpose. It is important to identify most benefits resulting from the project and to whom they accrue to in order to identify all of the potential financing sources (Mann, 2008). The summary information from the economic analysis describes the net benefits for each project user. This value will be used in the SCRB method for allocating joint costs. Values needed from the financial analysis include the total project cost as calculated over the period of analysis, which includes both capital and operations and maintenance costs.

6.2.3 Characterization of Benefits: Public versus Private

Benefits can be categorized as public or private. Private benefits and costs are attributable to individual groups and can be recovered through fees. Potential private benefits from water recycling include: water suppliers, wastewater providers, recreationists, and adjacent property owners (i.e. adjacent to water bodies, green areas, or golf courses). Public benefits result from public goods that do not provide a revenue stream. For water recycling projects within California these could include reduced shortage costs within the entire state, or ecosystem and environmental benefits to the State (i.e. to the Delta). The occurrence of public benefits and non-reimbursable costs provides justification for public funding from either the State, Federal, or regional government sources (Mann, 2008)

6.3 Cost Allocation - Separable Cost Remaining Benefits

Separable-Cost Remaining-Benefits (SCRB) is the approach selected for cost allocation. This method was chosen as it results in an equitable distribution of costs since it is founded on the benefits accrued to each party. SCRB is a systematic benefits-based approach to distributing joint costs and can be modified with additions to a multipurpose project. The steps in SCRB can be broken down into two broad steps: separation of costs and allocation of costs. The process is represented in Figure 6-1.

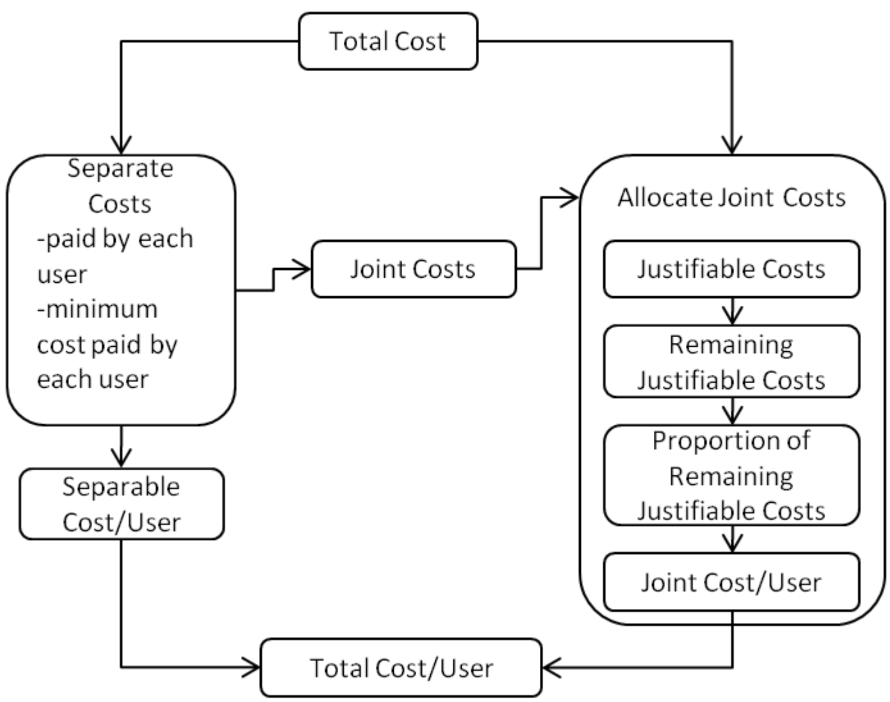

Figure 6-1 SCRB Process (adapted from USDOI 2008)

The goal of separating the costs is to establish the joint costs to be shared among all participants. This is done by finding the separable cost for each user, which represents the minimum amount each user should pay if participating in the project. Specifically, the steps involved in separating costs are:

1. Determine the total project cost (this value is taken from the financial analysis)
2. Estimate the cost for the project with each user excluded. This is done by excluding each user from the project and determining the cost to complete the project without their interests.
3. Solve for the separable cost for each user. This is equal to the difference between the total project cost and the cost of the project with the specific user excluded.
4. Sum the separable costs.
5. Solve for the total joint costs to be shared among all participants. This is equal to the total project cost less the total separable cost.

The goal of cost allocation is to distribute the joint costs among participants given their level of benefit from the multipurpose project. The remaining steps allocate costs:

6. Estimate benefits for each purpose (this is done as part of the economic analysis)
7. Estimate alternative costs for each user. This represents the cost for a single purpose project that results in the same benefit.
8. Solve for the justifiable cost. This is lesser of the two items above and represents the maximum allocated to a specific purpose.
9. Determine the remaining justifiable costs. This is difference between the justifiable cost and the separable costs and can only be calculated if the justifiable cost is greater than the separable cost. If the separable cost is greater, the participant should propose a single purpose project.
10. Determine the distribution of the remaining justifiable costs. This is the proportion of the remaining justifiable cost attributed to each user.
11. Allocate joint costs. Joint costs are allocated by multiplying the total joint costs by the percent distributions solved for in the previous step.

The total cost paid by each user is the sum of the separable cost (as solved for in step 3) and the allocated joint cost (as solved for in step 11).

6.4 Worked Examples

6.4.1 Example #1: Basic Distribution of Multi-Purpose Project Costs

A water recycling project has three participants: water supply agency A, water supply agency B, and wastewater agency C. The total project will cost $13 million over 20 years. From the economic analysis, the benefits to each participant are: $131 million to agency A, $50 million to agency B, and $10 million to agency C. For each to pursue a single purpose project it would cost $30 million, $9 million and $15 million respectively. If the project proceeded without agency A it would cost $11 million; without agency B, $8 million; and without agency C, $8 million. The separable cost for each agency and the total of joint costs to distribute is presented in Table 6-1.

Using the total project cost of $13 million and the costs with each purpose excluded ($11 million, $8million, and $8million), the *separable cost* is calculated. This is the difference between the total project cost and the cost with the purpose excluded. For agency A, this is $2 million ($13 million – $11 million). As mentioned previously, the separable cost represents the portion of costs that can be directly attributed to that user. The total of the separable costs is $12 million, leaving $1 million in joint costs to distribute among all participants. The *joint cost* is solved for by taking the difference of the total project cost and the total separable costs.

Table 6-1 Separation of Costs – Example #1

Total Multiple Purpose Project Cost	**$13,000,000**
Cost with Purpose Excluded	
Without Agency A Water Supply Purpose	**11,000,000**
Without Agency B Water Supply Purpose	**8,000,000**
Without Agency C Disposal Purpose	**8,000,000**
Separable Costs	
Agency A Water Supply ($13,000,000 less 11,000,000)	2,000,000
Agency B Water Supply ($13,000,000 less $8,000,000)	5,000,000
Agency C Disposal ($13,000,000 less $8,000,000)	5,000,000
Total Separable Costs	12,000,000
Joint Costs ($13,000,000 less $12,000,000)	1,000,000

Note: Grey shading indicates values pulled from the problem description. All other values are calculated.

The allocation of costs begins with benefits to each user as defined in the economic analysis and the cost of an alternative project for each user which results in the same benefits. These are written as the first two lines in Table 6-2. For each purpose, the lesser of these two values is the *justifiable cost*. The justifiable cost is compared to the separable cost calculated in Table 6-2. If the justifiable cost exceeds the separable cost, it is favorable for the user to participate in the multi-purpose project. The difference between the justifiable cost and separable cost is then calculated to determine the *remaining justifiable cost*. For Agency A, this equals $28 million ($30 million - $2 million). These costs are then converted into proportions by dividing the remaining justifiable cost for each user by the sum of remaining justifiable costs. For example, for Agency A, the remaining justifiable cost is 75.7% ($28 million/$37 million). Using these proportions, the joint costs are allocated. Continuing with agency A, the amount of the joint costs paid is 75.7% of the total joint cost of $1 million, which is $756,757. The total paid by each user is finally calculated as the sum of their allocated joint costs and their separable cost. These sum to the total project cost of $13 million. To determine the proportion of the total project cost by each user, the total paid by each user is divided by the total project cost. For agency A, this is equal to $2,756,757/$13,000,000 = 21.2%.

Using the SCRB approach, the total cost of $13 million is therefore divided into payments of $2.8 million from A, $5.1 million from B, and $5.1 million from C.

Table 6-2 Allocation of Costs – Example #1

	Agency A Water Supply	**Agency B Water Supply**	**Agency C Wastewater**	**Total**
Benefits (Present Worth)	**$131,000,000**	**$50,000,000**	**$10,000,000**	**191,000,000**
Alternative Cost (Least Cost Alternative)	**30,000,000**	**9,000,000**	**15,000,000**	54,000,000
Justifiable Cost (lesser of benefits and alternative cost -- *must be greater than or equal to Separable Costs*)	30,000,000	9,000,000	10,000,000	49,000,000
Separable Costs	2,000,000	5,000,000	5,000,000	12,000,000
Remaining Justifiable Cost	28,000,000	4,000,000	5,000,000	37,000,000
Percent (distribution of remaining justifiable costs)	75.7%	10.8%	13.5%	100.0%
Allocated Joint Costs	756,757	108,108	135,135	1,000,000
Total Allocated Costs (separable costs plus allocated joint costs)	2,756,757	5,108,108	5,135,135	13,000,000
Percent of Total Costs	21.2%	39.3%	39.5%	100.0%

Note: Grey shading indicates values pulled from the problem description. All other values are calculated within the table.

6.4.2 Example #2: Using SCRB with Indirect Beneficiaries

A recycled water project is being undertaken by two water districts in southern California. The facility will supply 10 TAF/yr for $25 million. Both districts receive water from an independent water wholesaler which receives water supplies via the Delta. District A is an irrigation district, uses 16 TAF/yr and intends on replacing 8 TAF/yr with recycled water. District B is a city with an annual consumption of 20 TAF/yr and B intends on replacing 2 TAF/yr of water used for landscape irrigation with recycled water. With District A excluded from the project, the cost would be $18 million; with District B excluded, the cost would be $12 million. The difference between these values and the total project cost results in separable costs of $7 million and $13 million. For the water wholesaler, the recycled water facility will allow them to reduce their deliveries ($150/acre-ft) and increase outflows for the Delta It is assumed water devoted to public benefits such as habitat conservation has a value of $50/acre-ft and is purchased by the wholesaler. This results in benefits for the wholesaler of $2 million per year. In this example, the $2 million benefits for the water wholesaler is the separable cost for the water wholesaler and is input directly into the table as opposed to being solved for through the exclusion costs (note the gray shadow in the table below). The joint costs, found by subtracting the total separable costs of $22 million from the total project cost of $25 million, are equal to $3 million.

Table 6-3 Separation of Costs – Example #2

Total Multiple Purpose Project Cost	**$25,000,000**
Cost with Purpose Excluded	
Without District A (Irrigation)	**18,000,000**
Without District B (City)	**12,000,000**
Without Water Wholesaler	
Separable Costs	
District A ("Total Multiple Purchase Cost" less "Cost with Purpose Excluded")	7,000,000
District B ("Total Multiple Purchase Cost" less "Cost with Purpose Excluded")	13,000,000
Water Wholesaler ("Total Multiple Purchase Cost" less "Cost with Purpose Excluded")	**2,000,000**
Total Separable Costs	22,000,000
Joint Costs (Total Multiple Purchase Cost less Total Separable Costs)	3,000,000

Note: Grey shading indicates values pulled from the problem description. All other values are calculated.

Information from the economic analysis found the benefit to District A and B to be $50 million and $100 million respectively. The recycling facility would also represent a benefit of $70 million to the regional water wholesaler (i.e. from reduced pumping costs, environmental benefits, and benefits from improved system reliability). The alternative cost to achieve the same benefit to each user would be $13 million, $28 million, and $3 million respectively. For each purpose, the lesser of these two values represents the *justifiable cost*. The difference between the justifiable cost and separable cost is then calculated to determine the *remaining justifiable cost*. These costs are converted into proportions by dividing the remaining justifiable cost for each user by the sum of remaining justifiable costs. For example, for District A, the remaining justifiable cost is equal to 27.3% ($6 million/$22 million). Using these proportions, the joint costs are allocated. Continuing with District A, the amount of the joint costs paid is equal to 27.3% of the total joint cost of $3 million, which is $818,182. The total paid by each user is finally calculated as the sum of their allocated joint costs and their separable cost. These sum to the total project cost of $25 million. To determine the proportion of the total project cost by each user, the total paid by each user is divided by the total project cost. For agency A, this is equal to $7,818,182/$25,000,000 = 31.3%.

In this example, although not a direct user of reclaimed water, the water wholesaler benefits from its use. The SCRB method is valuable as it is able to identify how much the wholesaler should contribute based on its benefits. Without using SCRB, the wholesaler may provide a subsidy which is irrespective of the value of the facility to them.

Table 6-4 Allocation of Costs – Example #2

	District A Irrigation	District B City	Wholesaler	Total
Benefits (Present Worth)	**$50,000,000**	**$100,000,000**	**$70,000,000**	**220,000,000**
Alternative Cost (Least Cost Alternative)	**13,000,000**	**28,000,000**	**3,000,000**	44,000,000
Justifiable Cost (lesser of benefits and alternative cost -- *must be greater than or equal to Separable Costs*)	13,000,000	28,000,000	3,000,000	44,000,000
Separable Costs	7,000,000	13,000,000	2,000,000	22,000,000
Remaining Justifiable Cost	6,000,000	15,000,000	1,000,000	22,000,000
Percent (distribution of remaining benefits)	27.3%	68.2%	4.5%	100.0%
Allocated Joint Costs	818,182	2,045,455	136,364	3,000,000
Total Allocated Costs (separable costs plus allocated joint costs)	7,818,182	15,045,455	2,136,364	25,000,000
Percent of Total Costs	31.3%	60.2%	8.5%	100.0%

Note: Grey shading indicates values pulled from the problem description. All other values are calculated.

6.5 Application Issues

Employing Beneficiary Pays Analysis to allocate project costs is not a cut and dry process. It is a challenge to employ because those who benefit more will pay more; therefore, participants have an economic incentive to report lower benefits so that they disburse fewer funds. This results in information asymmetries while estimating project benefits and costs, especially for benefits which are difficult to quantify. Further complexity arises when considering operations and maintenance (O&M) costs, including non-monetized costs and characterizing costs, and characterizing benefits as public or private.

Typical funding programs are based on capital expenditures and do not provide funds for ongoing O&M costs. The benefits of a project are dependent on the project being functional. Providing compensation for O&M is a potential future issue to address.

Challenges also stem from including non-monetized benefits and costs, and identifying of public benefits. A method to account for non-quantifiable benefits and costs is using Trade Off Analysis. This is presented in Section 4.5.4. Another challenge is identifying benefits as public or private. Public benefits do not generate a revenue stream which is later redistributed to society. Likewise, some private benefits may not generate a revenue stream and participants may be reluctant to include them as part of their benefits. In addition, there could be disputes over what is considered private versus public. Thus there is an incentive for funding applicants to identify more benefits as public rather than private to increase government funding received and minimize their own financial contribution.

Another issue related to public benefits is the extent to which they apply. Part of this is captured in the accounting stance established in the economic analysis. If a statewide stance is used, it is appropriate to include statewide benefits. If a local level is used however, wider state effects should not be included.

The other avenue related to extent is the actual measurable benefit. For example, currently, agencies receiving water from the Delta, who are promoting water recycling projects, may claim a beneficial reduction in water withdrawals from the Delta. However, the impact on Delta outflows of increased recycling may be minimal. Therefore, agencies claiming Delta environmental benefits as a justification for public finding should demonstrate how their proposed recycling projects would result in greater Delta outflows, either by showing their effect on future plans for diversions of Delta inflows, requests for Delta export deliveries under SWP or CVP contracts, or direct Delta exports.

7.0 CASE STUDY: INLAND VS COASTAL WATER RECYCLING

This case study examines the difference in the economic desirability of pursuing water recycling between inland and coastal locations. Water recycling occurs in both locations in California, but a comparison between them has not been done.

The following sections describe a location in southern California. The values used in the economic analysis are representative for the region, but the scenarios are hypothetical since they have been adapted for a more controlled and fair comparison. Local results may vary. Full results from the economic analysis are in Appendix A.

7.1 Description of Scenario

The two southern California communities are inland and coastal. Each serves a similar geographic area with approximately 1 million people. Current annual demand is 100 thousand acre feet (taf) and water sources are imported from the Metropolitan Water District (MWD) and groundwater (50 taf from each source). Effluent from the inland wastewater treatment plant (WWTP) discharges into a river which flows downstream to the coastal community. This surface water recharges the coastal groundwater basin. Effluent from the coastal WWTP discharges to the ocean (see Figure 7-1).

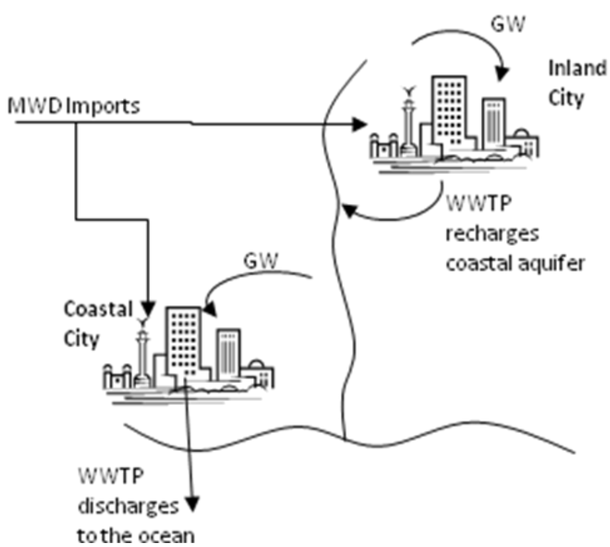

Figure 7-1 Schematic of Case Study

Future annual demand is 150 taf, due to population growth. To meet future demands both districts can increase imports by 50 taf/year. Groundwater would not supply the increased demand as further pumping would cause overdraft and poorer water quality which would require additional desalination. Increased demand would require expanded capacity to treat the additional supply as well as additional WWTP capacity. Conversely, both communities could build a water recycling facility to produce 50 taf/year of recycled water. Recycled water would act as a supply for future demand but would not offset the current supplies from imports or groundwater. Using recycled water would avoid some costs for treating imported water supplies. For inland recycling, reduced imports would maintain more surface water in

Northern California waterways with some environmental and recreation benefits (i.e. recreation on reservoirs). Recycling inland would reduce WWTP releases to the river with only 20% of the recycled volume flowing downstream to recharge the coastal aquifer. (This also assumes that inland would still meet any environmental flow constraints). The reduced recharge would reduce the volume of groundwater available for the coastal area. The available groundwater would be poor quality and would require the coastal location to desalinate the brackish groundwater to meet water quality guidelines. Four alternatives evaluating the economic benefit of recycling were considered. The alternatives are presented in Table 7-1 and depicted in Figure 7-2.

Table 7-1 Alternatives for Increased Demand

No	Alternative	Description
A	Base Case	Import additional demand from MWD. No water recycling.
B	Coast Only	Water recycling only for the coastal community. Inland community meets increased demand with increased imports. Effluent from WWTP recharges coastal aquifer.
C	Inland Only	Water recycling for the inland community. Coastal community meets increased demand with increased imports. 20% of WWTP effluent returns to the river resulting in 10 taf/yr of groundwater from the coastal aquifer. The coastal community therefore must desalinate groundwater.
D	Both Recycle	Both coastal and inland communities meet increased demand by recycling water. 20% of WWTP effluent from the inland city returns to the river resulting in 10 taf/yr of groundwater from the coastal aquifer. The coastal community therefore must desalinate groundwater.

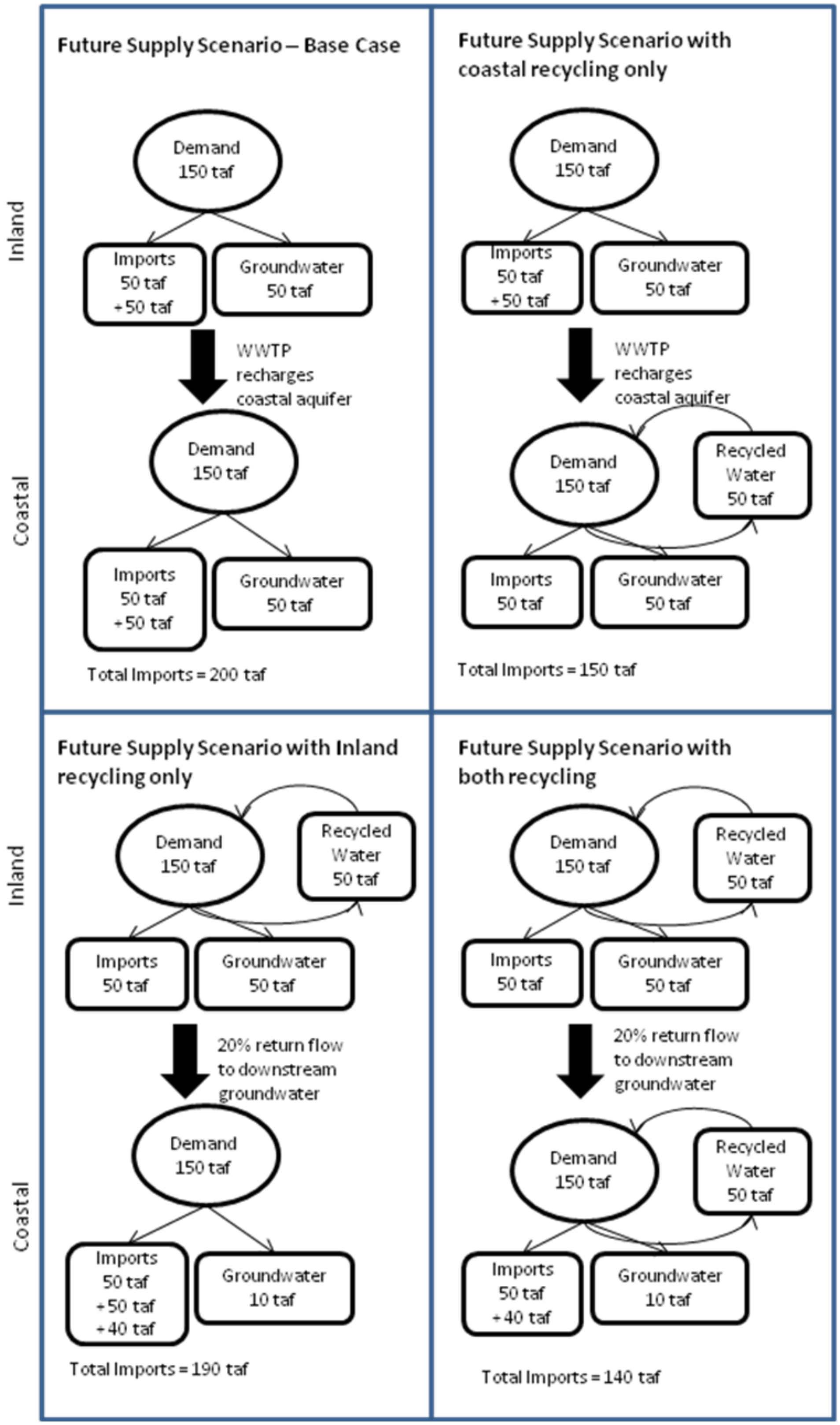

Figure 7-2 Future Supply Alternatives

7.2 Economic Benefits and Costs Included

The benefits for each location are presented in Table 7-2. For consistency, the same values were used for: reclaimed water revenue, incentives from MWD, tier one pricing for MWD purchases, and avoided water supply treatment costs. The MWD incentive of $250/af was taken to represent the difference between the average cost and marginal cost of supplying imports. For the case study the average cost to supply imported water was $527/af (the tier one purchase rate), the marginal cost to supply imports was therefore $777/af ($527 + $250). For the inland location, in-stream and near stream benefits were quantified. For the coast, benefits from reduced groundwater pumping were quantified.

Table 7-2 Benefits Quantified

Benefit	Inland Value	Coastal Value
Reclaimed water sales revenue	$76/AF price escalation of 4.5% per annum	$76/AF price escalation of 4.5% per annum
MWD Incentive (to reduce imports)	$250/AF of water replaced	$250/AF of water replaced
MWD Tier one purchases (MWD, 2010)	$527/AF price escalation of 4.5% per annum	$527/AF price escalation of 4.5% per annum
Avoided water supply treatment	New treatment plant for additional 50 taf. Estimated annual cost (capital and O&M) of $11.5 million.	New treatment plant for additional 50 taf. Estimated annual cost (capital and O&M) of $11.5 million.
In-stream recreation (Rosenberger and Loomis, 2000)	$30/person/day Assumes an average of 100 ppl per each weekend day (104 days total). Annual total of $312,000	$30/person/day Assumes an average of 100 ppl per each weekend day (104 days total). Annual total of $312,000
Near-stream recreation (Rosenberger and Loomis, 2000)	based on $45/person/day weekend attendance of 300ppl weekday of 100 ppl Annual Total of $2.6 million	based on $45/person/day weekend attendance of 300ppl weekday of 100 ppl Annual Total of $2.6 million
Avoided groundwater pumping	None	$130/AF price escalation of 4.5% per annum

Costs were categorized as capital or operations and maintenance (O&M). For the inland location, wastewater was assumed to be treated to a tertiary level and that the same treatment level would be attained by the WWTP regardless of whether the effluent was recycled. The capital cost to build a new WWTP to treat 50 taf was estimated to be $148 million. O&M costs were estimated to be $3.5 million. For the coast, wastewater was assumed to be treated to an advanced level to meet ocean discharge standards. Advanced treatment entails microfiltration, reverse osmosis, and UV treatment with hydrogen peroxide to remove organic and trace contaminants. As with inland, the coast would treat to this level regardless of recycling. The capital cost to build a new WWTP with advanced treatment of wastewater was estimated to be $463 million and the annual O&M costs were $33.5 million. The capital costs were more than three times greater and the O&M costs were more than nine times greater for the coast facility. This was due to the costs associated with advanced treatment of wastewater using the described methods.

With recycling water, additional costs would be incurred for the distribution, transmission, and retrofitting. These capital costs were estimated to be $18 million. For this case study, the additional capital costs were the same for both coast and inland locations. This assumes a similar distribution and transmission system would be constructed. The estimate was based on installation of approximately 17 miles of pipeline, construction of three new pump stations, and retrofits to accommodate recycled water. Additional O&M costs were estimated to be $500,000 annually. A summary of the costs for the WWTP and recycling facilities at each location is in Table 7-3. In addition, with inland recycling and reduced recharge in the coast aquifer (Alternatives C and D), an additional cost of $550/af to treat groundwater would be incurred.

Table 7-3 Costs Quantified

Cost	Inland WWTP	Inland Recycling	Coastal WWTP	Coastal Recycling
Capital Includes conveyance, distribution, construction, and retrofits Financed over 20 years at 4.25%	$148 million	$166 million	$463 million	$481 million
Annual Operations and Maintenance Includes all labor, materials.	$3.5 million	$4 million	$33.5million	$34 million
Notes: For the base case, costs for water supply treatment and importing water were also included (see Table 7-2 for values). For inland recycling scenarios (Alternatives C and D), costs to desalinate coastal groundwater were incurred. Desalination costs were estimated to be $550/af.				

Rates used to appropriately adjust benefits and costs appear in Table 7-4.

Table 7-4 Rates for Case Study

Rate	Value (%)	Values Adjusted
Interest Rate	4.25%	Capital costs. Finance payments over 20 years.
Price Escalation	4.5%	Price for groundwater, imported water, recycled water
Discount Rate	3.0%	Real discount rate (adjusted for inflation) used to adjust all benefits and costs.

7.3 Results and Discussion

Economic analyses results are summarized in Table 7-5. Full results appear in Appendix A. The best alternative (highest net benefit) was for both locations to recycle water which resulted in net benefits of -$269 million and an improvement of $2.7 billion from the base case alternative. The economic analysis demonstrated that recycling at the coast location only was better than recycling at the inland location only with net benefits for the coast alternative at -$1.0 billion versus -$1.5 billion for the inland alternative. The "inland only" alternative was less desirable because reductions in the volume of groundwater available increased the treatment costs of groundwater and required additional imports to make up the losses from groundwater (see Figure 7-2). The lowest ranking alternative was the base case, where both locations did not recycle, constructed a new WWTP, imported additional water, and constructed a new water supply treatment facility to meet the addition 50 taf demand. The largest benefit in all alternatives was the avoided cost associated with importing additional water.

Table 7-5 Economic Desirability of Inland and Coastal Water Recycling

Alt.	Net Benefit (Present Value)	Relative Diff. (relative to base case)	Annual Revenue Needed to break even	Total Volume RW (af)	Additional Cost/af of RW to break even	Total Cost/af of RW to break even
Base	-$2.9 billion	n/a	$ 172 million	0	n/a	n/a
Coast Only	-$1.0 billion	$1.7 billion	$ 60 million	50,000	$ 1,196	$1,273
Inland Only	-$1.5 billion	$1.2 billion	$ 89 million	50,000	$1,781	$1,857
Both Recycle	-$269 million	$2.4 billion	$ 16 million	100,000	$ 156	$232
Annual revenue to break even based on a period of 20 years, price escalation factor of 4.5%, discount rate of 3%, resulting in a rate of 1.5%. (A/P, 1.5%, 20 years) = 0.0582						

Because all alternatives were not desirable, the revenue needed to break even (i.e. Net Benefits = 0) was calculated. The benefits were assumed to come from increasing the price charged for reclaimed water. The price for reclaimed water was initially set at $76/af, escalated annually at 4.5%. With a price escalation factor of 4.5% and discount rate of 3.0%, the annual effective rate was 1.5%. Evaluated over 20 years, the additional annual revenue for each alternative was calculated. Results are presented in Table 7-5. To break even when both inland and coast recycle, the total additional price of recycled water was $156/af for a total price of $232/af.

The case study completed did not account for some benefits which may have affected the overall desirability. Certain benefits, such as increases in property value from greenbelts and golf courses and revenue from coastal beach activity, were not included. It was assumed that they would accrue in all alternatives since the additional supply needed was constant in all scenarios and the same treatment level would be attained at both locations regardless of recycling. Other benefits were not included because of the difficulty associated in quantifying them. These include increased reliability of the supply source and increased local control over water supply. The results for the cased study could be improved by accounting for additional benefits and costs.

8.0 DISCUSSION

Recycled water addresses a demand for water. Although economic and financial analyses consider broad financial implications and feasibility, there is never perfect predictability. Uncertainty is inescapable in water management and water recycling, as it always has been. Water demands, technologies, regulations, and water availability are always changing in uncertain ways. California needs alternative water supply sources. Given the size and cost of water recycling facilities it is important to determine, logically, whether they are likely to be a good investment. Economic analysis is a means to do this. Economic analysis allows a fair comparison between alternatives to show the likely value of a project to the region, not just the project proponent. For instance, if the only factors considered were the costs to build and operate the facility and the revenues from sales (and the MWD incentive), the coastal recycling facility would not be feasible. The broader benefits make water recycling desirable.

Demonstrating the value of the project and quantifying where the value is derived from also helps in justifying funding sources. For example, benefits from beach activity benefit the immediate city through supporting local businesses, but use of the beach is also a public benefit. The presence of public benefits provides weight when requesting funds from public sources. Because the project is economically feasible, funding agencies should recognize that it is a valid investment. If, following the beneficiary pays principle (BPP), the value of public benefits could justify a contribution from government sources. In the case study presented, MWD already employs the BPP by providing a financial incentive to reduce pressure on their resources.

The Beneficiary Pays Principle is important in designing and applying cost allocation schemes of a project among beneficiaries. The Separable Cost Remaining Benefit approach, advocated here, requires a large amount of information; however, it may result in a more economically efficient and equitable allocation of limited resources. Its application helps reduce the gap in funding between government agencies, other funding sources and ultimate project beneficiaries. By minimizing government contributions to projects, more funding would be available for projects which are not self-financing or which have greater public benefits (Misczynski, 2009). If a water recycling project is economically justified but not locally feasible financially, the state may lever funding to make the project financially feasible.

A simpler alternative to the BPP is to provide a standard subsidy, either an absolute value or percent contribution to projects which benefit society. This approach requires less computational effort but can result in large amounts of money going towards projects with small public benefits. With limited funds, the economic analyses could be used to rank projects and act as the selection criteria for funding projects. Affordable projects not requiring significant amounts of funding may be candidates for this less costly cost allocation approach.

Economic analysis provides valuable information. It quantifies the value of a project in monetary terms, which is easy for decision-makers to understand. It identifies why the project is valuable and feasible by highlighting key parameters. In addition, the results can be used to assist in securing funding.

9.0 SUMMARY AND CONCLUSIONS

This document describes how to complete an economic analysis, financial analysis, and cost allocation for a water recycling facility. Water recycling has gained importance in California given water scarcity, rising wastewater treatment and disposal costs, uncertainty in traditional supply sources, and incentives for conservation. Still, it is important to ensure that projects are carefully thought through and are beneficial to society. A logical means to assess the broad value of water recycling is through formal economic analysis.

The economic analysis compares alternatives. It takes a broad perspective and considers all direct costs and benefits of an alternative. There are many indicators for comparing alternatives. Here, the expected net present value (ENPV) approach is advocated because of its simplicity, rigor, and difficulty in manipulating values arbitrarily. Using ENPV, the alternative with the largest net benefit is considered the best alternative.

Results from an economic analysis also can aid in cost allocation. Multipurpose projects, like water recycling, have many project participants and beneficiaries. A major challenge is to determine who should pay how much. In addition, if public funding is needed, it can be difficult to assess the public contribution. Separable-cost remaining-benefits (SCRB) approach is recommended for cost allocation. It is a systematic benefits-based approach to distributing joint costs and can be modified with additions to a multipurpose project. Although relatively computationally intensive, it ensures an equitable distribution of costs.

Water recycling is a valuable supply source for California. As demonstrated in the case study comparing inland and coastal recycling, the economic analysis quantifies this value and can compare the differences between alternatives. Results from the economic analysis can help local officials determine the best alternative to pursue and can also assist public agencies in assessing which projects should qualify for funds, and how much funding they should receive.

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APPENDIX A

Standard Assumptions

Table A-1: Time and Interest

Description	Amount	Unit
Period of Analysis	20	years
Recycled Water Market Price	$76	per AF
Potable Water Replacement Factor (for RW)	1.0	
Project Reference Year (Ref Yr)	2011	year
Project Design Cost Year	2011	year
Project Construction Year	2012	year
Project First Year of Operation	2013	years
Project's last Year of Operation	2033	
Financing Period	20	years
Annual Interest Rate	4.25%	
Annual Inflation Rate	1.64%	
Discount Rate	3.00%	

Table A-2: Identification and Quantification of Benefits

Alternative *Base Case*

Item	Benefit	Comments	Quantifiable	Probability	2013	2014
		Annual Total			$0	$0

2015	2016	2017	2018	2019	2020	2021	2022
$0	$0	$0	$0	$0	$0	$0	$0

2023	2024	2025	2026	2027	2028	2029	2030
$0	$0	$0	$0	$0	$0	$0	$0

2031	2032	2033
$0	$0	$0

Table A-3: Identification and Quantification of Costs

Alternative *Base Case*

Item	Benefit	Comments	Quantifiable	Probability	2013
1	Financing costs	financing of $463 mil of capital costs (which include retrofit costs) over 20 years	YES		
	coastal WWTP		High Estimate		
			Best Estimate	1	34,826,784
			Low Estimate		
			Expected Value	**1.0**	**$34,826,784**
2	O&M costs for reclamation treatment	all O&M. $33.5 mil annually	YES		
			High Estimate		
			Best Estimate	1	$33,500,000
			Low Estimate		
			Expected Value	**1.0**	**$33,500,000**
3	Avoided capital costs of water supply treatment	Capital = $90 mil over 20 yrs,	YES		
	new water supply facility	O&M = $4.5 mil annually not inflated	High Estimate		
			Best Estimate	1	$11,269,785
			Low Estimate		
			Expected Value	**1.0**	**$11,269,785**
4	Avoided costs of water supply development/purchase (potable water)	purchase from MWD	YES		
	cost to import additional water	tier 1: $527/af	High Estimate		
		50 000 af	Best Estimate	1	$26,350,000
		4.5% escalation factor	Low Estimate		
			Expected Value	**1.0**	**$26,350,000**

5	Financing costs	financing of $148 mil of capital costs (which include retrofit costs) over 20 years	YES		
	for inland WWTP		High Estimate		
			Best Estimate	1	11,132,536
			Low Estimate		
			Expected Value	**1.0**	**$11,132,536**
6	O&M costs for reclamation treatment	all O&M	YES		
	for inland WWTP		High Estimate		
			Best Estimate	1	$3,500,000
			Low Estimate		
			Expected Value	**1.0**	**$3,500,000**
7	Avoided capital costs of water supply treatment	Capital = $90 mil over 20 yrs, O&M = $4.5 mil annually not inflated	YES		
	for inland facility		High Estimate		
			Best Estimate	1	$11,269,785
			Low Estimate		
			Expected Value	**1.0**	**$11,269,785**
8	Avoided costs of water supply development/purchase (potable water)	purchase from MWD	YES		
	for inland facility	tier 1: $527/af	High Estimate		
	cost to import additional water	50 000 af	Best Estimate	1	$26,350,000
		4.5% escalation factor	Low Estimate		
			Expected Value	**1.0**	**$26,350,000**
			Annual Total		$158,198,889

Table A-3: Identification and Quantification of Costs

Alternative

Item	2014	2015	2016	2017	2018	2019
1						
	34,826,784	34,826,784	34,826,784	34,826,784	34,826,784	34,826,784
	$34,826,784	**$34,826,784**	**$34,826,784**	**$34,826,784**	**$34,826,784**	**$34,826,784**
2						
	$33,500,000	$33,500,000	$33,500,000	$33,500,000	$33,500,000	$33,500,000
	$33,500,000	**$33,500,000**	**$33,500,000**	**$33,500,000**	**$33,500,000**	**$33,500,000**
3						
	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785
	$11,269,785	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**
4						
	$27,535,750	$28,774,859	$30,069,727	$31,422,865	$32,836,894	$34,314,554
	$27,535,750	**$28,774,859**	**$30,069,727**	**$31,422,865**	**$32,836,894**	**$34,314,554**
5						

	11,132,536	11,132,536	11,132,536	11,132,536	11,132,536	11,132,536
	$11,132,536	**$11,132,536**	**$11,132,536**	**$11,132,536**	**$11,132,536**	**$11,132,536**
6						
	$3,500,000	$3,500,000	$3,500,000	$3,500,000	$3,500,000	$3,500,000
	$3,500,000	**$3,500,000**	**$3,500,000**	**$3,500,000**	**$3,500,000**	**$3,500,000**
7						
	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785
	$11,269,785	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**
8						
	$27,535,750	$28,774,859	$30,069,727	$31,422,865	$32,836,894	$34,314,554
	$27,535,750	**$28,774,859**	**$30,069,727**	**$31,422,865**	**$32,836,894**	**$34,314,554**
	$160,570,389	$163,048,607	$165,638,344	$168,344,620	$171,172,677	$174,127,998

Table A-3: Identification and Quantification of Costs

Alternative

Item	2020	2021	2022	2023	2024	2025	2026	2027
1								
	34,826,784	34,826,784	34,826,784	34,826,784	34,826,784	34,826,784	34,826,784	34,826,784
	$34,826,784	**$34,826,784**	**$34,826,784**	**$34,826,784**	**$34,826,784**	**$34,826,784**	**$34,826,784**	**$34,826,784**
2								
	$33,500,000	$33,500,000	$33,500,000	$33,500,000	$33,500,000	$33,500,000	$33,500,000	$33,500,000
	$33,500,000	**$33,500,000**	**$33,500,000**	**$33,500,000**	**$33,500,000**	**$33,500,000**	**$33,500,000**	**$33,500,000**
3								
	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785
	$11,269,785	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**
4								
	$35,858,709	$37,472,351	$39,158,607	$40,920,744	$42,762,178	$44,686,476	$46,697,367	$48,798,749
	$35,858,709	**$37,472,351**	**$39,158,607**	**$40,920,744**	**$42,762,178**	**$44,686,476**	**$46,697,367**	**$48,798,749**
5								

	11,132,536	11,132,536	11,132,536	11,132,536	11,132,536	11,132,536	11,132,536	11,132,536
	$11,132,536	**$11,132,536**	**$11,132,536**	**$11,132,536**	**$11,132,536**	**$11,132,536**	**$11,132,536**	**$11,132,536**
6								
	$3,500,000	$3,500,000	$3,500,000	$3,500,000	$3,500,000	$3,500,000	$3,500,000	$3,500,000
	$3,500,000	**$3,500,000**	**$3,500,000**	**$3,500,000**	**$3,500,000**	**$3,500,000**	**$3,500,000**	**$3,500,000**
7								
	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785
	$11,269,785	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**
8								
	$35,858,709	$37,472,351	$39,158,607	$40,920,744	$42,762,178	$44,686,476	$46,697,367	$48,798,749
	$35,858,709	**$37,472,351**	**$39,158,607**	**$40,920,744**	**$42,762,178**	**$44,686,476**	**$46,697,367**	**$48,798,749**
	$177,216,308	$180,443,592	$183,816,103	$187,340,378	$191,023,245	$194,871,841	$198,893,624	$203,096,387

Table A-3: Identification and Quantification of Costs
Alternative

Item	2028	2029	2030	2031	2032	2033
1						
	34,826,784	34,826,784	34,826,784	34,826,784	34,826,784	34,826,784
	$34,826,784	**$34,826,784**	**$34,826,784**	**$34,826,784**	**$34,826,784**	**$34,826,784**
2						
	$33,500,000	$33,500,000	$33,500,000	$33,500,000	$33,500,000	$33,500,000
	$33,500,000	**$33,500,000**	**$33,500,000**	**$33,500,000**	**$33,500,000**	**$33,500,000**
3						
	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785
	$11,269,785	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**
4						
	$50,994,692	$53,289,454	$55,687,479	$58,193,415	$60,812,119	$63,548,665
	$50,994,692	**$53,289,454**	**$55,687,479**	**$58,193,415**	**$60,812,119**	**$63,548,665**
5						
	11,132,536	11,132,536	11,132,536	11,132,536	11,132,536	11,132,536
	$11,132,536	**$11,132,536**	**$11,132,536**	**$11,132,536**	**$11,132,536**	**$11,132,536**
6						

	$3,500,000	$3,500,000	$3,500,000	$3,500,000	$3,500,000	$3,500,000
	$3,500,000	**$3,500,000**	**$3,500,000**	**$3,500,000**	**$3,500,000**	**$3,500,000**
7						
	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785
	$11,269,785	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**
8						
	$50,994,692	$53,289,454	$55,687,479	$58,193,415	$60,812,119	$63,548,665
	$50,994,692	**$53,289,454**	**$55,687,479**	**$58,193,415**	**$60,812,119**	**$63,548,665**
	$207,488,274	$212,077,796	$216,873,847	$221,885,720	$227,123,128	$232,596,218

Table A-4: Project Evaluation

Alternative *Base Case* Discount Rate 3.0%

	Year	Annual Benefits	Discounted Benefits	Annual Costs	Discounted Costs	Net Benefits (discounted)
0	2013	$0	$0	$158,198,889	$158,198,889	-$158,198,889
1	2014	$0	$0	$160,570,389	$155,893,582	-$155,893,582
2	2015	$0	$0	$163,048,607	$153,688,950	-$153,688,950
3	2016	$0	$0	$165,638,344	$151,582,549	-$151,582,549
4	2017	$0	$0	$168,344,620	$149,572,014	-$149,572,014
5	2018	$0	$0	$171,172,677	$147,655,055	-$147,655,055
6	2019	$0	$0	$174,127,998	$145,829,457	-$145,829,457
7	2020	$0	$0	$177,216,308	$144,093,076	-$144,093,076
8	2021	$0	$0	$180,443,592	$142,443,838	-$142,443,838
9	2022	$0	$0	$183,816,103	$140,879,737	-$140,879,737
10	2023	$0	$0	$187,340,378	$139,398,835	-$139,398,835
11	2024	$0	$0	$191,023,245	$137,999,256	-$137,999,256
12	2025	$0	$0	$194,871,841	$136,679,188	-$136,679,188
13	2026	$0	$0	$198,893,624	$135,436,880	-$135,436,880
14	2027	$0	$0	$203,096,387	$134,270,638	-$134,270,638
15	2028	$0	$0	$207,488,274	$133,178,828	-$133,178,828
16	2029	$0	$0	$212,077,796	$132,159,871	-$132,159,871
17	2030	$0	$0	$216,873,847	$131,212,244	-$131,212,244
18	2031	$0	$0	$221,885,720	$130,334,476	-$130,334,476
19	2032	$0	$0	$227,123,128	$129,525,146	-$129,525,146
20	2033	$0	$0	$232,596,218	$128,782,887	-$128,782,887
	Subtotals	***$0***	***$0***	***$3,995,847,985***	**$2,958,815,395**	**-$2,958,815,395**

Table A-5: Identification and Quantification of Benefits

Alternative *Coast Only*

Item	Benefit	Comments	Quantifiable	Probability	2013
1	Other (specify):	MWD incentive	YES		
		$250/af replaced	High Estimate		
		replacing 50 000 af	Best Estimate	1	$12,500,000
			Low Estimate		
			Expected Value	**1.0**	**$12,500,000**
2	Reclaimed water sales revenues	sell at $76/af	YES		
		sell full capacity of 50 000 af	High Estimate		
		adjust for price escalation factor of 4.5%	Best Estimate	1	$3,800,000
			Low Estimate		
			Expected Value	**1.0**	**$3,800,000**
3	Avoided costs of water supply development/purchase (potable water)	purchase from MWD	YES		
	cost to import additional water at coast	tier 1: $527/af	High Estimate		
		50 000 af	Best Estimate	1	$26,350,000
		4.5% escalation factor	Low Estimate		
			Expected Value	**1.0**	**$26,350,000**
4	Avoided capital costs of water supply treatment	Capital = $90 mil over 20 yrs, O&M = $4.5 mil annually	YES		
	new water supply facility		High Estimate		
			Best Estimate	1	$11,269,785
			Low Estimate		

			Expected Value	**1.0**	**$11,269,785**
5	In-stream recreation	based on $30/person/day assumes an average of 100 ppl per each weekend day (104 days total)	YES		
			High Estimate		
			Best Estimate	1	**$312,000**
			Low Estimate		
			Expected Value	**1.0**	**$312,000**
6	Near-stream recreation	based on $45/person/day weekend attendance of 300ppl weekday of 100 ppl	YES		
			High Estimate		
			Best Estimate	1	$2,578,500
			Low Estimate		
			Expected Value	**1.0**	**$2,578,500**
			Annual Total		**$56,810,285**

Table A-5: Identification and Quantification of Benefits

Alternative *Coast Only*

Item	2014	2015	2016	2017	2018	2019	2020	2021	2022
1									
	$12,500,000	$12,500,000	$12,500,000	$12,500,000	$12,500,000	$12,500,000	$12,500,000	$12,500,000	$12,500,000
	$12,500,000	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**
2									
	$3,971,000	$4,149,695	$4,336,431	$4,531,571	$4,735,491	$4,948,588	$5,171,275	$5,403,982	$5,647,162
	$3,971,000	**$4,149,695**	**$4,336,431**	**$4,531,571**	**$4,735,491**	**$4,948,588**	**$5,171,275**	**$5,403,982**	**$5,647,162**
3									
	$27,535,750	$28,774,859	$30,069,727	$31,422,865	$32,836,894	$34,314,554	$35,858,709	$37,472,351	$39,158,607
	$27,535,750	**$28,774,859**	**$30,069,727**	**$31,422,865**	**$32,836,894**	**$34,314,554**	**$35,858,709**	**$37,472,351**	**$39,158,607**
4									
	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785

5	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**
	$312,000	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**
6	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**
	$2,578,500	$2,578,500	$2,578,500	$2,578,500	$2,578,500	$2,578,500	$2,578,500	$2,578,500	$2,578,500
	$2,578,500	**$2,578,500**	**$2,578,500**	**$2,578,500**	**$2,578,500**	**$2,578,500**	**$2,578,500**	**$2,578,500**	**$2,578,500**
	$58,167,035	**$59,584,839**	**$61,066,444**	**$62,614,721**	**$64,232,671**	**$65,923,428**	**$67,690,269**	**$69,536,619**	**$71,466,054**

Table A-5: Identification and Quantification of Benefits

Alternative *Coast Only*

Item	2023	2024	2025	2026	2027	2028	2029	2030
1								
	$12,500,000	$12,500,000	$12,500,000	$12,500,000	$12,500,000	$12,500,000	$12,500,000	$12,500,000
	$12,500,000	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**
2								
	$5,901,284	$6,166,842	$6,444,349	$6,734,345	$7,037,391	$7,354,073	$7,685,007	$8,030,832
	$5,901,284	**$6,166,842**	**$6,444,349**	**$6,734,345**	**$7,037,391**	**$7,354,073**	**$7,685,007**	**$8,030,832**
3								
	$40,920,744	$42,762,178	$44,686,476	$46,697,367	$48,798,749	$50,994,692	$53,289,454	$55,687,479
	$40,920,744	**$42,762,178**	**$44,686,476**	**$46,697,367**	**$48,798,749**	**$50,994,692**	**$53,289,454**	**$55,687,479**
4								
	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785

5	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**
	$312,000	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**
6	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**
	$2,578,500	$2,578,500	$2,578,500	$2,578,500	$2,578,500	$2,578,500	$2,578,500	$2,578,500
	$2,578,500	**$2,578,500**	**$2,578,500**	**$2,578,500**	**$2,578,500**	**$2,578,500**	**$2,578,500**	**$2,578,500**
	$73,482,313	**$75,589,304**	**$77,791,110**	**$80,091,997**	**$82,496,425**	**$85,009,051**	**$87,634,745**	**$90,378,596**

Table A-5: Identification and Quantification of Benefits

Alternative *Coast Only*

Item	2031	2032	2033
1			
	$12,500,000	$12,500,000	$12,500,000
	$12,500,000	**$12,500,000**	**$12,500,000**
2			
	$8,392,219	$8,769,869	$9,164,513
	$8,392,219	**$8,769,869**	**$9,164,513**
3			
	$58,193,415	$60,812,119	$63,548,665
	$58,193,415	**$60,812,119**	**$63,548,665**
4			
	$11,269,785	$11,269,785	$11,269,785

	$11,269,785	**$11,269,785**	**$11,269,785**
5			
	$312,000	**$312,000**	**$312,000**
	$312,000	**$312,000**	**$312,000**
6			
	$2,578,500	$2,578,500	$2,578,500
	$2,578,500	**$2,578,500**	**$2,578,500**
	$93,245,920	**$96,242,274**	**$99,373,463**

Table A-6: Identification and Quantification of Costs

Alternative *Coast Only*

Item	Benefit	Comments	Quantifiable	Probability	2013
1	Financing costs	financing of $481 mil of capital costs (which include retrofit costs) over 20 years	YES		
	coastal recycling facility		High Estimate		
			Best Estimate	1	36,180,741
			Low Estimate		
			Expected Value	**1.0**	**$36,180,741**
2	O&M costs for reclamation treatment	all O&M. $34 mil annually	YES		
	coastal recycling facility		High Estimate		
			Best Estimate	1	$34,000,000
			Low Estimate		
			Expected Value	**1.0**	**$34,000,000**
3	Financing costs	financing of $148 mil of capital costs (which include retrofit costs) over 20 years	YES		
	for inland WWTP		High Estimate		
			Best Estimate	1	11,132,536
			Low Estimate		
			Expected Value	**1.0**	**$11,132,536**
4	O&M costs for reclamation treatment	all O&M	YES		
	for inland WWTP		High Estimate		
			Best Estimate	1	$3,500,000
			Low Estimate		
			Expected Value	**1.0**	**$3,500,000**
5	capital costs of water supply treatment	Capital = $90 mil over 20 yrs,	YES		
	for inland facility		High Estimate		

		O&M = $4.5 mil annually	Best Estimate	1	12,486,493
			Low Estimate		
			Expected Value	**1.0**	**$12,486,493**
6	costs of water supply development/purchase (potable water)	purchase from MWD	YES		
	for inland facility	tier 1: $527/af	High Estimate		
	cost to import additional water	50 000 af	Best Estimate	1	$26,350,000
		4.5% escalation factor	Low Estimate		
			Expected Value	**1.0**	**$26,350,000**
			Annual Total		$123,649,769

Table A-6: Identification and Quantification of Costs

Alternative *Coast Only*

Item	2014	2015	2016	2017	2018	2019	2020	2021
1								
	36,180,741	36,180,741	36,180,741	36,180,741	36,180,741	36,180,741	36,180,741	36,180,741
	$36,180,741	**$36,180,741**	**$36,180,741**	**$36,180,741**	**$36,180,741**	**$36,180,741**	**$36,180,741**	**$36,180,741**
2								
	$34,000,000	$34,000,000	$34,000,000	$34,000,000	$34,000,000	$34,000,000	$34,000,000	$34,000,000
	$34,000,000	**$34,000,000**	**$34,000,000**	**$34,000,000**	**$34,000,000**	**$34,000,000**	**$34,000,000**	**$34,000,000**
3								
	11,132,536	11,132,536	11,132,536	11,132,536	11,132,536	11,132,536	11,132,536	11,132,536
	$11,132,536	**$11,132,536**	**$11,132,536**	**$11,132,536**	**$11,132,536**	**$11,132,536**	**$11,132,536**	**$11,132,536**
4								
	$3,500,000	$3,500,000	$3,500,000	$3,500,000	$3,500,000	$3,500,000	$3,500,000	$3,500,000
	$3,500,000	**$3,500,000**	**$3,500,000**	**$3,500,000**	**$3,500,000**	**$3,500,000**	**$3,500,000**	**$3,500,000**
5								
	12,486,493	12,486,493	12,486,493	12,486,493	12,486,493	12,486,493	12,486,493	12,486,493

	$12,486,493	**$12,486,493**	**$12,486,493**	**$12,486,493**	**$12,486,493**	**$12,486,493**	**$12,486,493**	**$12,486,493**
6								
	$27,535,750	$28,774,859	$30,069,727	$31,422,865	$32,836,894	$34,314,554	$35,858,709	$37,472,351
	$27,535,750	**$28,774,859**	**$30,069,727**	**$31,422,865**	**$32,836,894**	**$34,314,554**	**$35,858,709**	**$37,472,351**
	$124,835,519	$126,074,627	$127,369,496	$128,722,634	$130,136,663	$131,614,323	$133,158,478	$134,772,120

Table A-6: Identification and Quantification of Costs

Alternative *Coast Only*

Item	2022	2023	2024	2025	2026	2027
1						
	36,180,741	36,180,741	36,180,741	36,180,741	36,180,741	36,180,741
	$36,180,741	**$36,180,741**	**$36,180,741**	**$36,180,741**	**$36,180,741**	**$36,180,741**
2						
	$34,000,000	$34,000,000	$34,000,000	$34,000,000	$34,000,000	$34,000,000
	$34,000,000	**$34,000,000**	**$34,000,000**	**$34,000,000**	**$34,000,000**	**$34,000,000**
3						
	11,132,536	11,132,536	11,132,536	11,132,536	11,132,536	11,132,536
	$11,132,536	**$11,132,536**	**$11,132,536**	**$11,132,536**	**$11,132,536**	**$11,132,536**
4						
	$3,500,000	$3,500,000	$3,500,000	$3,500,000	$3,500,000	$3,500,000
	$3,500,000	**$3,500,000**	**$3,500,000**	**$3,500,000**	**$3,500,000**	**$3,500,000**
5						
	12,486,493	12,486,493	12,486,493	12,486,493	12,486,493	12,486,493

	$12,486,493	**$12,486,493**	**$12,486,493**	**$12,486,493**	**$12,486,493**	**$12,486,493**
6						
	$39,158,607	$40,920,744	$42,762,178	$44,686,476	$46,697,367	$48,798,749
	$39,158,607	**$40,920,744**	**$42,762,178**	**$44,686,476**	**$46,697,367**	**$48,798,749**
	$136,458,376	$138,220,513	$140,061,946	$141,986,244	$143,997,136	$146,098,517

Table A-6: Identification and Quantification of Costs

Alternative *Coast Only*

Item	2028	2029	2030	2031	2032	2033
1						
	36,180,741	36,180,741	36,180,741	36,180,741	36,180,741	36,180,741
	$36,180,741	**$36,180,741**	**$36,180,741**	**$36,180,741**	**$36,180,741**	**$36,180,741**
2						
	$34,000,000	$34,000,000	$34,000,000	$34,000,000	$34,000,000	$34,000,000
	$34,000,000	**$34,000,000**	**$34,000,000**	**$34,000,000**	**$34,000,000**	**$34,000,000**
3						
	11,132,536	11,132,536	11,132,536	11,132,536	11,132,536	11,132,536
	$11,132,536	**$11,132,536**	**$11,132,536**	**$11,132,536**	**$11,132,536**	**$11,132,536**
4						
	$3,500,000	$3,500,000	$3,500,000	$3,500,000	$3,500,000	$3,500,000
	$3,500,000	**$3,500,000**	**$3,500,000**	**$3,500,000**	**$3,500,000**	**$3,500,000**
5						
	12,486,493	12,486,493	12,486,493	12,486,493	12,486,493	12,486,493

	$12,486,493	**$12,486,493**	**$12,486,493**	**$12,486,493**	**$12,486,493**	**$12,486,493**
6						
	$50,994,692	$53,289,454	$55,687,479	$58,193,415	$60,812,119	$63,548,665
	$50,994,692	**$53,289,454**	**$55,687,479**	**$58,193,415**	**$60,812,119**	**$63,548,665**
	$148,294,461	$150,589,222	$152,987,248	$155,493,184	$158,111,888	$160,848,433

Table A-7: Project Evaluation

Alternative *Coast Only* Discount Rate 3.0%

	Year	Annual Benefits	Discounted Benefits	Annual Costs	Discounted Costs	Net Benefits (discounted)
0	2013	$56,810,285	$56,810,285	$123,649,769	$123,649,769	-$66,839,484
1	2014	$58,167,035	$56,472,850	$124,835,519	$121,199,533	-$64,726,683
2	2015	$59,584,839	$56,164,425	$126,074,627	$118,837,428	-$62,673,003
3	2016	$61,066,444	$55,884,447	$127,369,496	$116,561,132	-$60,676,685
4	2017	$62,614,721	$55,632,369	$128,722,634	$114,368,393	-$58,736,024
5	2018	$64,232,671	$55,407,666	$130,136,663	$112,257,028	-$56,849,363
6	2019	$65,923,428	$55,209,833	$131,614,323	$110,224,923	-$55,015,090
7	2020	$67,690,269	$55,038,383	$133,158,478	$108,270,028	-$53,231,645
8	2021	$69,536,619	$54,892,849	$134,772,120	$106,390,356	-$51,497,507
9	2022	$71,466,054	$54,772,779	$136,458,376	$104,583,982	-$49,811,203
10	2023	$73,482,313	$54,677,742	$138,220,513	$102,849,043	-$48,171,300
11	2024	$75,589,304	$54,607,322	$140,061,946	$101,183,730	-$46,576,408
12	2025	$77,791,110	$54,561,120	$141,986,244	$99,586,295	-$45,025,175
13	2026	$80,091,997	$54,538,753	$143,997,136	$98,055,043	-$43,516,290
14	2027	$82,496,425	$54,539,855	$146,098,517	$96,588,331	-$42,048,476
15	2028	$85,009,051	$54,564,075	$148,294,461	$95,184,572	-$40,620,497
16	2029	$87,634,745	$54,611,076	$150,589,222	$93,842,225	-$39,231,149
17	2030	$90,378,596	$54,680,537	$152,987,248	$92,559,801	-$37,879,264
18	2031	$93,245,920	$54,772,151	$155,493,184	$91,335,858	-$36,563,707
19	2032	$96,242,274	$54,885,624	$158,111,888	$90,169,000	-$35,283,377
20	2033	$99,373,463	$55,020,677	$160,848,433	$89,057,878	-$34,037,201
	Subtotals	***$1,578,427,562***	***$1,157,744,817***	***$2,933,480,797***	**$2,186,754,347**	**-$1,029,009,530**

Table A-8: Identification and Quantification of Benefits

Alternative *Inland Only*

Item	Benefit	Comments	Quantifiable	Probability	2013
1	Other (specify):	MWD incentive	YES		
		$250/af replaced	High Estimate		
		replacing 50 000 af	Best Estimate	1	$12,500,000
			Low Estimate		
			Expected Value	**1.0**	**$12,500,000**
2	Reclaimed water sales revenues	sell at $76/af	YES		
		sell full capacity of 50 000 af adjust for price escalation factor of 4.5%	High Estimate		
			Best Estimate	1	$3,800,000
			Low Estimate		
			Expected Value	**1.0**	**$3,800,000**
3	In-stream recreation	based on $30/person/day assumes an average of 100 ppl per each weekend day (104 days total)	YES		
			High Estimate		
			Best Estimate	1	**$312,000**
			Low Estimate		
			Expected Value	**1.0**	**$312,000**
4	Near-stream recreation	based on $45/person/day weekend attendance of 300ppl weekday of 100 ppl	YES		
			High Estimate		
			Best Estimate	1	$2,578,500
			Low Estimate		
			Expected Value	**1.0**	**$2,578,500**
5	Avoided capital costs of water	Capital = $90 mil over 20 yrs,	YES		

	supply treatment	O&M = $4.5 mil annually			
	for inland facility	not inflated	High Estimate		
			Best Estimate	1	$11,269,785
			Low Estimate		
			Expected Value	**1.0**	**$11,269,785**
6	Avoided costs of water supply development/purchase (potable water)	purchase from MWD	YES		
	for coast location	tier 1: $527/af	High Estimate		
	cost to import additional water	50 000 af	Best Estimate	1	$26,350,000
		4.5% escalation factor	Low Estimate		
			Expected Value	**1.0**	**$26,350,000**
7	Avoided costs of water supply development/purchase (recharge water)	gw pumping	YES		
		$130/af	High Estimate		
		no longer pumping 40 taf	Best Estimate	1	$5,200,000
		4.5% escalation factor	Low Estimate		
			Expected Value	**1.0**	**$5,200,000**
			Annual Total		**$62,010,285**

Table A-8: Identification and Quantification of Benefits

Alternative *Inland Only*

Item	2014	2015	2016	2017	2018	2019	2020	2021
1								
	$12,500,000	$12,500,000	$12,500,000	$12,500,000	$12,500,000	$12,500,000	$12,500,000	$12,500,000
	$12,500,000	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**
2								
	$3,971,000	$4,149,695	$4,336,431	$4,531,571	$4,735,491	$4,948,588	$5,171,275	$5,403,982
	$3,971,000	**$4,149,695**	**$4,336,431**	**$4,531,571**	**$4,735,491**	**$4,948,588**	**$5,171,275**	**$5,403,982**
3								
	$312,000	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**
	$312,000	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**
4								
	$2,578,500	$2,578,500	$2,578,500	$2,578,500	$2,578,500	$2,578,500	$2,578,500	$2,578,500
	$2,578,500	**$2,578,500**	**$2,578,500**	**$2,578,500**	**$2,578,500**	**$2,578,500**	**$2,578,500**	**$2,578,500**
5								
	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785

	$11,269,785	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**
6								
	$27,535,750	$28,774,859	$30,069,727	$31,422,865	$32,836,894	$34,314,554	$35,858,709	$37,472,351
	$27,535,750	**$28,774,859**	**$30,069,727**	**$31,422,865**	**$32,836,894**	**$34,314,554**	**$35,858,709**	**$37,472,351**
7								
	$5,434,000	$5,678,530	$5,934,064	$6,201,097	$6,480,146	$6,771,753	$7,076,482	$7,394,923
	$5,434,000	**$5,678,530**	**$5,934,064**	**$6,201,097**	**$6,480,146**	**$6,771,753**	**$7,076,482**	**$7,394,923**
	$63,601,035	**$65,263,369**	**$67,000,508**	**$68,815,818**	**$70,712,817**	**$72,695,181**	**$74,766,751**	**$76,931,542**

Table A-8: Identification and Quantification of Benefits

Alternative

Item	2022	2023	2024	2025	2026	2027	2028	2029
1								
	$12,500,000	$12,500,000	$12,500,000	$12,500,000	$12,500,000	$12,500,000	$12,500,000	$12,500,000
	$12,500,000	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**
2								
	$5,647,162	$5,901,284	$6,166,842	$6,444,349	$6,734,345	$7,037,391	$7,354,073	$7,685,007
	$5,647,162	**$5,901,284**	**$6,166,842**	**$6,444,349**	**$6,734,345**	**$7,037,391**	**$7,354,073**	**$7,685,007**
3								
	$312,000	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**
	$312,000	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**
4								
	$2,578,500	$2,578,500	$2,578,500	$2,578,500	$2,578,500	$2,578,500	$2,578,500	$2,578,500
	$2,578,500	**$2,578,500**	**$2,578,500**	**$2,578,500**	**$2,578,500**	**$2,578,500**	**$2,578,500**	**$2,578,500**
5								
	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785

	$11,269,785	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**
6								
	$39,158,607	$40,920,744	$42,762,178	$44,686,476	$46,697,367	$48,798,749	$50,994,692	$53,289,454
	$39,158,607	**$40,920,744**	**$42,762,178**	**$44,686,476**	**$46,697,367**	**$48,798,749**	**$50,994,692**	**$53,289,454**
7								
	$7,727,695	$8,075,441	$8,438,836	$8,818,583	$9,215,420	$9,630,114	$10,063,469	$10,516,325
	$7,727,695	**$8,075,441**	**$8,438,836**	**$8,818,583**	**$9,215,420**	**$9,630,114**	**$10,063,469**	**$10,516,325**
	$79,193,748	**$81,557,754**	**$84,028,140**	**$86,609,694**	**$89,307,417**	**$92,126,538**	**$95,072,519**	**$98,151,070**

Table A-8: Identification and Quantification of Benefits

Alternative *Inland Only*

Item	**2030**	**2031**	**2032**	**2033**
1				
	$12,500,000	$12,500,000	$12,500,000	$12,500,000
	$12,500,000	**$12,500,000**	**$12,500,000**	**$12,500,000**
2				
	$8,030,832	$8,392,219	$8,769,869	$9,164,513
	$8,030,832	**$8,392,219**	**$8,769,869**	**$9,164,513**
3				
	$312,000	**$312,000**	**$312,000**	**$312,000**
	$312,000	**$312,000**	**$312,000**	**$312,000**
4				
	$2,578,500	$2,578,500	$2,578,500	$2,578,500
	$2,578,500	**$2,578,500**	**$2,578,500**	**$2,578,500**
5				
	$11,269,785	$11,269,785	$11,269,785	$11,269,785

	$11,269,785	**$11,269,785**	**$11,269,785**	**$11,269,785**
6				
	$55,687,479	$58,193,415	$60,812,119	$63,548,665
	$55,687,479	**$58,193,415**	**$60,812,119**	**$63,548,665**
7				
	$10,989,559	$11,484,090	$12,000,874	$12,540,913
	$10,989,559	**$11,484,090**	**$12,000,874**	**$12,540,913**
	$101,368,155	**$104,730,010**	**$108,243,147**	**$111,914,376**

Table A-9: Identification and Quantification of Costs

Alternative *Inland Only*

Item	Benefit	Comments	Quantifiable	Probability	2013
1	Financing costs	financing of $463 mil of capital costs (which include retrofit costs) over 20 years	YES		
	for coastal WWTP		High Estimate		
			Best Estimate	1	34,826,784
			Low Estimate		
			Expected Value	**1.0**	**$34,826,784**
2	O&M costs for reclamation treatment	all O&M. $33.5 mil annually	YES		
	for coastal WWTP		High Estimate		
			Best Estimate	1	$33,500,000
			Low Estimate		
			Expected Value	**1.0**	**$33,500,000**
3	Avoided capital costs of water supply treatment	Capital = $90 mil over 20 yrs, O&M = $4.5 mil annually not inflated	YES		
	new water supply facility		High Estimate		
			Best Estimate	1	$11,269,785
			Low Estimate		
			Expected Value	**1.0**	**$11,269,785**
4	Avoided costs of water supply development/purchase (potable water)	purchase from MWD	YES		
	cost to import additional water	tier 1: $527/af	High Estimate		
		90 000 af	Best Estimate	1	$47,430,000
		4.5% escalation factor	Low Estimate		

			Expected Value	**1.0**	**$47,430,000**
5	Financing costs	financing of $166 mil of capital costs (which include retrofit costs) over 20 years	YES		
	for inland recycling facility		High Estimate		
			Best Estimate	1	12,486,493
			Low Estimate		
			Expected Value	**1.0**	**$12,486,493**
6	O&M costs for reclamation treatment	all O&M	YES		
	for inland recycling facility		High Estimate		
			Best Estimate	1	$4,000,000
			Low Estimate		
			Expected Value	**1.0**	**$4,000,000**
7	Other (specify):	desalting gw. Additional $550/af, escalated at 4.5% 10 taf/yr (Rand)	YES		
	desalinate brackish water		High Estimate		
			Best Estimate	1	$5,500,000
			Low Estimate		
			Expected Value	**1.0**	**$5,500,000**
			Annual Total		$149,013,061

Table A-9: Identification and Quantification of Costs

Alternative *Inland Only*

Item	2014	2015	2016	2017	2018	2019	2020	2021
1								
	34,826,784	34,826,784	34,826,784	34,826,784	34,826,784	34,826,784	34,826,784	34,826,784
	$34,826,784	**$34,826,784**	**$34,826,784**	**$34,826,784**	**$34,826,784**	**$34,826,784**	**$34,826,784**	**$34,826,784**
2								
	$33,500,000	$33,500,000	$33,500,000	$33,500,000	$33,500,000	$33,500,000	$33,500,000	$33,500,000
	$33,500,000	**$33,500,000**	**$33,500,000**	**$33,500,000**	**$33,500,000**	**$33,500,000**	**$33,500,000**	**$33,500,000**
3								
	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785
	$11,269,785	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**
4								
	$49,564,350	$51,794,746	$54,125,509	$56,561,157	$59,106,409	$61,766,198	$64,545,677	$67,450,232
	$49,564,350	**$51,794,746**	**$54,125,509**	**$56,561,157**	**$59,106,409**	**$61,766,198**	**$64,545,677**	**$67,450,232**
5								

	12,486,493	12,486,493	12,486,493	12,486,493	12,486,493	12,486,493	12,486,493	12,486,493
	$12,486,493	**$12,486,493**	**$12,486,493**	**$12,486,493**	**$12,486,493**	**$12,486,493**	**$12,486,493**	**$12,486,493**
6								
	$4,000,000	$4,000,000	$4,000,000	$4,000,000	$4,000,000	$4,000,000	$4,000,000	$4,000,000
	$4,000,000	**$4,000,000**	**$4,000,000**	**$4,000,000**	**$4,000,000**	**$4,000,000**	**$4,000,000**	**$4,000,000**
7								
	$5,747,500	$6,006,138	$6,276,414	$6,558,852	$6,854,001	$7,162,431	$7,484,740	$7,821,553
	$5,747,500	**$6,006,138**	**$6,276,414**	**$6,558,852**	**$6,854,001**	**$7,162,431**	**$7,484,740**	**$7,821,553**
	$151,394,911	$153,883,944	$156,484,984	$159,203,071	$162,043,471	$165,011,690	$168,113,478	$171,354,847

Table A-9: Identification and Quantification of Costs

Alternative *Inland Only*

Item	2022	2023	2024	2025	2026	2027	2028	2029
1								
	34,826,784	34,826,784	34,826,784	34,826,784	34,826,784	34,826,784	34,826,784	34,826,784
	$34,826,784	**$34,826,784**	**$34,826,784**	**$34,826,784**	**$34,826,784**	**$34,826,784**	**$34,826,784**	**$34,826,784**
2								
	$33,500,000	$33,500,000	$33,500,000	$33,500,000	$33,500,000	$33,500,000	$33,500,000	$33,500,000
	$33,500,000	**$33,500,000**	**$33,500,000**	**$33,500,000**	**$33,500,000**	**$33,500,000**	**$33,500,000**	**$33,500,000**
3								
	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785
	$11,269,785	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**
4								
	$70,485,493	$73,657,340	$76,971,920	$80,435,656	$84,055,261	$87,837,748	$91,790,446	$95,921,016
	$70,485,493	**$73,657,340**	**$76,971,920**	**$80,435,656**	**$84,055,261**	**$87,837,748**	**$91,790,446**	**$95,921,016**
5								

	12,486,493	12,486,493	12,486,493	12,486,493	12,486,493	12,486,493	12,486,493	12,486,493
	$12,486,493	**$12,486,493**	**$12,486,493**	**$12,486,493**	**$12,486,493**	**$12,486,493**	**$12,486,493**	**$12,486,493**
6								
	$4,000,000	$4,000,000	$4,000,000	$4,000,000	$4,000,000	$4,000,000	$4,000,000	$4,000,000
	$4,000,000	**$4,000,000**	**$4,000,000**	**$4,000,000**	**$4,000,000**	**$4,000,000**	**$4,000,000**	**$4,000,000**
7								
	$8,173,523	$8,541,332	$8,925,692	$9,327,348	$9,747,079	$10,185,697	$10,644,053	$11,123,036
	$8,173,523	**$8,541,332**	**$8,925,692**	**$9,327,348**	**$9,747,079**	**$10,185,697**	**$10,644,053**	**$11,123,036**
	$174,742,077	$178,281,733	$181,980,673	$185,846,065	$189,885,401	$194,106,506	$198,517,561	$203,127,113

Table A-9: Identification and Quantification of Costs

Alternative *Inland Only*

Item	2030	2031	2032	2033
1				
	34,826,784	34,826,784	34,826,784	34,826,784
	$34,826,784	**$34,826,784**	**$34,826,784**	**$34,826,784**
2				
	$33,500,000	$33,500,000	$33,500,000	$33,500,000
	$33,500,000	**$33,500,000**	**$33,500,000**	**$33,500,000**
3				
	$11,269,785	$11,269,785	$11,269,785	$11,269,785
	$11,269,785	**$11,269,785**	**$11,269,785**	**$11,269,785**
4				
	$100,237,462	$104,748,148	$109,461,815	$114,387,596
	$100,237,462	**$104,748,148**	**$109,461,815**	**$114,387,596**
5				

	12,486,493	12,486,493	12,486,493	12,486,493
	$12,486,493	**$12,486,493**	**$12,486,493**	**$12,486,493**
6				
	$4,000,000	$4,000,001	$4,000,002	$4,000,003
	$4,000,000	**$4,000,001**	**$4,000,002**	**$4,000,003**
7				
	$11,623,572	$12,146,633	$12,693,232	$13,264,427
	$11,623,572	**$12,146,633**	**$12,693,232**	**$13,264,427**
	$207,944,096	$212,977,843	$218,238,109	$223,735,088

Table A-10: Project Evaluation

Alternative *Inland Only* Discount Rate 3.0%

	Year	Annual Benefits	Discounted Benefits	Annual Costs	Discounted Costs	Net Benefits (discounted)
0	2013	$62,010,285.13	$62,010,285.13	$149,013,061.23	$149,013,061.23	-$87,002,776.10
1	2014	$63,601,035.13	$61,748,577.80	$151,394,911.23	$146,985,350.71	-$85,236,772.91
2	2015	$65,263,368.88	$61,516,984.53	$153,883,944.48	$145,050,376.55	-$83,533,392.02
3	2016	$67,000,507.65	$61,314,955.75	$156,484,984.22	$143,205,928.13	-$81,890,972.38
4	2017	$68,815,817.67	$61,141,962.69	$159,203,070.76	$141,449,866.36	-$80,307,903.67
5	2018	$70,712,816.63	$60,997,496.79	$162,043,471.19	$139,780,121.70	-$78,782,624.91
6	2019	$72,695,180.55	$60,881,069.24	$165,011,689.64	$138,194,692.24	-$77,313,623.00
7	2020	$74,766,750.84	$60,792,210.44	$168,113,477.92	$136,691,641.84	-$75,899,431.40
8	2021	$76,931,541.80	$60,730,469.50	$171,354,846.67	$135,269,098.30	-$74,538,628.80
9	2022	$79,193,748.35	$60,695,413.83	$174,742,077.01	$133,925,251.67	-$73,229,837.84
10	2023	$81,557,754.19	$60,686,628.61	$178,281,732.72	$132,658,352.45	-$71,971,723.85
11	2024	$84,028,140.30	$60,703,716.38	$181,980,672.94	$131,466,710.06	-$70,762,993.68
12	2025	$86,609,693.78	$60,746,296.65	$185,846,065.46	$130,348,691.13	-$69,602,394.48
13	2026	$89,307,417.17	$60,814,005.39	$189,885,400.66	$129,302,718.02	-$68,488,712.63
14	2027	$92,126,538.11	$60,906,494.73	$194,106,505.93	$128,327,267.30	-$67,420,772.56
15	2028	$95,072,519.50	$61,023,432.51	$198,517,560.94	$127,420,868.26	-$66,397,435.75
16	2029	$98,151,070.04	$61,164,501.90	$203,127,113.43	$126,582,101.55	-$65,417,599.65
17	2030	$101,368,155.36	$61,329,401.08	$207,944,095.78	$125,809,597.76	-$64,480,196.68
18	2031	$104,730,009.52	$61,517,842.85	$212,977,843.33	$125,102,036.72	-$63,584,193.87
19	2032	$108,243,147.12	$61,729,554.30	$218,238,109.48	$124,458,144.36	-$62,728,590.05
20	2033	$111,914,375.91	$61,964,276.49	$223,735,087.56	$123,876,693.34	-$61,912,416.86
	Subtotals	***$1,754,099,873.64***	***$1,284,415,576.60***	***$3,805,885,722.57***	**$2,814,918,569.66**	**-$1,530,502,993**

Table A-11: Identification and Quantification of Benefits

Alternative *Both Recycle*

Item	Benefit	Comments	Quantifiable	Probability	2013
1	Other (specify):	MWD incentive	YES		
	for coastal facility	$250/af replaced	High Estimate		
	no price escalation	replacing 50 000 af	Best Estimate	1	$ 12,500,000
			Low Estimate		
			Expected Value	**1.0**	**$12,500,000**
2	Other (specify):	MWD incentive	YES		
	for inland facility	$250/af replaced	High Estimate		
	no price escalation	replacing 50 000 af	Best Estimate	1	$ 12,500,000
			Low Estimate		
			Expected Value	**1.0**	**$12,500,000**
3	Reclaimed water sales revenues	sell at $76/af	YES		
	coastal	sell full capacity of 50 000 af	High Estimate		
		adjust for price escalation factor of 4.5%	Best Estimate	1	$3,800,000
			Low Estimate		
			Expected Value	**1.0**	**$3,800,000**
4	Reclaimed water sales revenues	sell at $76/af	YES		
	inland	sell full capacity of 50 000 af	High Estimate		

		adjust for price escalation factor of 4.5%	Best Estimate	1	$3,800,000
			Low Estimate		
			Expected Value	**1.0**	**$3,800,000**
5	Avoided costs of water supply development/purchase (potable water)	purchase from MWD	YES		
	for inland facility	tier 1: $527/af	High Estimate		
	cost to import additional water	50 000 af	Best Estimate	1	$26,350,000
		4.5% escalation factor	Low Estimate		
			Expected Value	**1.0**	**$26,350,000**
6	Avoided capital costs of water supply treatment	Capital = $90 mil over 20 yrs, O&M = $4.5 mil annually	YES		
	for inland facility	not inflated	High Estimate		
			Best Estimate	1	$11,269,785
			Low Estimate		
			Expected Value	**1.0**	**$11,269,785**
7	In-stream recreation	based on $30/person/day	YES		
		assumes an average of 100 ppl per each weekend day (104 days total)	High Estimate		
			Best Estimate	1	**$312,000**
			Low Estimate		
			Expected Value	**1.0**	**$312,000**
8	Near-stream recreation	based on $45/person/day	YES		
		weekend attendance of 300ppl	High Estimate		
		weekday of 100 ppl	Best Estimate	1	$2,578,500
			Low Estimate		

			Expected Value	**1.0**	**$2,578,500**
9	Avoided capital costs of water supply treatment	Capital = $90 mil over 20 yrs, O&M = $4.5 mil annually	YES		
	new water supply facility coastal	not inflated	High Estimate		
			Best Estimate	1	$11,269,785
			Low Estimate		
			Expected Value	**1.0**	**$11,269,785**
10	Avoided costs of water supply development/purchase (recharge water)	gw pumping	YES		
		$130/af	High Estimate		
		no longer pumping 40 taf	Best Estimate	1	$5,200,000
		4.5% escalation factor	Low Estimate		
			Expected Value	**1.0**	**$5,200,000**
			Annual Total		**$89,580,070**

Table A-11: Identification and Quantification of Benefits

Alternative *Both Recycle*

Item	2014	2015	2016	2017	2018	2019
1						
	$ 12,500,000	$ 12,500,000	$ 12,500,000	$ 12,500,000	$ 12,500,000	$ 12,500,000
	$12,500,000	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**
2						
	$ 12,500,000	$ 12,500,000	$ 12,500,000	$ 12,500,000	$ 12,500,000	$ 12,500,000
	$12,500,000	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**
3						
	$3,971,000	$4,149,695	$4,336,431	$4,531,571	$4,735,491	$4,948,588
	$3,971,000	**$4,149,695**	**$4,336,431**	**$4,531,571**	**$4,735,491**	**$4,948,588**
4						
	$3,971,000	$4,149,695	$4,336,431	$4,531,571	$4,735,491	$4,948,588

	$3,971,000	**$4,149,695**	**$4,336,431**	**$4,531,571**	**$4,735,491**	**$4,948,588**
5						
	$27,535,750	$28,774,859	$30,069,727	$31,422,865	$32,836,894	$34,314,554
	$27,535,750	**$28,774,859**	**$30,069,727**	**$31,422,865**	**$32,836,894**	**$34,314,554**
6						
	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785
	$11,269,785	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**
7						
	$312,000	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**
	$312,000	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**
8						
	$2,578,500	$2,578,500	$2,578,500	$2,578,500	$2,578,500	$2,578,500
	$2,578,500	**$2,578,500**	**$2,578,500**	**$2,578,500**	**$2,578,500**	**$2,578,500**
9						
	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785
	$11,269,785	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**
10						

	$5,434,000	$5,678,530	$5,934,064	$6,201,097	$6,480,146	$6,771,753
	$5,434,000	**$5,678,530**	**$5,934,064**	**$6,201,097**	**$6,480,146**	**$6,771,753**
	$91,341,820	**$93,182,849**	**$95,106,724**	**$97,117,173**	**$99,218,093**	**$101,413,554**

Table A-11: Identification and Quantification of Benefits

Alternative *Both Recycle*

Item	2020	2021	2022	2023	2024	2025	2026
1							
	$ 12,500,000	$ 12,500,000	$ 12,500,000	$ 12,500,000	$ 12,500,000	$ 12,500,000	$ 12,500,000
	$12,500,000	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**
2							
	$ 12,500,000	$ 12,500,000	$ 12,500,000	$ 12,500,000	$ 12,500,000	$ 12,500,000	$ 12,500,000
	$12,500,000	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**
3							
	$5,171,275	$5,403,982	$5,647,162	$5,901,284	$6,166,842	$6,444,349	$6,734,345
	$5,171,275	**$5,403,982**	**$5,647,162**	**$5,901,284**	**$6,166,842**	**$6,444,349**	**$6,734,345**
4							
	$5,171,275	$5,403,982	$5,647,162	$5,901,284	$6,166,842	$6,444,349	$6,734,345

	$5,171,275	**$5,403,982**	**$5,647,162**	**$5,901,284**	**$6,166,842**	**$6,444,349**	**$6,734,345**
5							
	$35,858,709	$37,472,351	$39,158,607	$40,920,744	$42,762,178	$44,686,476	$46,697,367
	$35,858,709	**$37,472,351**	**$39,158,607**	**$40,920,744**	**$42,762,178**	**$44,686,476**	**$46,697,367**
6							
	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785
	$11,269,785	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**
7							
	$312,000	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**
	$312,000	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**
8							
	$2,578,500	$2,578,500	$2,578,500	$2,578,500	$2,578,500	$2,578,500	$2,578,500
	$2,578,500	**$2,578,500**	**$2,578,500**	**$2,578,500**	**$2,578,500**	**$2,578,500**	**$2,578,500**
9							
	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785
	$11,269,785	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**
10							

	$7,076,482	$7,394,923	$7,727,695	$8,075,441	$8,438,836	$8,818,583	$9,215,420
	$7,076,482	**$7,394,923**	**$7,727,695**	**$8,075,441**	**$8,438,836**	**$8,818,583**	**$9,215,420**
	$103,707,811	**$106,105,309**	**$108,610,695**	**$111,228,823**	**$113,964,767**	**$116,823,828**	**$119,811,547**

Table A-11: Identification and Quantification of Benefits

Alternative *Both Recycle*

Item	2027	2028	2029	2030	2031	2032	2033
1							
	$ 12,500,000	$ 12,500,000	$ 12,500,000	$ 12,500,000	$ 12,500,000	$ 12,500,000	$ 12,500,000
	$12,500,000	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**
2							
	$ 12,500,000	$ 12,500,000	$ 12,500,000	$ 12,500,000	$ 12,500,000	$ 12,500,000	$ 12,500,000
	$12,500,000	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**	**$12,500,000**
3							
	$7,037,391	$7,354,073	$7,685,007	$8,030,832	$8,392,219	$8,769,869	$9,164,513
	$7,037,391	**$7,354,073**	**$7,685,007**	**$8,030,832**	**$8,392,219**	**$8,769,869**	**$9,164,513**
4							
	$7,037,391	$7,354,073	$7,685,007	$8,030,832	$8,392,219	$8,769,869	$9,164,513

	$7,037,391	**$7,354,073**	**$7,685,007**	**$8,030,832**	**$8,392,219**	**$8,769,869**	**$9,164,513**
5							
	$48,798,749	$50,994,692	$53,289,454	$55,687,479	$58,193,415	$60,812,119	$63,548,665
	$48,798,749	**$50,994,692**	**$53,289,454**	**$55,687,479**	**$58,193,415**	**$60,812,119**	**$63,548,665**
6							
	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785
	$11,269,785	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**
7							
	$312,000	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**
	$312,000	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**	**$312,000**
8							
	$2,578,500	$2,578,500	$2,578,500	$2,578,500	$2,578,500	$2,578,500	$2,578,500
	$2,578,500	**$2,578,500**	**$2,578,500**	**$2,578,500**	**$2,578,500**	**$2,578,500**	**$2,578,500**
9							
	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785	$11,269,785
	$11,269,785	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**	**$11,269,785**
10							

	$9,630,114	$10,063,469	$10,516,325	$10,989,559	$11,484,090	$12,000,874	$12,540,913
	$9,630,114	**$10,063,469**	**$10,516,325**	**$10,989,559**	**$11,484,090**	**$12,000,874**	**$12,540,913**
	$122,933,714	**$126,196,378**	**$129,605,862**	**$133,168,772**	**$136,892,014**	**$140,782,801**	**$144,848,674**

Table A-12: Identification and Quantification of Costs

Alternative *Both Recycle*

Item	Benefit	Comments	Quantifiable	Probability	2013
1	Financing costs	financing of $481 mil of capital costs (which include retrofit costs) over 20 years	YES		
			High Estimate		
			Best Estimate	1	36,180,741
			Low Estimate		
			Expected Value	**1.0**	**$36,180,741**
2	O&M costs for reclamation treatment	all O&M. $34 mil annually	YES		
			High Estimate		
			Best Estimate	1	$34,000,000
			Low Estimate		
			Expected Value	**1.0**	**$34,000,000**
3	Financing costs	financing of $166 mil of capital costs (which include retrofit costs) over 20 years	YES		
	for inland facility		High Estimate		

			Best Estimate	1	12,486,493
			Low Estimate		
			Expected Value	**1.0**	**$12,486,493**
4	O&M costs for reclamation treatment	all O&M	YES		
	for inland facility	$4 million annually	High Estimate		
			Best Estimate	1	$4,000,000
			Low Estimate		
			Expected Value	**1.0**	**$4,000,000**
5	Avoided costs of water supply development/purchase (potable water)	purchase from MWD	YES		
	cost to import additional water by coast	tier 1: $527/af	High Estimate		
		40 000 af	Best Estimate	1	$21,080,000
		4.5% escalation factor	Low Estimate		
			Expected Value	**1.0**	**$21,080,000**
6	Other (specify):	desalting gw. Additional $550/af, escalated at 4.5%	YES		

	10 taf/yr (Rand)			
desalinate brackish water		High Estimate		
		Best Estimate	1	$5,500,000
		Low Estimate		
		Expected Value	**1.0**	**$5,500,000**
		Annual Total		$113,247,233

Table A-12: Identification and Quantification of Costs

Alternative *Both Recycle*

Item	2014	2015	2016	2017	2018	2019	2020
1							
	36,180,741	36,180,741	36,180,741	36,180,741	36,180,741	36,180,741	36,180,741
	$36,180,741	**$36,180,741**	**$36,180,741**	**$36,180,741**	**$36,180,741**	**$36,180,741**	**$36,180,741**
2							
	$34,000,000	$34,000,000	$34,000,000	$34,000,000	$34,000,000	$34,000,000	$34,000,000
	$34,000,000	**$34,000,000**	**$34,000,000**	**$34,000,000**	**$34,000,000**	**$34,000,000**	**$34,000,000**
3							

	12,486,493	12,486,493	12,486,493	12,486,493	12,486,493	12,486,493	12,486,493
	$12,486,493	**$12,486,493**	**$12,486,493**	**$12,486,493**	**$12,486,493**	**$12,486,493**	**$12,486,493**
4							
	$4,000,000	$4,000,000	$4,000,000	$4,000,000	$4,000,000	$4,000,000	$4,000,000
	$4,000,000	**$4,000,000**	**$4,000,000**	**$4,000,000**	**$4,000,000**	**$4,000,000**	**$4,000,000**
5							
	$22,028,600	$23,019,887	$24,055,782	$25,138,292	$26,269,515	$27,451,643	$28,686,967
	$22,028,600	**$23,019,887**	**$24,055,782**	**$25,138,292**	**$26,269,515**	**$27,451,643**	**$28,686,967**
6							

	$5,747,500	$6,006,138	$6,276,414	$6,558,852	$6,854,001	$7,162,431	$7,484,740
	$5,747,500	**$6,006,138**	**$6,276,414**	**$6,558,852**	**$6,854,001**	**$7,162,431**	**$7,484,740**
	$114,443,333	$115,693,258	$116,999,429	$118,364,378	$119,790,749	$121,281,307	$122,838,941

Table A-12: Identification and Quantification of Costs

Alternative *Both Recycle*

Item	2021	2022	2023	2024	2025	2026	2027
1							
	36,180,741	36,180,741	36,180,741	36,180,741	36,180,741	36,180,741	36,180,741
	$36,180,741	**$36,180,741**	**$36,180,741**	**$36,180,741**	**$36,180,741**	**$36,180,741**	**$36,180,741**
2							
	$34,000,000	$34,000,000	$34,000,000	$34,000,000	$34,000,000	$34,000,000	$34,000,000
	$34,000,000	**$34,000,000**	**$34,000,000**	**$34,000,000**	**$34,000,000**	**$34,000,000**	**$34,000,000**
3							

	12,486,493	12,486,493	12,486,493	12,486,493	12,486,493	12,486,493	12,486,493
	$12,486,493	**$12,486,493**	**$12,486,493**	**$12,486,493**	**$12,486,493**	**$12,486,493**	**$12,486,493**
4							
	$4,000,000	$4,000,000	$4,000,000	$4,000,000	$4,000,000	$4,000,000	$4,000,000
	$4,000,000	**$4,000,000**	**$4,000,000**	**$4,000,000**	**$4,000,000**	**$4,000,000**	**$4,000,000**
5							
	$29,977,881	$31,326,886	$32,736,595	$34,209,742	$35,749,181	$37,357,894	$39,038,999
	$29,977,881	**$31,326,886**	**$32,736,595**	**$34,209,742**	**$35,749,181**	**$37,357,894**	**$39,038,999**
6							

	$7,821,553	$8,173,523	$8,541,332	$8,925,692	$9,327,348	$9,747,079	$10,185,697
	$7,821,553	**$8,173,523**	**$8,541,332**	**$8,925,692**	**$9,327,348**	**$9,747,079**	**$10,185,697**
	$124,466,667	$126,167,642	$127,945,160	$129,802,667	$131,743,762	$133,772,205	$135,891,929

Table A-12: Identification and Quantification of Costs

Alternative *Both Recycle*

Item	2028	2029	2030	2031	2032	2033
1						
	36,180,741	36,180,741	36,180,741	36,180,741	36,180,741	36,180,741
	$36,180,741	**$36,180,741**	**$36,180,741**	**$36,180,741**	**$36,180,741**	**$36,180,741**
2						
	$34,000,000	$34,000,000	$34,000,000	$34,000,000	$34,000,000	$34,000,000
	$34,000,000	**$34,000,000**	**$34,000,000**	**$34,000,000**	**$34,000,000**	**$34,000,000**
3						

	12,486,493	12,486,493	12,486,493	12,486,493	12,486,493	12,486,493
	$12,486,493	**$12,486,493**	**$12,486,493**	**$12,486,493**	**$12,486,493**	**$12,486,493**
4						
	$4,000,000	$4,000,000	$4,000,000	$4,000,001	$4,000,002	$4,000,003
	$4,000,000	**$4,000,000**	**$4,000,000**	**$4,000,001**	**$4,000,002**	**$4,000,003**
5						
	$40,795,754	$42,631,563	$44,549,983	$46,554,732	$48,649,695	$50,838,932
	$40,795,754	**$42,631,563**	**$44,549,983**	**$46,554,732**	**$48,649,695**	**$50,838,932**
6						

	$10,644,053	$11,123,036	$11,623,572	$12,146,633	$12,693,232	$13,264,427
	$10,644,053	**$11,123,036**	**$11,623,572**	**$12,146,633**	**$12,693,232**	**$13,264,427**
	$138,107,040	$140,421,832	$142,840,789	$145,368,600	$148,010,162	$150,770,595

Table A-13: Project Evaluation

Alternative *Both Recycle* Discount Rate 3.0%

	Year	Annual Benefits	Discounted Benefits	Annual Costs	Discounted Costs	Net Benefits (discounted)
0	2013	$89,580,070	$89,580,070	$113,247,233	$113,247,233	-$23,667,163
1	2014	$91,341,820	$88,681,379	$114,443,333	$111,110,032	-$22,428,653
2	2015	$93,182,849	$87,833,772	$115,693,258	$109,051,991	-$21,218,219
3	2016	$95,106,724	$87,036,125	$116,999,429	$107,071,051	-$20,034,926
4	2017	$97,117,173	$86,287,351	$118,364,378	$105,165,216	-$18,877,866
5	2018	$99,218,093	$85,586,399	$119,790,749	$103,332,552	-$17,746,154
6	2019	$101,413,554	$84,932,255	$121,281,307	$101,571,185	-$16,638,930
7	2020	$103,707,811	$84,323,941	$122,838,941	$99,879,300	-$15,555,359
8	2021	$106,105,309	$83,760,511	$124,466,667	$98,255,137	-$14,494,626
9	2022	$108,610,695	$83,241,054	$126,167,642	$96,696,992	-$13,455,938
10	2023	$111,228,823	$82,764,690	$127,945,160	$95,203,215	-$12,438,525
11	2024	$113,964,767	$82,330,572	$129,802,667	$93,772,208	-$11,441,636
12	2025	$116,823,828	$81,937,883	$131,743,762	$92,402,424	-$10,464,541
13	2026	$119,811,547	$81,585,834	$133,772,205	$91,092,363	-$9,506,529
14	2027	$122,933,714	$81,273,667	$135,891,929	$89,840,574	-$8,566,907
15	2028	$126,196,378	$81,000,653	$138,107,040	$88,645,654	-$7,645,001
16	2029	$129,605,862	$80,766,088	$140,421,832	$87,506,243	-$6,740,155
17	2030	$133,168,772	$80,569,297	$142,840,789	$86,421,026	-$5,851,729
18	2031	$136,892,014	$80,409,631	$145,368,600	$85,388,732	-$4,979,101
19	2032	$140,782,801	$80,286,464	$148,010,162	$84,408,127	-$4,121,663
20	2033	$144,848,674	$80,199,199	$150,770,595	$83,478,023	-$3,278,824
	Subtotals	***$2,381,641,281***	***$1,754,386,836***	***$2,717,967,678***	**$2,023,539,280**	**-$269,152,443**

Table A-14: Comparison of Alternatives

Rank	**Alternative**	**Net Benefit Discounted**	**Percent Difference**	**Percent Change**	**Annual Revenue Needed to break even**	**Total Volume Recycled (AF)**	**Cost/AF to break even**	**Total Cost/AF of RW to break even**	**Relative difference**
1	Base	*-$2,958,815,395*	0	*0*	$ 172,203,056				-
2	Coast Only	-$1,029,009,530	97	*65*	$ 59,888,355	50000	$ 1,197.77	$ 1,273.77	$1,929,805,865
3	Inland Only	*-$1,530,502,993*	64	*48*	$ 89,075,274	50000	$ 1,781.51	$ 1,857.51	$1,428,312,402
4	Both Recycle	*-$269,152,443*	167	*91*	$ 15,664,672	100000	$ 156.65	$ 232.65	$2,689,662,952