Covington Water District and King County

Reclaimed Water Feasibility Study

(Phase 2 – Benefit Cost Analysis)

Final Draft Report

December 1, 2009

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Executive Summary

Background

The Covington Water District (District) encompasses an urban and rural growth area that includes three cities and a large transition area in the Soos Creek Basin in southern King County. Water demand, wastewater management, and conservation of the water resources within the District's service area require a partnership with other local governments. The District's long-term water supply plan includes the use of imported surface water and in-basin groundwater, as well as consideration of water reclamation and reuse to meet the municipal and environmental needs of the area.

King County (County), through its Department of Natural Resources and Parks, Wastewater Treatment Division, is the regional wastewater services provider for a large portion of King County, including most of the District's water supply service area. New and/or upgraded wastewater facilities will be needed in the coming decade to serve the growing population in southern King County. Development of reclaimed water production and distribution facilities may aid in addressing this need, while also promoting sustainable management of the area's water resources.

Due to the mutual interest in reclaimed water held by the District and the County, the two parties have elected to jointly study and develop reclaimed water facility alternatives that have the potential to retain water resources within the basin, thereby meeting the multiple needs described above. The two entities entered into a Memorandum of Agreement (MOA) on December 6, 2007, that outlines the approach being taken to explore reclaimed water opportunities, and defines the activities to be completed by each party in achieving the MOA objectives.

Purpose

The District/County MOA sets forth a phased work approach. Phase 1 of this effort, completed in 2008, consisted of a feasibility study in which potential reclaimed water system configurations were identified and evaluated. The results of Phase 1 are summarized in Section 2.0 of this report. Phase 2, which is the subject of this report, primarily involves the development of a Benefit Cost Analysis (BCA) of select reclaimed water system options defined in the Phase 1 work. The purpose of the BCA is to better understand the benefits and costs of reclaimed water program implementation in the District's service area within a broad economic analysis framework.

At this stage, the analysis presented in this study has focused on Covington Water District and King County. This work has not been coordinated with other jurisdictions or water suppliers whose needs and wants regarding development of a reclaimed water program in this area will ultimately need to be incorporated prior to making any conclusions about the need for or feasibility of producing and utilizing reclaimed water within or near the District's service area. The District and the County will evaluate the results of the Phase 1 and Phase 2 efforts to determine the appropriate next steps toward implementing the terms of the MOA. It is anticipated that the results of this study will be included in broader regional discussions about

reclaimed water, and into the County's reclaimed water comprehensive planning process that is currently underway.

Alternative Satellite Reclaimed Water System Configurations

There are no current providers or generators of Class A reclaimed water within the District's service area. The nearest existing source of Class A reclaimed water is at the County's South Treatment Plant in Renton. Based on the likely prohibitive expense of delivering reclaimed water from South Plant to serve uses exclusively within this limited study area, satellite facilities appeared to be the most feasible alternatives warranting further analysis in Phase 2. Under such an approach, raw wastewater flow generated in and near the District's service area would be captured, treated to Class A[1] reclaimed water standards, and then retained for beneficial reuse within the District's service area.

Regional reclaimed water distribution extensions from the South Treatment Plant, as well as other facility configurations that would meet regional needs, will be examined during development of the King County Reclaimed Water Comprehensive Plan. At that time, the costs and benefits of those approaches will likely be compared with the satellite options discussed in this report.

Many potential configurations exist for a satellite system that would produce and deliver reclaimed water within and near the District's service area. Four system configurations were identified in the Phase 1 effort. To simplify the BCA analysis, while still capturing the full range of estimated potential reclaimed water costs and benefits, two of the four system configurations (the smallest and largest in terms of reclaimed water volume produced) have been carried forward into the BCA. These two configurations are:

1) **Satellite Facility at Black Diamond (smallest)**. This configuration, referred to as Alternative A in the Phase 1 Report, involves construction of a satellite reclaimed water facility near the existing Black Diamond Pump Station. Initial (Phase 1) provision of reclaimed water is for potential uses identified by the District (primarily for irrigation of a nearby golf course), while Phase 2 expansion of the distribution system could support irrigation of additional golf courses and other sites near the golf courses.
2) **Satellite Facility near Pump Station D Site (largest)**. This configuration, referred to as Alterative D in the Phase 1 Report, involves construction of a satellite reclaimed water facility near a County-owned property that is the future site of Pump Station D. This location is further downstream in the context of the regional and local wastewater conveyance systems; therefore, this option represents a larger reclaimed water volume potential. Initial (Phase 1) provision of reclaimed water is for potential uses identified by the District (primarily for multiple golf courses, and various irrigation sites in the City of Covington). Phase 2 expansion of the distribution system could support irrigation of additional golf courses and other sites near the golf courses.

[1] Class A reclaimed water is considered in this feasibility study as it represents the highest level of treatment and public health protection, and therefore results in the greatest range of potential allowable beneficial uses.

Two sub-options have been considered for each of the reclaimed water system alternatives described above. These are:

- **Seasonal Use (Irrigation Only).** A seasonal use system would require a treatment facility designed to generate enough Class A reclaimed water to support only projected irrigation demand during the assumed irrigation months of May through September. Distribution facilities (pumping and transmission piping) would be needed to convey reclaimed water to identified irrigation sites. So as to represent the lower end of the cost spectrum, such a system would not be designed to provide environmental enhancement flows[2]. Though this option results in less investment in facilities, there are operational complexities to consider, including the need to startup and shutdown the process seasonally.
- **Year-Round Use (Irrigation and Environmental Enhancement).** A year-round use system would require a larger treatment facility designed to provide reclaimed water for irrigation use, as well as environmental enhancement. For the purpose of this analysis, it is assumed that the environmental enhancement application of reclaimed water would most likely take the form of shallow groundwater recharge, via surface percolation. While specific analysis of recharge options has not been conducted as part of this effort, information gathered from previous work, including that documented in the County's *Black Diamond Wastewater Infrastructure Feasibility Study (December 14, 2007)*, indicates that gravel outwash areas in the Soos Creek Basin would provide potentially suitable recharge sites. Assumptions in this prior report regarding the nature and cost of such infiltration facilities have been carried forward into this analysis.

Therefore, the combination of the two primary configurations, along with the two sub-options considered for each, yields a total of four alternatives being considered in the BCA. Each alternative is envisioned to be implemented in phases, with Phase 1 being operational by 2020 (assumed to be roughly the earliest date by which such a system could be fully planned, designed, permitted, and constructed), and Phase 2 being fully operational by 2050 (providing for a 30-year time period in this benefit cost analysis)[3].

Table ES-1 summarizes the projected reclaimed water demand produced and beneficially reused for each alternative, by phase.

[2] Such uses of reclaimed water include wetland creation/enhancement and streamflow augmentation via groundwater infiltration.
[3] In addition, County sewer flow projections for this area do not currently extend beyond 2050.

Table ES-1. Summary of Alternative Reclaimed Water System Configurations

	Design Capacity (mgd)	
	Phase 1 (2020)	Phase 2 (2050)
Alternative 1 - Black Diamond		
Alt. 1-A (Seasonal Use/Irrigation Only) (1)	0.50	1.20
Alt. 1-B (Year-Round Use/Irrigation and Environmental Uses) (2)	2.45	3.20
Alternative 2 – King County Pump Station D Site		
Alt. 2-A (Seasonal Use/Irrigation Only) (1)	2.00	2.50
Alt. 2-B (Year-Round Use/Irrigation and Environmental Uses) (3)	4.90	8.30

Notes:

mgd = million gallons per day

(1) Basis of design capacity for "seasonal use" satellite reclaimed water facility (all alternatives):

Phase 1 = Approximate Seasonal Average Day Irrigation Demand, and within Projected Average Base Flow at Facility Location (2020), to provide only dry season beneficial reuse.

Phase 2 = Approximate Seasonal Average Day Irrigation Demand, and within Projected Average Base Flow at Facility Location (2050), to provide only dry season beneficial reuse.

(2) Basis of design capacity for "year-round use" satellite reclaimed water facility (Alternative 1):

Phase 1 = 2020 Maximum Month Flow at plant location. Peak flows are equalized by planned 0.75 MG storage facility at Black Diamond.

Phase 2 = 2050 Maximum Month Flow at plant location. Peak flows are equalized by planned 0.75 MG storage facility at Black Diamond.

(3) Basis of design capacity for "year-round use" satellite reclaimed water facility (Alternative 2):

Phase 1 = Sized to provide reclaimed water for identified irrigation use and environmental enhancement, in an amount estimated to mitigate 50% of total net water extractions from the Soos Creek Basin (see Section 6 of the Phase 1 Report for details). Peak flows in excess of reclaimed water system design capacity are diverted to existing downstream conveyance system.

Phase 2 = Sized to provide reclaimed water for identified irrigation use and environmental enhancement, in an amount estimated to mitigate 100% of total net water extractions from the Soos Creek Basin (see Section 6 of the Phase 1 Report for details). Peak flows in excess of reclaimed water system design capacity are diverted to existing downstream conveyance system.

Approach to Benefit Cost Analysis

The purpose of this analysis is to better understand the benefits and costs of implementing a reclaimed water program in the District's service area within a broad economic analysis framework. Performing a BCA study involves weighing the benefits against the costs (capital investment, operations, and maintenance), with respect to the associated timeframes in which the costs and benefits are incurred. The benefits and costs are then summed in their present values to determine if the subject under study generates benefits in excess of the costs in today's dollars. Often the costs are much more concrete and defined than the benefits in the sense that they can be more readily anticipated and evaluated from a monetary standpoint. The benefits tend to be much more far reaching and involve many other elements, but also include evaluation of intangible benefits or benefits to which there may not be a market value attached (e.g., aesthetics).

This BCA uses the approach for benefit cost analyses of reclaimed water projects established in the guidance document entitled *An Economic Framework for Evaluating the Benefits and Costs of Water Reuse – WateReuse Foundation* (R. Raucher, et al, 2006), referred to hereafter as the WateReuse Foundation Economic Framework. This methodology established a comprehensive

accounting framework for the full range of costs, benefits, and who might bear them. This approach has been expanded upon within the context of this study to account for comparison amongst multiple project alternatives while also incorporating a comprehensive risk and uncertainty analysis.

Some benefits are well defined and easily quantifiable whereas others may have insufficient data to quantify them. For that reason the analysis is conducted in two parts:

1) Quantitative Analysis. The quantitative analysis focuses only on benefits that could be monetized and includes the development of baseline values for project costs and those benefits that can be monetized (in "real" or non-inflated terms) which in turn are converted to present value. The analysis considers a 30-year timeframe, starting in 2018 (when design and construction costs would begin to be expended to implement any of the reclaimed water system alternatives) and terminating in 2047. The present value benefits and costs are then used to calculate a "net benefits" metric (i.e., benefits less costs) to compare each of the four alternatives.
2) Qualitative Assessment. Those benefits that could not be quantitatively analyzed were qualitatively assessed in a workshop setting. In this process, benefits were scored by District and County staff according to the potential impact a given alternative would have upon each benefit, using a scale of 0 (no impact) to 5 (very large impact). A likelihood of each benefit being realized was then assigned to each alternative, ranging from 0 to 100%. Finally, the impact scores are multiplied by the likelihoods to arrive at a magnitude, with a maximum value of 5. This calculation allows for the relative comparison of each alternative within the context of the individual benefits.

The results of the quantitative analysis and qualitative assessment are then combined to arrive at a final comparison amongst the alternatives, as summarized in Table ES-5 later in this executive summary.

Summary of Benefits Considered

Several types of potential benefits were considered during the construction of the BCA model. The process of benefit identification began with a review of potential benefits prepared by the County in conjunction with the King County Reclaimed Water Comprehensive Planning process. In the King County document titled *Identification of Potential Economic Benefits of Production and Use of Reclaimed Water (Draft, September 2009)*, a sizeable list of benefits is presented, identified and organized according to the WateReuse Foundation Economic Framework. These benefits are ones that have been identified as potentially applicable to reclaimed water projects in King County. This list includes benefits for which information may be available with which to quantitatively assess the benefits, as well as benefits which may be important to consider but for which there is inadequate information with which to conduct a quantitative assessment.

Using this initial list as a starting point, specific benefits were identified as being applicable for consideration in the context of this particular analysis. Additional benefits not on the initial list were also developed, to capture issues unique to this study. The resulting list of benefits considered in this BCA is summarized in Table ES-2, organized according to anticipated beneficiary.

Table ES-2. Benefits Summary

ID	Description
Quantitatively-Assessed Benefits	
Wastewater Utility (King County) Benefits	
WW-1	Avoided wastewater conveyance capital costs (Pump Station H and related conveyance)
WW-2	Avoided wastewater conveyance capital costs (Pump Station D and related conveyance)
WW-3	Avoided wastewater treatment capital costs related to capacity increases (South Plant)
WW-4	Reclaimed water revenues (King County)
Water Utility (Covington Water District) Benefits	
WU-1	Reclaimed water revenues (Covington Water District)
Self-Supplied Water User (Reclaimed Water End User) Benefits	
SS-1	Avoided groundwater pumping costs
General Public Benefits	
Environmental	
GP-1	Increased instream flows
GP-2	Savings in fertilizer usage
GP-3	Reduced greenhouse gas emissions
Recreational	
GP-4	Increased in-stream recreation (fishing)
GP-5	Increased near-stream recreation (wildlife viewing)
Qualitatively-Assessed Benefits	
Wastewater Utility (King County) Benefits	
WW-10	Increased flexibility in management of treated wastewater
WW-11	Avoided wastewater treatment capital costs related to nutrient removal (South Plant)
Water Utility (Covington Water District) Benefits	
WU-10	Protection of water source areas
Self-Supplied Water User (Reclaimed Water End User) Benefits	
SS-10	Increased water supply reliability
SS-11	Reduced risk of enforcement/litigation costs associated with water rights
General Public Benefits	
Environmental	
GP-10	Enhanced coastal ecosystems
GP-11	Improvements in in-stream water quality
GP-12	Reductions in risk associated with climate change
Societal	
GP-13	Increased economic growth
GP-14	Improved management of water resources
GP-15	Reinforced cultural/spiritual values
GP-16	Reinforced cultural values associated with a conservation ethic
GP-17	Enhanced aesthetic values
GP-18	Reductions in risk associated with population and economic growth
GP-19	Increased public education

Compared to the initial list, this revised list (particularly with respect to quantitatively assessed benefits) is significantly shorter. This is primarily a result of certain benefits being removed from the initial list during a series of County/District workshops. For the most part, such deletions were based on certain benefits being deemed not applicable to this particular analysis or study area, or as having such minimal impact (due to the limited scale of the study area) as to not warrant inclusion.

In addition, some benefits categorized in the initial list as quantitatively-assessed have been re-categorized as qualitatively-assessed. This is generally predicated on a lack of sufficient information being available with which to calculate a monetized benefit.

It is important to note that the approach taken to evaluating benefits in this particular study (primarily with regard to distinguishing between those benefits that could be quantitatively analyzed versus those that could be qualitatively assessed) is specific to this analysis. A similar evaluation in another portion of King County will likely utilize different assumptions and approaches, due to differences in the nature of the study area relative to that in this study. For example, if a given study area is larger than that considered here (i.e., the District's service area), the quantitative analysis of more benefits may be warranted, due to larger impacts of benefits resulting from a larger scale study area. Furthermore, if more data exist that can be used to monetize environmental benefits, then additional benefits may warrant quantitative analysis than are considered in this analysis.

The assumptions regarding how certain benefits were treated in this analysis is summarized below, depicted as key differences between the list of benefits included in this BCA model, compared to the initial list starting point.

Wastewater Utility Benefits

- Benefits WW-1 through WW-3 represent potential benefits to the wastewater utility, in the form of avoided capital costs. In the initial benefits list, these three items were rolled into one benefit. For transparency in the BCA calculation, these benefits have been broken out into three distinct items, to clearly capture significant benefits unique to this particular study.

- Benefit WW-11 is an addition to the list, and represents avoided capital costs related to potential future nutrient removal requirements at the South Treatment Plant. Through the workshop discussions, it was determined that this benefit could be significant and warrants mention, but that there is insufficient data currently available with which to quantify or monetize the benefit.

Water Utility Benefits

- Many of the water utility benefits present in the initial list were determined during the course of this work to be not applicable to the current analysis, primarily because implementation of a reclaimed water program in the District's service area would not alter or defer the District's present course of action relative to its exercise of its water supply portfolio during this time period.

Self-Supplied Water User Benefits

- Some water-side benefits (e.g., avoided groundwater pumping costs and increased water supply reliability) were determined to be applicable only to those water users that are currently self-supplied. As such, a distinct grouping of such benefits has been developed.

General Public Benefits

- Many of the general public benefits (i.e., environmental, societal, etc.) presented in the initial list were removed during this analysis. Similar to other benefits that were removed, this was due to them being either not applicable or of marginal impact due to the small scale of the study area.
- Some specific benefits were removed only after additional analysis was conducted to determine their relevancy. Key examples include:
  - Wetlands restoration. This benefit was removed since the alternatives being considered in this analysis do not involve beneficial reuse in the form of wetland restoration. Furthermore, review of the County's study *Identification of Wetlands Likely to Benefit from Additional Water Inputs (July 2009)* indicates that there are few to no wetlands in the study area that would benefit from additional water.
  - Reduced risks to threatened/endangered species other than salmon. A review by County staff of threatened/endangered species presence in the Covington area indicated that while there are some species whose presence is possible (e.g., Bald Eagle, Red-Tailed Hawk), in most instances the extent of that presence is unknown or undocumented. Furthermore, the likely impact of increased water flows upon species survival is difficult to characterize and is likely minimal in any event.
  - Reduced risks to threatened/endangered species – Pacific Salmon. A review was conducted of available data regarding salmon presence in Covington and Soos Creeks, and an attempt to relate increases in instream flows to increased salmon production and species survival was made. The findings of this analysis are as follows:
    - This area provides spawning and year-round rearing habitat for Coho and Steelhead, and spawning habitat for Fall Chinook. Of these, Steelhead and Fall Chinook are listed as threatened species.
    - The amount of habitat utilized year-round by Steelhead in the study area is approximately 12 river miles (3 miles on Soos Creek and 9 miles on Covington Creek). Compared to the total habitat area utilized by Puget Sound Steelhead (thousands of river miles), the extent of area impacted by increased flows resulting from these reclaimed water alternatives is very minimal.
    - There have been no studies in the Soos Creek Basin that directly relate instream flows to available habitat and fish productivity. This, coupled with the small fraction of total Puget Sound Steelhead habitat represented by the study area, renders this benefit (which is characterized in the initial benefit list as the ability of a given project to increase total species population by 50%) unquantifiable. Even if it could be quantified with greater confidence, the impact would be negligible, relative to the entire Puget Sound Steelhead population.
    - Fall Chinook are not present in the study area during times of critical low-flow conditions. In addition, similar to Steelhead, the Soos Creek Basin

represents a very small fraction of the total Puget Sound Fall Chinook habitat. Thus, this benefit does not warrant quantification relative to Fall Chinook.

- Additional analysis was conducted to determine if any salmon production-related benefits could be realized by the Washington Department of Fish and Wildlife's (WDFW) Soos Creek Hatchery. Based upon discussions with hatchery managers, flow conditions in Soos Creek do not appear to be a limiting factor in the hatchery's operations. WDFW holds multiple water rights, some of which are associated with springs and not streamflow, which enable it to meet its water supply needs even when flows in Soos Creek decrease in late spring and summer.

- Increased commercial and recreational salmon harvest. As a result of the findings above regarding the limited benefits imparted to Puget Sound salmon with the increased flows provided to Covington and Soos Creeks, it was determined that it would be difficult to characterize with confidence the number of additional adult salmon that would be available for harvest in the basin. Regardless, the amount is anticipated to be minimal. Furthermore, another benefit remaining on the list (GP-4) captures the general increase in fishing-related recreation resulting from increased flows. Thus, an attempt to include a recreational salmon harvest benefit would likely constitute double-counting.

Analysis Results

Quantitative Analysis

The present value costs and benefits (for those benefits that could be monetized) were used to calculate the net benefits for each alternative. Table ES-3 summarizes the results. Based on the quantitative analysis, none of the alternatives provides positive net benefits within the 30 year period of analysis. The net benefits range between -$183.5 and -$38.8 million. While a longer time period could yield more benefit, the discounting of future streams of benefits as well as the addition of future operations, maintenance and rehabilitation costs would likely offset those future year benefits.

Table ES-3. Summary of Net Monetized Benefits

	Alt 1-A (Black Diamond, Seasonal)	Alt 1-B (Black Diamond, Year-Round)	Alt 2-A (Pump Station D, Seasonal)	Alt 2-B (Pump Station D, Year-Round)
Design Capacity (mgd)				
Phase 1 (2020)	0.50	2.45	2.00	4.90
Phase 2 (2050)	1.20	3.20	2.50	8.30
Benefits				
Wastewater Utility Benefits	$2,600,000	$91,600,000	$5,200,000	$59,800,000
Water Utility Benefits	$5,300,000	$5,300,000	$11,200,000	$11,200,000
Self-Supplied Water User Benefits (1)	$100,000	$100,000	$100,000	$100,000
General Public Benefits (Environmental)	$300,000	$600,000	$700,000	$2,300,000
General Public Benefits (Recreational)	$300,000	$700,000	$500,000	$1,600,000
Total Benefits	**$8,600,000**	**$98,300,000**	**$17,700,000**	**$75,000,000**
Costs				
Capital Costs	$55,200,000	$117,800,000	$109,800,000	$222,800,000
O&M Costs	$4,400,000	$19,200,000	$8,900,000	$35,700,000
Total Costs	**$59,600,000**	**$137,000,000**	**$118,700,000**	**$258,500,000**
Net Benefits (2)	**($51,000,000)**	**($38,800,000)**	**($100,900,000)**	**($183,500,000)**

Notes:

(1) The values for these benefits range from $65,000 (Alts 1-A and 1-B) to $130,000 (Alts 2-A and 2-B). They appear equal in this summary due to rounding.

(2) These values represent the net benefits calculated based upon the expected values for the cost and benefit inputs to the BCA model. These values are depicted on Figure ES-1, in conjunction with their probability of occurrence within the context of the range of potential cost and benefit value inputs.

Analysis of the net benefits indicates the Black Diamond options generate the highest net benefits of the four alternatives. Specifically, Alternative 1-B, the Black Diamond year-round option, generates the best return. While this option is the second most costly alternative, it provides the largest return on investment out of the four alternatives mostly through large direct benefits to the wastewater and water utilities (i.e., avoided capital costs for expanded conveyance facilities, with regard to the County, and increased reclaimed water revenues, with regard to the District).

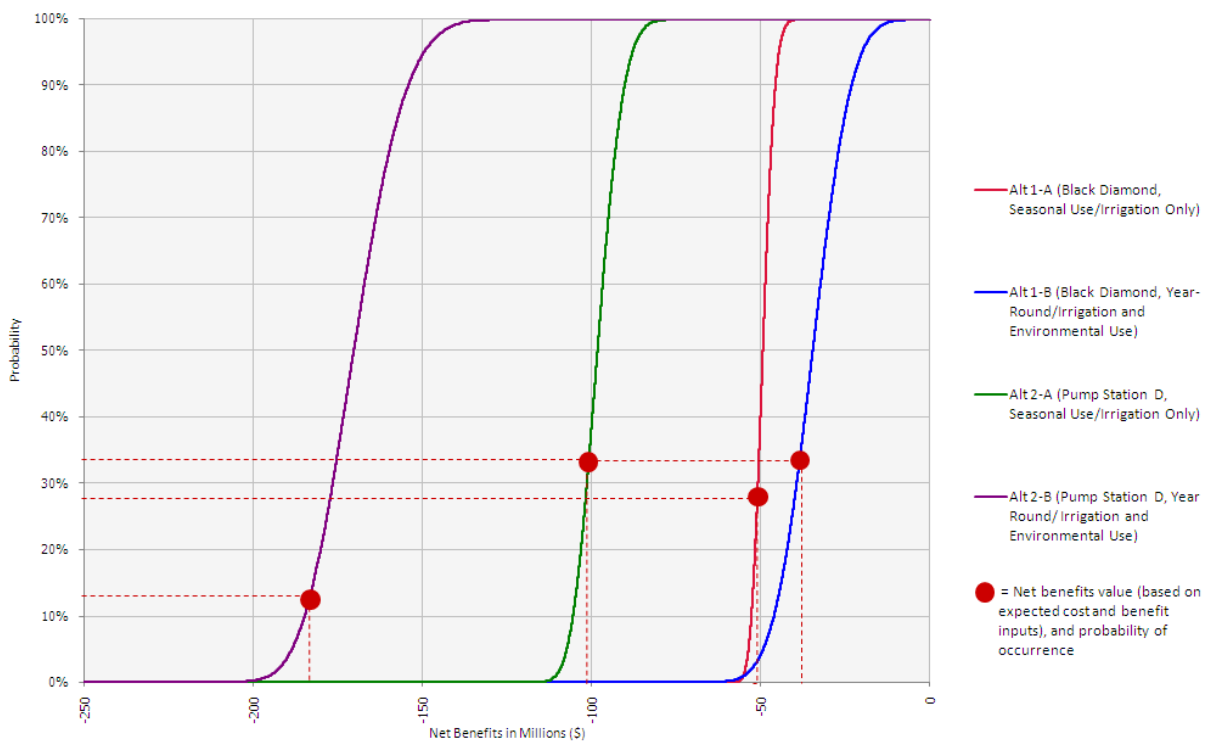
The Pump Station D alternatives fall significantly behind the Black Diamond alternatives when comparing the four. When compared to the benefits they generate, the costs are simply too large to arrive at net benefits similar to the Black Diamond options.

A risk and uncertainty model was assembled using the ranges of values for costs and benefits input into the BCA. The model was used to forecast the probability distribution of the net benefit results for each alternative, which are based upon the expected values of the cost and benefit inputs to the BCA model, given the established criteria set forth by the input value ranges.

The results from this forecast are summarized in Figure ES-1 as cumulative probability density functions. These curves compare the alternatives against one another, identifying the net benefit values that are based upon expected input values, and demonstrating the likelihood of net benefits. The curves illustrate a heavy presence of stochastic dominance for the Black Diamond alternatives over the Pump Station D alternatives. This means that for every possible combination of input values in the net benefits, the Black Diamond alternatives will always generate net benefits greater than those of the other two options.

In addition, this analysis reveals that the results of the net benefits calculation (i.e., the net benefits value based upon expected values for cost and benefit inputs) are at the low end of the cumulative density functions. This indicates that from a standpoint of risk or uncertainty, each alternative presents a good chance of realizing higher net benefits than what the baseline net benefits results present. For example, for Alternative 1-B, there is a 33% probability that realized net benefits will be less than the result based upon expected input values, and a 77% probability that the net benefits would be greater than this baseline result.

Figure ES-1. Net Benefits Cumulative Probability Density Functions



Qualitative Assessment

Additional comparative information about the alternatives, particularly with respect to one another, is provided in the qualitative benefit assessment, the results of which are summarized in Table ES-4. Each alternative received a "relative magnitude" score, based upon the combination of a "relative impact" score multiplied by a "likelihood". The maximum possible relative magnitude score to be achieved for each benefit by a given alternative is 5.0.

Based on the scoring, Alternative 1-B received the highest score, meaning that the benefits were determined to have the greatest potential impact and likelihood of being realized under this alternative. Alternatives 1-A and 2-B followed with similar total scores. Alternative 2-A scored the lowest.

The benefits that contribute most significantly to differentiating Alternative 1-B from the other options are:

- WW-10: Increased flexibility in management of treated wastewater. With respect to this benefit, the year-round use alternatives score significantly higher than the seasonal use alternatives, due to the ability of the year-round use alternatives to manage wet weather flows.
- GP-11: Improvements to instream water quality. Alternatives 1-A and 1-B score higher in regard to this benefit because of the more extensive length of stream reach potentially benefitted (i.e., due to reclaimed water use and streamflow enhancements higher in the watershed, both Covington and Soos Creeks may be benefitted, as opposed to just Soos Creek under Alternatives 2-A and 2-B).
- GP-12: Reductions in risk associated with climate change. The differentiation between scoring is due to the same effects noted for Benefit GP-11, related to stream lengths.

It is important to note that the scoring of these qualitatively-assessed benefits is specific to this analysis, and is largely a function of the relatively small size of the study area and the resultant minimal potential impact of the alternatives upon some benefits. For example, while benefit WW-11 (avoided costs related to nutrient removal at South Plant) shows a high likelihood of being realized via any of the alternatives, its impact score is 0 due to the very small volumes of reclaimed water produced and used under the alternatives, relative to the total volume of wastewater treated at South Plant.

Table ES-4. Qualitative Benefit Assessment Results

Benefit		Alt 1-A Black Diamond Seasonal Use			Alt 1-B Black Diamond Year-Round Use			Alt 2-A Pump Station D Seasonal Use			Alt 2-B Pump Station D Year-Round Use		
		I	L	M	I	L	M	I	L	M	I	L	M
WW-10	Increased flexibility in management of treated wastewater	1	75%	0.75	2	75%	1.50	1	75%	0.75	2	75%	1.50
WW-11	Avoided wastewater treatment capital costs related to nutrient removal (South Plant)	0	75%	0.00	1	75%	0.75	0	75%	0.00	1	75%	0.75
WU-10	Protection of water source areas	2	10%	0.20	2	10%	0.20	2	10%	0.20	2	10%	0.20
SS-10	Increased water supply reliability	2	25%	0.50	2	25%	0.50	2	25%	0.50	2	25%	0.50
SS-11	Reduced risk of enforcement/litigation costs associated with water rights	4	10%	0.40	4	10%	0.40	4	10%	0.40	4	10%	0.40
GP-10	Enhanced coastal ecosystems	1	10%	0.10	1	10%	0.10	1	10%	0.10	1	10%	0.10
GP-11	Improvements in in-stream water quality	2	50%	1.00	3	75%	2.25	1	10%	0.10	2	25%	0.50
GP-12	Reductions in risk associated with climate change	2	30%	0.60	3	50%	1.50	1	10%	0.10	2	20%	0.40
GP-13	Increased economic growth	1	10%	0.10	1	10%	0.10	1	10%	0.10	1	10%	0.10
GP-14	Improved management of water resources	1	10%	0.10	1	10%	0.10	1	10%	0.10	1	10%	0.10
GP-15	Reinforced cultural/spiritual values	4	75%	3.00	4	75%	3.00	3	75%	2.25	3	75%	2.25
GP-16	Reinforced cultural values associated with a conservation ethic	3	25%	0.75	3	25%	0.75	2	25%	0.50	2	25%	0.50
GP-17	Enhanced aesthetic values	1	10%	0.10	1	10%	0.10	1	10%	0.10	1	10%	0.10
GP-18	Reductions in risk associated with population and economic growth such as moratorium	3	20%	0.60	3	20%	0.60	3	20%	0.60	3	20%	0.60
GP-19	Increased public education	3	75%	2.25	3	75%	2.25	3	75%	2.25	3	75%	2.25
	Total Magnitude			**10.45**			**14.10**			**8.05**			**10.25**

Note: I = Impact Score (0-5); L = Likelihood (0-100%); M = Magnitude (I x L)

Key Findings

Key findings of the benefit cost analysis, considering the results of both the quantitative analysis and the qualitative assessment, are summarized below. While this summary of key findings is consistent with the methodology established in the WateReuse Foundation Economic Framework, the presentation of results varies slightly from the table templates presented in the Framework guidance document. This is due to the large list of benefits considered in this analysis (particularly with respect to the qualitatively-assessed benefits), and the lengthy tables that would be necessary if the detailed results from both the quantitative and qualitative components of the analysis were to be depicted together. As such, the summaries below serve as the most appropriate presentation of analysis results in this case.

1) The results of both the quantitative benefit cost analysis and the qualitative benefit assessment are provided below in Table ES-5, and indicate that the Black Diamond alternatives are clearly the top two alternatives. Alternative 1-B (Black Diamond, Year-Round Use) is the preferred reclaimed water system alternative amongst those options being considered in this analysis, while Alternative 1-A (Black Diamond, Seasonal Use) ranks second. The results are somewhat ambiguous with respect to the remaining two alternatives. Alternative 2-B (Pump Station D Site, Year-Round Use) presents a likely fourth place ranking in the quantitative analysis but third in the qualitative assessment, whereas Alternative 2-A (Pump Station D Site, Seasonal Use) has the opposite results.

Table ES-5. Summary of Alternative Rankings

Alternative	Quantitative Benefit Cost Analysis Ranking	Qualitative Benefit Assessment Ranking
Alt 1-A Black Diamond: Seasonal Use	2	2
Alt 1-B Black Diamond: Year-Round Use	1	1
Alt 2-A Pump Station D Site: Seasonal Use	3	4
Alt 2-B Pump Station D Site: Year-Round Use	4	3

2) Alternative 1-B (Black Diamond, Year-Round Use) has the highest net benefits of all the alternatives. This is because although it is the second most costly alternative, it provides by far the largest benefit due to avoided and deferred wastewater utility capital costs. Furthermore, this alternative, rather strongly also, received the highest ranking from the qualitative benefit assessment process with more than a two-point score difference from the other alternatives.

3) Based on the risk and uncertainty analysis, there is a good chance that the baseline values for the net benefits (i.e., those results based upon the expected cost and benefit inputs) for each alternative would be exceeded, given the potential range of input values and the probability distribution of resultant net benefits values.

4) The benefit split amongst beneficiaries, which could potentially be used to inform project cost allocations if a program were implemented, varies amongst the alternatives. For

example, for Alternative 1-B (the highest ranking option) benefits that would be realized by the County amount to 93% of the total benefits that could be quantified and assigned dollar values. Benefits received by the District and the general public amount to approximately 5% and 2% of the total, respectively. By contrast, for the seasonal alternatives (regardless of location), the benefits realized by the District amount to slightly more than 60% of the total, while those realized by the County represent 30% of the total, with the remainder realized by the general public and self-supplied water users.

Next Steps

Key future steps to be taken by the District and the County in advancing the planning of a potential reclaimed water program in this portion of the County include the following:

- Integration of this local level of reclaimed water planning with other concurrent efforts, such as the King County Reclaimed Water Comprehensive Plan, which is exploring reclaimed water alternatives at the regional level.
- Discussions and coordination with other local jurisdictions (e.g., municipalities and utility districts) so as to incorporate their needs and desires relative to reclaimed water in future planning stages. It is anticipated that new and/or modified reclaimed water system configurations may develop from this additional level of coordination. Furthermore, additional benefits may be identified which change the results of the benefit cost analysis presented herein.
- Updating of this benefit cost analysis if additional information comes to light which may have the potential to significantly alter the analysis outcomes. Potential items of significance include:
  - More definition regarding nutrient removal requirements at South Plant. Nutrient removal at South Plant is anticipated based on various discussions between the County, the Department of Ecology, and others regarding dissolved oxygen and nutrient levels in south Puget Sound. However, the nature, extent, and timing of potential nutrient removal requirements the County may have to meet in the future are uncertain at this time. As such requirements become better defined, this reclaimed water system benefit cost analysis could be revisited to examine if implementation of a reclaimed water program in the District's service area has the potential to reduce the magnitude of treatment plant upgrades at South Plant.
  - Increased State enforcement of potentially illegal water uses in the District's service area. There is great uncertainty in the probability of currently self-supplied water users in the basin to convert to reclaimed water or municipal water supplies. If more resources were used to ensure legal uses of water rights and water right-exempt sources, it is possible that the extent of reclaimed water use for non-potable purposes such as irrigation could increase. This analysis did not include any potential changes in law or enforcement relative to this issue. Therefore, the analysis could be revisited at the time when such changes are enacted, to determine if these increased benefits relative to water supply would lead to satellite reclaimed water program implementation becoming a more economically attractive strategy.

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Section 1.0 Introduction

1.1 Background

The Covington Water District (District) encompasses an urban and rural growth area that includes three cities and a large transition area in the Soos Creek Basin in southern King County. Figure 1-1 depicts the District's location within the County, while Figure 1-2 shows the District's service area relative to the many municipal and other utility service area boundaries in the basin. Water demand, wastewater management, and conservation of the water resources within the District's service area require a partnership with other local governments. The District's long-term water supply plan includes the use of imported surface water and in-basin groundwater, as well as consideration of water reclamation and reuse to meet the municipal and environmental needs of the area.

King County (County), through its Department of Natural Resources and Parks, Wastewater Treatment Division, is the regional wastewater services provider for a large portion of King County, including most of the District's water supply service area. New and/or upgraded wastewater facilities will be needed in the coming decade to serve the growing population in southern King County. Development of reclaimed water production and distribution facilities may aid in addressing this need, while also promoting sustainable management of the area's water resources.

Due to the mutual interest in reclaimed water held by the District and the County, the two parties have elected to jointly study and develop reclaimed water facility alternatives that have the potential to retain water resources within the basin, thereby meeting the multiple needs described above. The two entities entered into a Memorandum of Agreement (MOA) on December 6, 2007, that outlines the approach being taken to explore reclaimed water opportunities, and defines the activities to be completed by each party in achieving the MOA objectives.

1.2 Purpose of Study

The District/County MOA sets forth a phased work approach. Phase 1 of this effort, completed in 2008, consisted of a feasibility study in which potential reclaimed water system configurations were identified and evaluated. The results of Phase 1 are summarized in Section 2.0 of this report. Phase 2, which is the subject of this report, primarily involves the development of a Benefit Cost Analysis (BCA) of select reclaimed water system options defined in the Phase 1 work. The purpose of the BCA is to better understand the benefits and costs of reclaimed water program implementation in the District's service area within a broad economic analysis framework.

At this stage, the analysis presented in this study has focused on Covington Water District and King County. This work has not been coordinated with other jurisdictions or water suppliers whose needs and wants regarding development of a reclaimed water program in this area will ultimately need to be incorporated prior to making any conclusions about the need for or feasibility of producing and utilizing reclaimed water within or near the District's service area. The District and the County will evaluate the results of the Phase 1 and Phase 2 efforts to determine the appropriate next steps toward implementing the terms of the MOA. It is

anticipated that the results of this study will be included in broader regional discussions about reclaimed water, and into the County's reclaimed water comprehensive planning process that is currently underway.

1.3 Sources of Information

The following comprise the primary sources of information used in preparation of this study:

- *Covington Water District and King County Reclaimed Water Feasibility Study (Phase 1) – Final Report* (December 30, 2008). Referred to hereafter as the Phase 1 Report.
- *An Economic Framework for Evaluating the Benefits and Costs of Water Reuse – WateReuse Foundation* (R. Raucher, et al, 2006). Referred to hereafter as the WateReuse Foundation Economic Framework.
- *Identification of Potential Economic Benefits of Production and Use of Reclaimed Water - DRAFT* (King County, September 2009).

Other sources of data used in the study are referenced throughout the text.

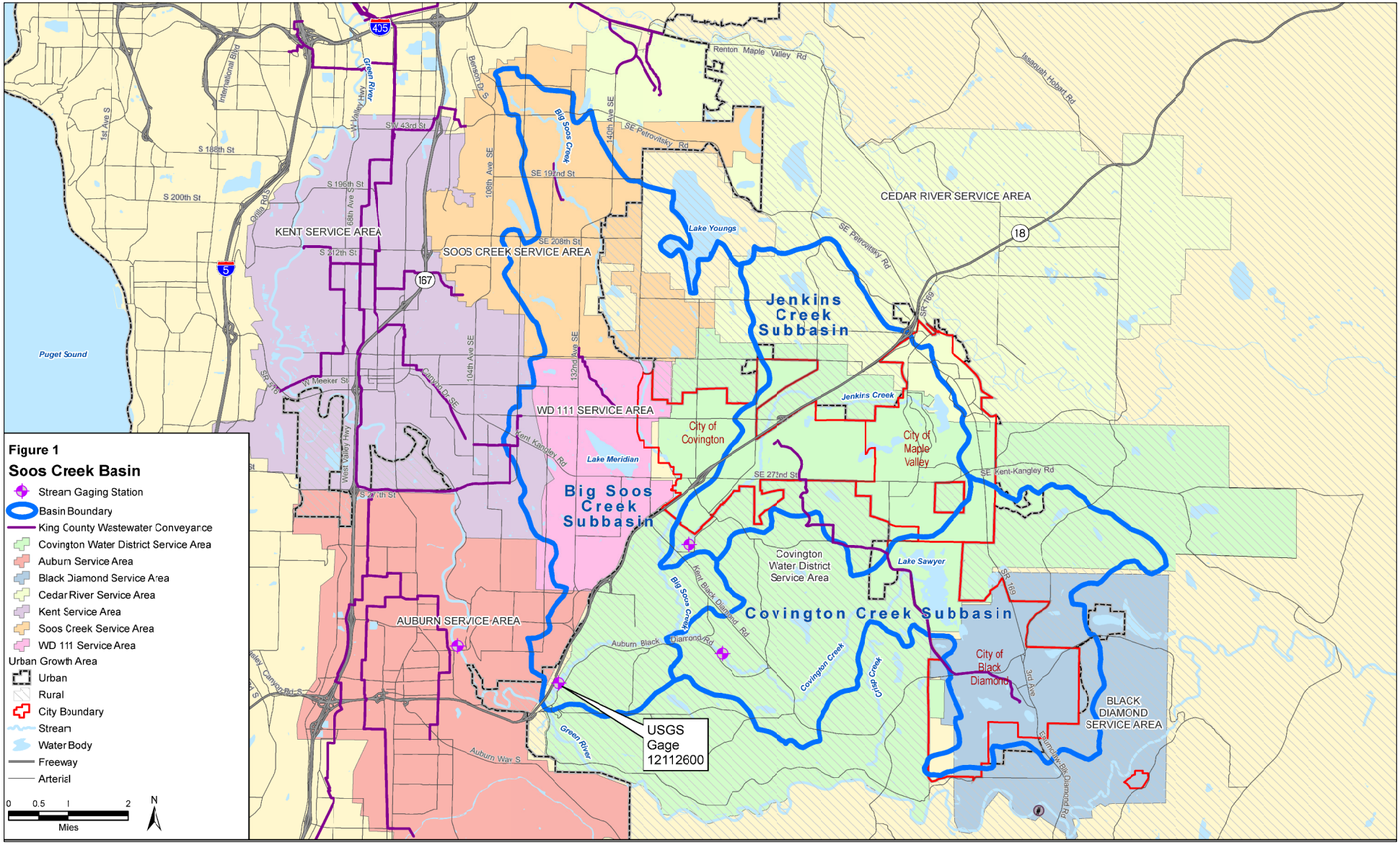
HDR

Covington Water District
Service Area

DATE
December 2009

FIGURE
1-1

Covington_Water_District\O_CWD_RecImd_Wtr_Phs2_BCA\05.00_Project_Data_Reference_Data\cad\10-23-09\FIG-1-1-oct



HDR

Soos Creek Basin
Water Purveyors, Wastewater Conveyance
and Key Drainage Features

DATE
December 2009

FIGURE
1-2

Covington_Water_District\O_CWD_Reclmd_Wtr_Phs2_BCA\05.00_Project_Data_Reference_Data\cad\10-23-09\FIG-2-1-oct

Section 2.0 Potential Reclaimed Water Alternatives Considered

2.1 Description of Analysis Alternatives

There are no current providers or generators of Class A reclaimed water within the District's service area. The nearest existing source of Class A reclaimed water is at the County's South Treatment Plant in Renton. Based on the likely prohibitive expense of delivering reclaimed water from South Plant to serve uses exclusively within this limited study area, satellite facilities appeared to be the most feasible alternatives warranting further analysis in Phase 2. Under such an approach, raw wastewater flow generated in and near the District's service area would be captured, treated to Class A[4] reclaimed water standards, and then retained for beneficial reuse within the District's service area.

Regional reclaimed water distribution extensions from the South Treatment Plant, as well as other facility configurations that would meet regional needs, will be examined during development of the King County Reclaimed Water Comprehensive Plan. At that time, the costs and benefits of those approaches will likely be compared with the satellite options discussed in this report.

Many potential configurations exist for a satellite system that would produce and deliver reclaimed water within and near the District's service area. Four system configurations were identified in the Phase 1 effort. To simplify the BCA analysis, while still capturing the full range of estimated potential reclaimed water costs and benefits, two of the four system configurations (the smallest and largest in terms of reclaimed water volume produced) have been carried forward into the BCA. These two configurations are:

1) **Satellite Facility at Black Diamond (smallest)**. This configuration, referred to as Alternative A in the Phase 1 Report, involves construction of a satellite reclaimed water facility near the existing Black Diamond Pump Station. Initial (Phase 1) provision of reclaimed water is for potential uses identified by the District (primarily intended for irrigation of a nearby golf course), while Phase 2 expansion of the distribution system could support irrigation of additional golf courses and other sites near the golf courses.

2) **Satellite Facility near Pump Station D Site (largest)**. This configuration, referred to as Alterative D in the Phase 1 Report, involves construction of a satellite reclaimed water facility near a County-owned property that is the future site of Pump Station D. This location is further downstream in the context of the regional and local wastewater conveyance systems; therefore, this option represents a larger reclaimed water volume potential. Initial (Phase 1) provision of reclaimed water is for potential uses identified by the District (primarily for multiple golf courses, and various irrigation sites in the City of Covington). Phase 2 expansion of the distribution system could support irrigation of additional golf courses and other sites near the golf courses.

   Note: Alternative 2 initially considered location of a satellite reclaimed water facility near Soos Creek Water and Sewer District (SCWSD) Lift Station (LS) No. 10B. This is the manner in which the alternative is presented in the Phase 1 Report. The alternative was modified in early 2009, as further analysis by the County indicated that the Pump

[4] Class A reclaimed water is considered in this feasibility study as it represents the highest level of treatment and public health protection, and therefore results in the greatest range of potential allowable beneficial uses.

Station D site would likely be a more feasible location for siting a reclaimed water facility. As the new site is in close proximity to the prior SCWSD LS No. 10B location, all assumptions in the Phase 1 Report regarding design capacities and implementation costs remain the same for this alternative.

Two sub-options have been considered for the two reclaimed water system configurations described above. These are:

- **Seasonal Use (Irrigation Only).** A seasonal use system would require a treatment facility designed to generate enough Class A reclaimed water to support only projected irrigation demand during the assumed irrigation months of May through September. Distribution facilities (pumping and transmission piping) would be needed to convey reclaimed water to identified irrigation sites. So as to represent the lower end of the cost spectrum, such a system would not be designed to provide environmental enhancement flows[5]. Though this option results in less investment in facilities, there are operational complexities to consider, including the need to startup and shutdown the process seasonally.
- **Year-Round Use (Irrigation and Environmental Enhancement).** A year-round use system would require a larger treatment facility designed to provide reclaimed water for irrigation use, as well as environmental enhancement. For the purpose of this analysis, it is assumed that the environmental enhancement application of reclaimed water would most likely take the form of shallow groundwater recharge, via surface percolation. While specific analysis of recharge options has not been conducted as part of this effort, information gathered from previous work, including that documented in the County's *Black Diamond Wastewater Infrastructure Feasibility Study (December 14, 2007)*, indicates that gravel outwash areas in the Soos Creek Basin would provide potentially suitable recharge sites. Assumptions in this prior report regarding the nature and cost of such infiltration facilities have been carried forward into this analysis.

Therefore, the combination of the two primary configurations, along with the two sub-options considered for each, yields a total of four alternatives being considered in the BCA. Each alternative is envisioned to be implemented in phases, with Phase 1 being operational by 2020 (assumed to be roughly the earliest date by which such a system could be fully planned, designed, permitted, and constructed), and Phase 2 being fully operational by 2050 (providing for a 30-year time period in this benefit cost analysis)[6].

Table 2-1 summarizes the projected reclaimed water demand produced and beneficially reused for each alternative, by phase. Figure 2-1 depicts the locations of the reclaimed water production facilities considered in each alternative, while Figures 2-2 and 2-3 illustrate the potential reclaimed water production and distribution system configurations.

[5] Such uses of reclaimed water include wetland creation/enhancement and streamflow augmentation via groundwater infiltration.
[6] In addition, County sewer flow projections for this area do not currently extend beyond 2050.

Table 2-1. Summary of Alternative Reclaimed Water System Configurations

	Design Capacity (mgd)	
	Phase 1 (2020)	Phase 2 (2050)
Alternative 1 - Black Diamond		
Alt. 1-A (Seasonal Use/Irrigation Only) (1)	0.50	1.20
Alt. 1-B (Year-Round Use/Irrigation and Environmental Uses) (2)	2.45	3.20
Alternative 2 – King County Pump Station D Site		
Alt. 2-A (Seasonal Use/Irrigation Only) (1)	2.00	2.50
Alt. 2-B (Year-Round Use/Irrigation and Environmental Uses) (3)	4.90	8.30

Notes:

mgd = million gallons per day

(1) Basis of design capacity for "seasonal use" satellite reclaimed water facility (all alternatives):

Phase 1 = Approximate Seasonal Average Day Irrigation Demand, and within Projected Average Base Flow at Facility Location (2020), to provide only dry season beneficial reuse.

Phase 2 = Approximate Seasonal Average Day Irrigation Demand, and within Projected Average Base Flow at Facility Location (2050), to provide only dry season beneficial reuse.

(2) Basis of design capacity for "year-round use" satellite reclaimed water facility (Alternative 1):

Phase 1 = 2020 Maximum Month Flow at plant location. Peak flows are equalized by planned 0.75 MG storage facility at Black Diamond.

Phase 2 = 2050 Maximum Month Flow at plant location. Peak flows are equalized by planned 0.75 MG storage facility at Black Diamond.

(3) Basis of design capacity for "year-round use" satellite reclaimed water facility (Alternative 2):

Phase 1 = Sized to provide reclaimed water for identified irrigation use and environmental enhancement, in an amount estimated to mitigate 50% of total net water extractions from the Soos Creek Basin (see Section 6 of the Phase 1 Report for details). Peak flows in excess of reclaimed water system design capacity are diverted to existing downstream conveyance system.

Phase 2 = Sized to provide reclaimed water for identified irrigation use and environmental enhancement, in an amount estimated to mitigate 100% of total net water extractions from the Soos Creek Basin (see Section 6 of the Phase 1 Report for details). Peak flows in excess of reclaimed water system design capacity are diverted to existing downstream conveyance system.

2.2 Summary of Cost Estimates for Alternatives

Tables 2-2 and 2-3 summarize the estimated capital and annual operations and maintenance costs for each alternative. Details regarding the development of the reclaimed water demand projections and cost estimates are provided in the Phase 1 Report. These tables summarize the most pertinent information that has been incorporated into the BCA model.

Table 2-2. Summary of Capital Costs for Alternatives

	Alternative 1 Black Diamond			Alternative 2 County Pump Station D Site		
	Phase 1	Phase 2	Total	Phase 1	Phase 2	Total
Seasonal Use Option (Irrigation Use Only)	**Alt. 1-A (0.5 mgd)**	**Alt. 1-A (1.2 mgd)**		**Alt. 2-A (2.0 mgd)**	**Alt. 2-A (2.5 mgd)**	
Construction Cost [From Feasibility Study] (1)	$21,274,000	$12,317,000	$33,591,000	$46,996,000	$15,604,000	$62,600,000
ENR Adjustment [November 2008 to June 2009] (2)	$21,214,000	$12,282,000	$33,496,000	$ 46,864,000	$15,560,000	$62,424,000
Subtotal	$21,214,000	$12,282,000	$33,496,000	$46,864,000	$15,560,000	$62,424,000
Construction Contingency [@ 10%] (3)	$ 2,121,000	$1,228,000	$3,350,000	$ 4,686,000	$1,556,000	$ 6,242,000
Subtotal	$23,395,000	$13,545,000	$36,941,000	$51,682,000	$17,160,000	$68,842,000
Sales Tax [@8.9%]	$2,082,000	$1,206,000	$3,288,000	$4,600,000	$1,527,000	$6,127,000
Subtotal Construction Cost	$25,477,000	$14,751,000	$40,229,000	$56,282,000	$18,687,000	$74,969,000
Allied Costs (Engineering, Permitting, Legal, Admin.) [@ 53%](4)	$ 12,399,000	$7,179,000	$19,579,000	$27,391,000	$9,095,000	$36,486,000
Project Contingency [@ 30%] (3)	$ 7,019,000	$4,064,000	$11,082,000	$15,505,000	$5,148,000	$20,653,000
Total Project Cost	**$45,000,000**	**$26,000,000**	**$71,000,000**	**$99,000,000**	**$33,000,000**	**$132,000,000**
Year-Round Use Option (Irrigation and Environmental Uses)	**Alt. 1-B (2.45 mgd)**	**Alt. 1-B (3.2 mgd)**		**Alt. 2-B (4.9 mgd)**	**Alt. 2-B (8.3 mgd)**	
Construction Cost [From Feasibility Study] (1)	$47,450,000	$14,455,000	$61,905,000	$ 87,412,000	$34,145,000	$121,557,000
ENR Adjustment [November 2008 to June 2009] (2)	$47,317,000	$14,414,000	$61,731,000	$ 87,166,000	$34,049,000	$121,215,000
Inclusion of Infiltration Facility Costs (5)	$3,915,000	$ 979,000	$4,894,000	$ 6,025,000	$1,506,000	$7,531,000
Subtotal	$ 51,232,000	$15,393,000	$66,625,000	$93,191,000	$35,555,000	$128,746,000
Construction Contingency [@ 10%] (3)	$ 5,123,000	$ 1,539,000	$6,663,000	$9,319,000	$3,556,000	$12,875,000
Subtotal	$56,355,000	$16,932,000	$73,288,000	$102,510,000	$39,111,000	$141,621,000
Sales Tax [@8.9%]	$5,016,000	$1,507,000	$6,523,000	$9,123,000	$3,481,000	$12,604,000
Subtotal Construction Cost	$61,371,000	$18,439,000	$79,811,000	$111,633,000	$42,592,000	$154,225,000
Allied Costs (Engineering, Permitting, Legal, Admin.) [@ 53%](4)	$ 29,868,000	$8,974,000	$38,843,000	$54,330,000	$20,729,000	$75,059,000
Project Contingency [@ 30%] (3)	$16,907,000	$5,080,000	$21,986,000	$30,753,000	$11,733,000	$42,486,000
Total Project Cost	**$108,000,000**	**$32,000,000**	**$141,000,000**	**$197,000,000**	**$75,000,000**	**$272,000,000**

Notes:

(1) Total construction costs presented in the Phase 1 Report (December 30, 2008). Includes costs of reclaimed water production, pumping, and distribution facilities. Costs are in November 2008 dollars.

(2) ENR adjustment of costs to present them in June 2009 dollars.

(3) Construction and project contingencies are based upon typical King County assumptions applied to project cost estimates at this stage of planning.

(4) Allied costs include engineering design, administration, construction management, and utility-incurred staffing and resource costs related to project implementation. Assumed level of cost is based upon typical King County allied costs observed in other recent projects.

(5) Additional costs related to construction of groundwater infiltration facilities, not originally included in the Phase 1 Report. Based upon cost estimates presented in the County's *Black Diamond Wastewater Infrastructure Feasibility Study (December 14, 2007)*, Table 13-7. Assumes the high end of the cost estimate range, predicated on land costs of $55,000 per acre. Assumes use of the northwest outwash deposits (20-30 acres for a 3.2 mgd facility at Black Diamond). A similar site is assumed to be within the same distance of the Pump Station D site. Costs include development of the infiltration basins and construction of a pipeline to convey reclaimed water from the production site to the basins.

Table 2-3. Summary of Annual Operations and Maintenance Costs for Alternatives

	Alternative 1 Black Diamond		Alternative 2 County Pump Station D Site	
	Phase 1	Phase 2	Phase 1	Phase 2
Seasonal Use Option (Irrigation Use Only)	**Alt. 1-A (0.5 mgd)**	**Alt. 1-A (1.2 mgd)**	**Alt. 2-A (2.0 mgd)**	**Alt. 2-A (2.5 mgd)**
Annual O&M Cost [From Feasibility Study] (1)	$267,000	$393,000	$594,000	$673,000
ENR Adjustment [November 2008 to June 2009] (2)	$266,000	$392,000	$592,000	$671,000
Total Annual O&M Cost	$266,000	$392,000	$592,000	$671,000
Year-Round Use Option (Irrigation and Environmental Uses)	**Alt. 1-B (2.45 mgd)**	**Alt. 1-B (3.2 mgd)**	**Alt. 2-B (4.9 mgd)**	**Alt. 2-B (8.3 mgd)**
Annual O&M Cost [From Feasibility Study] (1)	$1,209,000	$1,521,000	$2,142,000	$3,141,000
ENR Adjustment [November 2008 to June 2009] (2)	$1,206,000	$1,517,000	$2,136,000	$3,132,000
Inclusion of Infiltration Facility O&M Costs (3)	$25,000	$25,000	$25,000	$25,000
Total Annual O&M Cost	$1,231,000	$1,542,000	$2,161,000	$3,157,000

Notes:
(1) Total O&M costs presented in the Phase 1 Report (December 30, 2008).
(2) ENR adjustment of costs to present them in June 2009 dollars.
(3) Addition of O&M costs related to the groundwater infiltration facilities.

2.3 Definition of the Baseline

As described in the WateReuse Foundation Economic Framework, the definition of the baseline in an economic analysis is critical because it establishes both the "accounting stance" for the analysis and the problem-solving context within which the analysis is being conducted. For the purposes of this BCA, the baseline has been defined from three perspectives: water supply, wastewater management, and environmental conditions. The baseline represents the projected state of each of these perspectives if no reclaimed water project were to be implemented (i.e., a "status quo" or "do nothing" alternative relative to the reclaimed water alternatives described above). Then, the impacts of envisioned reclaimed water alternatives upon the baseline can be determined. The baseline definition for each perspective, and the associated impact of a reclaimed water program upon the baseline, is provided below.

2.3.1 Water Supply Baseline

Often an intended benefit of reclaimed water projects is the avoidance or deferral of development of new/additional water supplies. In this case, while the District (the primary supplier of potable water in the study area) would utilize reclaimed water to replace a portion of its future potable water demand, there are no water supply projects or major water system investments that would be avoided or deferred if a reclaimed water program were implemented. The District has secured ample water supply to meet its needs well into the future. This includes the use of its own supplies (groundwater wells), purchases from the City of Tacoma, and future supplies that will be made available by the District's participation in the Cascade Water Alliance. The magnitude and timing of water system investments planned to support this supply portfolio are primarily a function of regional water supply planning initiatives and will not be significantly influenced by any reductions in potable water demand the District might realize from the use of reclaimed water.

Therefore, the benefits to the District of reclaimed water program implementation are likely minimal, and are associated primarily with additional revenues gained from distribution of reclaimed water to new, currently self-supplied customers. This is discussed further in Section 5.

2.3.2 Wastewater Management Baseline

Similar to water supply, intended benefits of a reclaimed water program relative to wastewater management include the avoidance or deferral of capacity-related capital improvements. In this case, the baseline conditions include a variety of wastewater conveyance and treatment plant improvement projects planned for implementation by King County. Specific planned projects that would be impacted (i.e., reduced in capacity and/or delayed in timing) by the reclaimed water alternatives described earlier include the following.

- **Black Diamond Area Conveyance Improvements**. As described in detail in the County's *Black Diamond Wastewater Infrastructure Feasibility Study (December 14, 2007)*, the existing Black Diamond Force Main is hydraulically limited to 1.7 mgd. As wastewater flows increase in the southern portion of the Soos Creek Basin, this capacity is anticipated to be exceeded in the near future. The County plans to implement a series of improvements to address this capacity deficiency. Those improvements include construction of Pump Station H and associated downstream conveyance capacity. With implementation of Alternative 1-B (a year-round reclaimed water facility located at Black Diamond), these conveyance capacity improvements can be avoided. The other alternatives do not impart such a benefit. Alternative 1-A involves only summer use and does not therefore address peak, wet season flows. Alternatives 2-A and 2-B capture wastewater flows lower in the basin and thus do not provide the benefit of reduced wastewater flows higher in the basin.
- **Pump Station D Project**. The County's Pump Station D project, which provides for increased wastewater conveyance capacity lower in the Soos Creek Basin, could be reduced in size if a year-round reclaimed water project were implemented at or upstream of the Pump Station D site. Therefore, Alternatives 1-B and 2-B would both impart a benefit relative to this project, since both alternatives reduce wastewater flows year-round, including peak flow events, for which the Pump Station D conveyance improvements are sized. Under Alternative 1-B, the Pump Station D capacity can be reduced from 29 to 26 mgd. Under Alternative 2-B, the capacity can be reduced from 29 to 21 mgd.
- **South Treatment Plant Capacity**. Similar to the above impacts upon the Pump Station D project, year-round reclaimed water projects implemented in the Soos Creek Basin would have the effect of reducing the planned capacity increases at the County's South Treatment Plant, where all sewer flows from the basin are now treated. Currently, the County plans on increasing treatment plant capacity from 126 mgd to 145 mgd by 2029. Under Alternative 1-B, the upgraded treatment capacity could be reduced to 142 mgd, and the project could be delayed for one year (to 2030). Under Alternative 2-B, the upgraded treatment capacity could be reduced to 136 mgd, and the project could be delayed for four years (to 2033).

The translation into quantifiable benefits of these positive impacts relative to the baseline is discussed in detail in Section 5.

2.3.3 Environmental Conditions Baseline

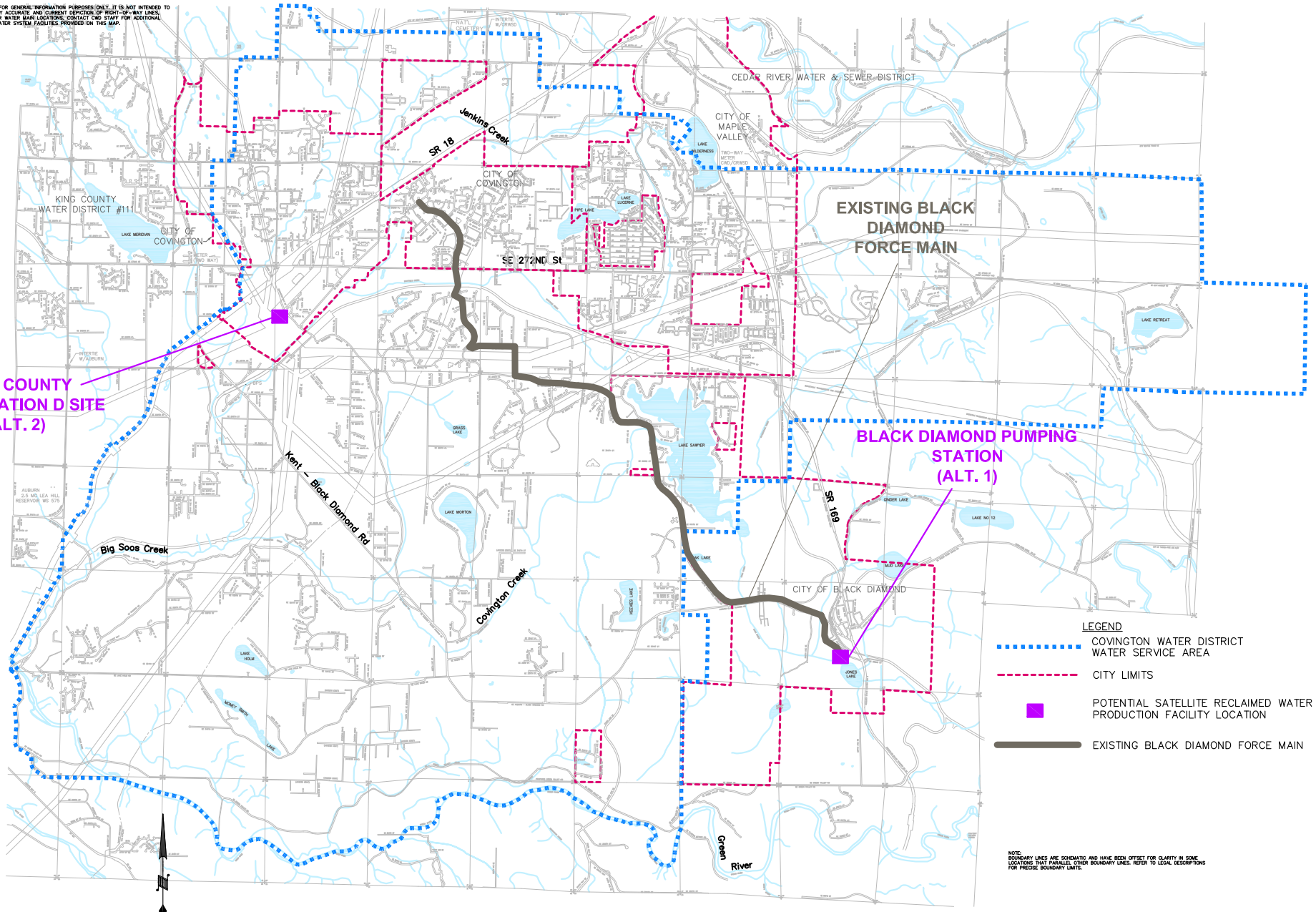
Reclaimed water projects also often impart benefits to the local area environment. In this case, a primary way in which this is envisioned to occur is through the retention of wastewater flows in the Soos Creek Basin, as opposed to continued conveyance out of the basin. By converting such flows into reclaimed water beneficially reused to offset potable water needs and to provide environmental enhancements (such as increased stream base flows through groundwater infiltration), the basin's water resources will be benefited.

There are many ways by which to characterize and measure environmental conditions. For this analysis, stream flows in Soos Creek, as gaged at the mouth of the waterbody, have been selected as the primary metric against which impacts of reclaimed water programs are to be evaluated. As described in detail in the Phase 1 Report, a "water balance" tool has been constructed that projects baseline stream flow conditions, as well as modified conditions under the influence of the range of considered reclaimed water projects. The impact to stream flow is characterized as "net water extraction", or the net amount of water withdrawn from the basin (in cfs), after considering all inflows and outflows to the basin. Details regarding how the water balance tool was constructed are provided in the Phase 1 Report.

Figure 2-4 displays a summary of the projected baseline conditions of net water extractions, along with the estimated impacts of implementation of the reclaimed water alternatives. The alternatives impart a range of positive impact upon the basin's net water extraction (i.e., a reduction in extraction), as a function of the amount of reclaimed water beneficially reused within the basin.

While it is clear that implementation of a reclaimed water program in the Soos Creek Basin positively impacts instream flows, a key question is to what extent do these increased flows address or remedy specific adverse environmental conditions in the basin. This is discussed in detail in Section 5, but in brief it has been determined that while impaired conditions exist in the streams in this basin (including degraded water quality and fisheries habitat), it is impossible to quantifiably determine the impact increased flows would have on specific conditions, given the level of data and analyses available. Therefore, as presented in Section 5, the only stream flow-related benefit that is considered quantitatively in the BCA is a general economic benefit that is imparted by increased flows.

THIS MAP IS DESIGNED FOR GENERAL INFORMATION PURPOSES ONLY. IT IS NOT INTENDED TO PROVIDE AN ABSOLUTELY ACCURATE AND CURRENT DEPICTION OF RIGHT-OF-WAY LINES, STREAMS, WETLANDS, OR WATER MAIN LOCATIONS. CONTACT CWD STAFF FOR ADDITIONAL VERIFICATION OF THE WATER SYSTEM FACILITIES PROVIDED ON THIS MAP.



0 3500 7000 14000

SCALE IN FEET

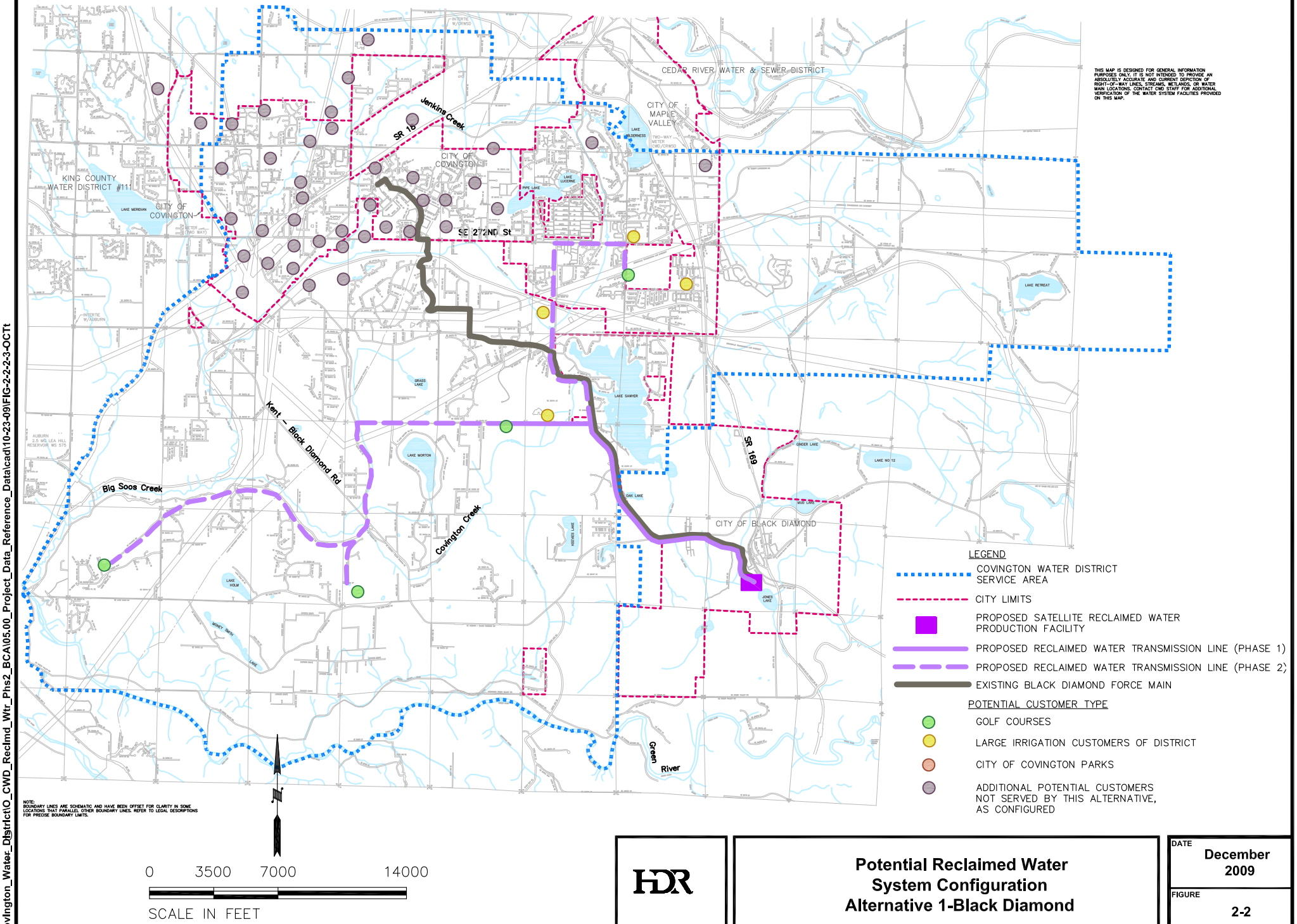
HDR

Potential Reclaimed Water Production Facility Locations

DATE
December 2009

FIGURE
2-1

Covington_Water_District\O_CWD_Reclmd_Wtr_Phs2_BCA\05.00_Project_Data_Reference_Data\cad\10-23-09\FIG-2-1-oct



THIS MAP IS DESIGNED FOR GENERAL INFORMATION PURPOSES ONLY. IT IS NOT INTENDED TO PROVIDE AN ABSOLUTELY ACCURATE AND CURRENT DEPICTION OF RIGHT-OF-WAY LINES, STREAMS, WETLANDS, OR WATER MAIN LOCATIONS. CONTACT CWD STAFF FOR ADDITIONAL VERIFICATION OF THE WATER SYSTEM FACILITIES PROVIDED ON THIS MAP.

NOTE:
BOUNDARY LINES ARE SCHEMATIC AND HAVE BEEN OFFSET FOR CLARITY IN SOME LOCATIONS THAT PARALLEL OTHER BOUNDARY LINES. REFER TO LEGAL DESCRIPTIONS FOR PRECISE BOUNDARY LIMITS.

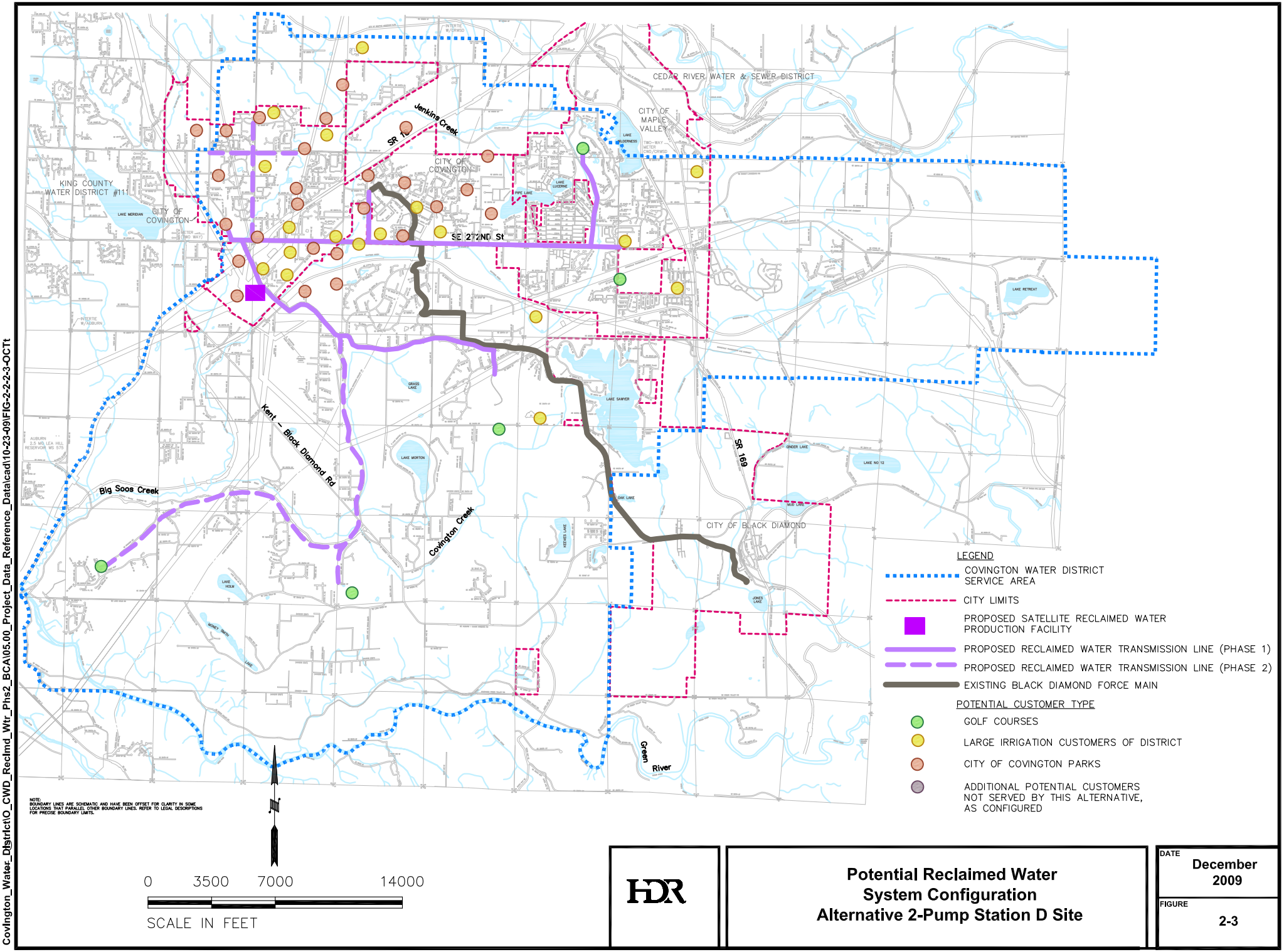
HDR

Potential Reclaimed Water System Configuration Alternative 1-Black Diamond

DATE
December 2009

FIGURE
2-2

Covington_Water_District\O_CWD_Reclmd_Wtr_Phs2_BCA\05.00_Project_Data_Reference_Data\cad\10-23-09\FIG-2-2-2-3-OCTt



HDR

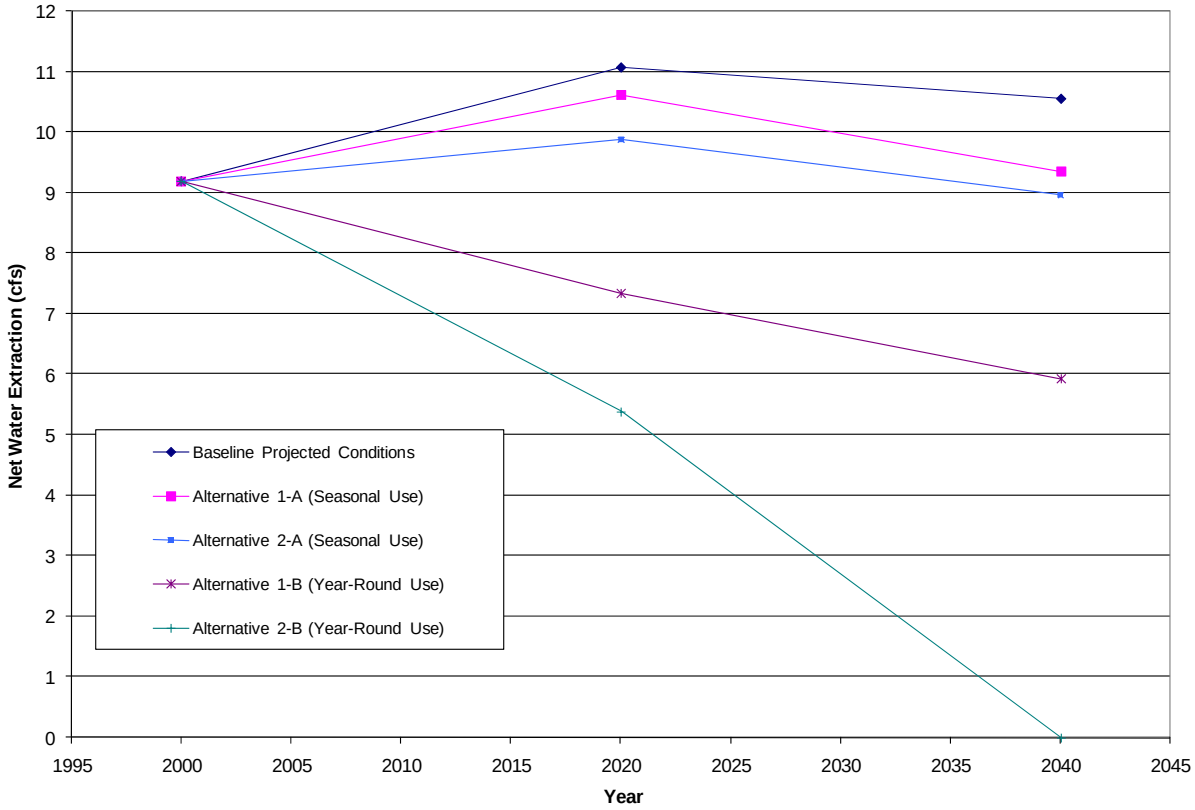
Potential Reclaimed Water System Configuration Alternative 2-Pump Station D Site

DATE: December 2009

FIGURE: 2-3

Covington_Water_District\O_CWD_Reclmd_Wtr_Phs2_BCA\05.00_Project_Data_Reference_Data\cad\10-23-09\FIG-2-2-2-3-OCTt

Figure 2-4. Environmental Baseline Conditions and Impacts of Reclaimed Water Alternatives



Section 3.0 Benefit Cost Analysis Methodology

3.1 Approach to Benefit Cost Analysis

The purpose of this benefit cost analysis is to better understand the benefits and costs of implementing a reclaimed water program in the District's service area within a broad economic analysis framework. Performing a BCA study involves weighing the benefits against the costs (capital investment, operations, and maintenance), with respect to the associated timeframes in which the costs and benefits are incurred. The benefits and costs are then summed in their present values to determine if the subject under study generates benefits in excess of the costs in today's dollars. Often the costs are much more concrete and defined than the benefits in the sense that they can be more readily anticipated and evaluated from a monetary standpoint. The benefits tend to be much more far reaching and involve many other elements, but also include evaluation of intangible benefits or benefits to which there may not be a market value attached (e.g., aesthetics).

This study uses the guidelines for benefit cost analysis of reclaimed water projects established in the WateReuse Foundation Economic Framework. This methodology established a comprehensive accounting framework for the full range of costs, benefits, and who might bear them. This approach has been expanded upon within the context of this study to account for comparison amongst multiple project alternatives while also incorporating a comprehensive risk and uncertainty analysis.

The benefits evaluated in this study fall into two functional categories. These categories are direct benefits that are realized by a utility or associated customers, and indirect benefits incurred by society in the impacted region. Indirect benefits include environmental benefits, recreational benefits, and economic and social benefits. Each of these benefits has been identified on the basis of providing an impact as a result of the usage of reclaimed water ranging across efficiency and productivity gains, increased values of ecosystem goods and services, reduced uncertainty and risk associated with water supplies, improvements in perceived fairness, economic growth in the region, and potential financial benefits in the present and future.

Some benefits are well defined and easily quantifiable, whereas others may have insufficient data to quantify them. For that reason the analysis is conducted in two parts, (1) a comprehensive analysis of all project costs and those benefits that are quantifiable and for which dollar values may be assigned; and (2) a qualitative benefit assessment of other potential benefits. The approaches for each analysis are described in the following sections.

3.2 Quantitative Analysis

The quantitative analysis includes the development of baseline values for project costs and benefits (in "real" or non-inflated terms) which in turn are converted to present value. The present value benefits and costs are then used to calculate a "net benefits" metric (i.e., benefits less costs) to compare each of the four alternatives. A second metric, referred to as a benefits-to-costs ratio (B/C ratio), has also been evaluated. However, the focus of this report is upon the net benefits metric, as it is more suitable and informative in the context of this type of public policy

investment analysis, where the objective is to maximize benefits rather than striving to achieve a situation where benefits necessarily outweigh costs.

The calculation of benefits that may be incurred in future years is complex in some cases, as it often involves multiple variables, some of which are anticipated to vary seasonally and over time (e.g., reclaimed water usage and streamflow enhancements). Details regarding the calculation algorithms are provided in Section 5.

3.2.1 Key Model Assumptions

To ensure an apples-to-apples comparison of alternatives, the analysis relies on some key assumptions that are consistent across the alternatives.

First, all four alternatives are evaluated with a 30-year project life beginning in 2018 and ending in 2047. Any benefits and costs occurring during this time period are evaluated during the years in which they occur. For example, each alternative is assumed to have two construction phases: Phase 1 occurs in the years 2018 and 2019, with Phase 2 occurring in 2034 and 2035.

The second key assumption is the usage of present value to discount future year real benefits and costs. The discount rate used in the present value calculation is 4.50%, which is the federally approved discount rate for 2009 from the U.S. Army Corps of Engineers for water supply projects[7]. The usage of present value takes into account the altruistic nature of society's perception towards the future and the time value of money for future years.

3.2.2 Risk and Uncertainty Analysis

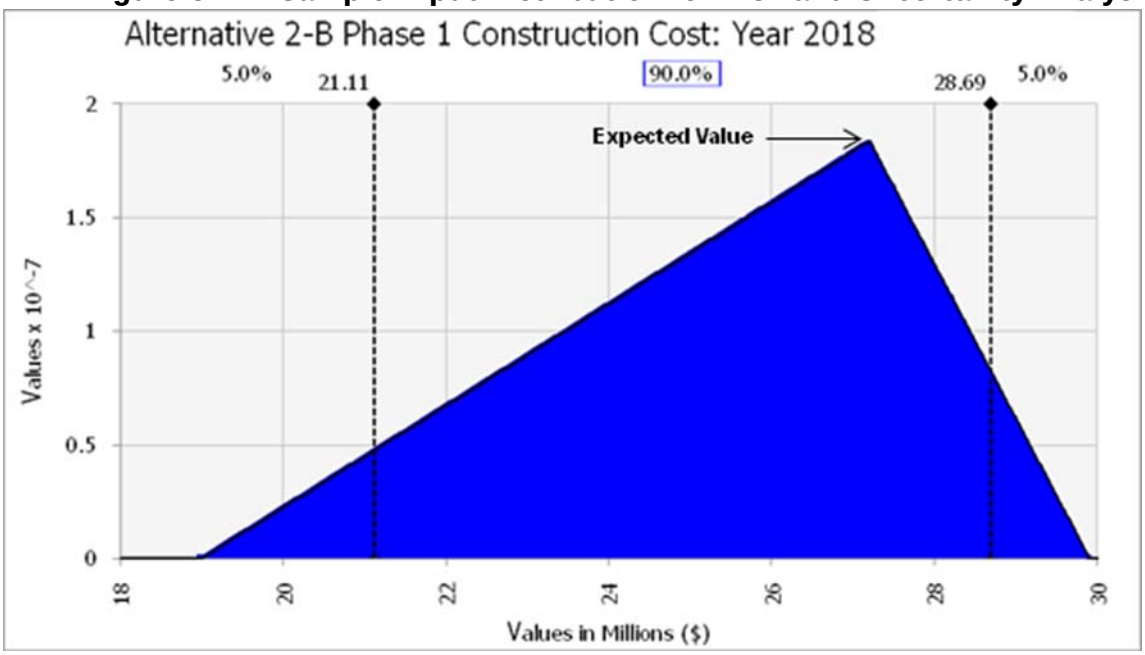
The cost benefit analysis discussed above presents the best estimate of the future. For example, costs are estimated using best available information about what costs would be incurred to construct the alternatives. For the benefits, the analysis has considered the best available information to describe what future values of benefits may be. That said, the future cannot be known and these values can be influenced by many factors including: political, economic, environmental, and social factors which change the ultimate values of these benefits. Because of this the BCA incorporates a comprehensive assessment of risk and uncertainty of these benefits and costs using software called @Risk, from Palisade Corporation.

The risk and uncertainty analysis uses a technique called Monte Carlo simulation to test the sensitivity of the calculated net benefits to changes in their inputs. In this approach, the values of inputs for the cost and benefits are treated as the expected values against high and low value ranges. These values are then linked to distributions which represent the likelihood of a value from that input occurring during the simulation. An example of one of the distributions is shown below in Figure 3.1. The sample demonstrates the distribution for one input variable,

[7]U.S. Army Corps of Engineers. "Economic Guidance Memorandum, 09-01: Federal Interest Rates for Corps of Engineers Projects for Fiscal Year 2009".
http://www.usace.army.mil/CECW/PlanningCOP/Documents/egms/egm09_01.pdf
The discount rate used in this analysis (4.50%) is the water supply interest rate (4.625%) less that portion associated with transaction costs (0.125%).

construction cost in year 2018 for Alternative 2-B. As shown, the expected value, which was used in the benefit cost analysis, is $27.2 million and occurs at the peak of the curve. The variable was determined to have a high end of $29.9 million but could be as low as $19 million. Based upon this range definition, 90% of the values used in the risk and uncertainty analysis could statistically occur between $28.7 million and $21.1 million.

Figure 3-1. Sample Input Distribution for Risk and Uncertainty Analysis



Once the model inputs are assembled with these distribution functions, thousands of iterations of the various combinations of inputs are created which returns a distribution of the net benefits.

This approach provides useful information supplemental to the benefit cost analysis, including: determination of the likelihood of a given net benefits value, identification of the ranges of benefits and/or costs, and identification of which factors most influence the outcome of a net benefits value.

3.3 Qualitative Benefit Assessment

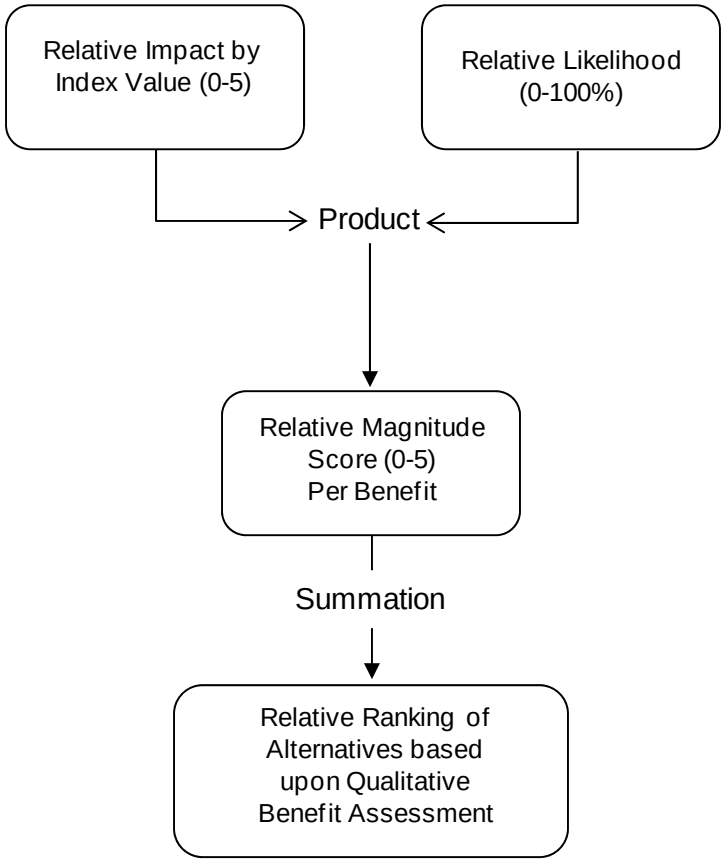
The qualitative-analyzed benefits were assessed in a workshop setting. The logic model which was used to guide this process is shown below in Figure 3-2. The workshop process elicits stakeholder input on the potential impact and likelihood of those benefits which are then combined to score and rank the alternatives. In the workshop, benefits were scored according to their potential impact using a scale of 0 to 5 where a value of:

- 0 indicates no impact,
- 1 indicates very little impact,
- 2 indicate little impact,
- 3 for moderate impacts,
- 4 are large impacts, and
- 5 are very large impacts.

The benefits were then assigned a likelihood that they would occur ranging between 0 and 100%.

Next, the impacts are combined with the likelihood to determine the magnitude of the impact for each alternative. This calculation allows for the relative comparison of each alternative within the context of the individual benefits. Using the ranges for the impact and likelihood, the maximum score an alternative can receive for a given benefit is 5 and the lowest is 0. The magnitudes of the impacts for the qualitatively assessed benefits were then summed yielding a ranking for qualitative benefits for each alternative.

Figure 3-2. Qualitative Benefit Assessment Logic Model



Section 4.0 Cost Inputs to Model

The estimated costs of developing and operating the reclaimed water system alternatives described in Section 2.1 were previously defined in the Phase 1 Report, and are summarized in Section 2.2 of this document. For the purpose of inclusion in the BCA, the costs for each alternative have been allocated to specific years of projected implementation. In addition, to support the uncertainty analysis performed in the BCA, a range of values has been established for each cost component. Table 4-1 summarizes the cost-side BCA model inputs. The range of values is based upon the following assumptions:

- The "Best Estimate" equals the full estimated cost, as presented in Tables 2-2 and 2-3.
- The "Low Estimate" equals 70% of the estimated cost. This is based on a 30% project contingency having been included in the full cost estimate.
- The "High Estimate" equals 110% of the estimated cost. This assumes the cost estimates may be slightly underestimated.

All costs presented in Table 4-1 are in 2009 dollars.

Table 4-1. Summary of Capital and O&M Cost Inputs to BCA Model

Year	Stage	Key Assumptions	Alt 1-A			Alt 1-B			Alt 2-A			Alt 2-B		
			Best Estimate	Low	High	Best Estimate	Low	High	Best Estimate	Low	High	Best Estimate	Low	High
Capital Costs														
Phase 1														
2018	Design	50% of Allied Costs	$6,200,000	$4,300,000	$6,800,000	$14,900,000	$10,400,000	$16,400,000	$13,700,000	$9,600,000	$15,100,000	$27,200,000	$19,000,000	$29,900,000
2019	Const	50% of Remaining Project Costs	$19,400,000	$13,600,000	$21,300,000	$46,600,000	$32,600,000	$51,300,000	$42,700,000	$29,900,000	$47,000,000	$84,900,000	$59,400,000	$93,400,000
2020	Const	50% of Remaining Project Costs	$19,400,000	$13,600,000	$21,300,000	$46,600,000	$32,600,000	$51,300,000	$42,700,000	$29,900,000	$47,000,000	$84,900,000	$59,400,000	$93,400,000
Phase 2														
2033	Design	50% of Allied Costs	$3,600,000	$2,500,000	$4,000,000	$4,500,000	$3,200,000	$5,000,000	$4,500,000	$3,200,000	$5,000,000	$10,400,000	$7,300,000	$11,400,000
2034	Const	50% of Remaining Project Costs	$11,200,000	$7,800,000	$12,300,000	$13,800,000	$9,700,000	$15,200,000	$14,300,000	$10,000,000	$15,700,000	$32,300,000	$22,600,000	$35,500,000
2035	Const	50% of Remaining Project Costs	$11,200,000	$7,800,000	$12,300,000	$13,800,000	$9,700,000	$15,200,000	$14,300,000	$10,000,000	$15,700,000	$32,300,000	$22,600,000	$35,500,000
Annual O&M Costs														
Phase 1														
2021-2035		Annual cost (recurring)	$266,000	$186,000	$293,000	$ 1,231,000	$862,000	$1,354,000	$592,000	$414,000	$651,000	$2,161,000	$1,513,000	$2,377,000
Phase 2														
2036-2050		Annual cost (recurring)	$392,000	$274,000	$431,000	$ 1,542,000	$1,079,000	$1,696,000	$671,000	$470,000	$738,000	$3,157,000	$2,210,000	$3,473,000

Section 5.0 Benefit Inputs to Model

5.1 Summary of Benefits Considered

Several types of potential benefits were considered during the construction of the BCA model. The process of benefit identification began with a review of potential benefits prepared by the County, under a separate effort being conducted in conjunction with the King County Reclaimed Water Comprehensive Planning process. In the King County document titled *Identification of Potential Economic Benefits of Production and Use of Reclaimed Water (Draft, September 2009)*, a sizeable list of benefits is presented, identified and organized according to the WateReuse Foundation Economic Framework. These benefits are ones that have been identified as potentially applicable to reclaimed water projects in King County. Appendix A contains this comprehensive list of benefits (referred to hereafter as the "initial list"). This list includes benefits for which information may be available with which to quantitatively assess the benefits, as well as benefits which may be important to consider but for which there is inadequate information with which to conduct a quantitative assessment.

Using this initial list as a starting point, specific benefits were identified as being applicable for consideration in the context of this particular analysis. Additional benefits not on the initial list were also developed, to capture issues unique to this study. The resulting list of benefits considered in this BCA is summarized in Table 5-1, organized according to anticipated beneficiary.

Compared to the initial list, this revised list (particularly with respect to quantitatively assessed benefits) is significantly shorter. This is primarily a result of certain benefits being removed from the initial list during a series of County/District workshops. For the most part, such deletions were based on certain benefits being deemed not applicable to this particular analysis or study area, or as having such minimal impact (due to the limited scale of the study area) as to not warrant inclusion.

In addition, some benefits categorized in the initial list as quantitatively-assessed have been re-categorized as qualitatively-assessed. This is generally predicated on a lack of sufficient information being available with which to calculate a monetized benefit.

Table 5-1. Benefits Summary (Organized by Anticipated Beneficiary)

ID	Description
Quantitatively-Assessed Benefits	
Wastewater Utility (King County) Benefits	
WW-1	Avoided wastewater conveyance capital costs (Pump Station H and related conveyance)
WW-2	Avoided wastewater conveyance capital costs (Pump Station D and related conveyance)
WW-3	Avoided wastewater treatment capital costs related to capacity increases (South Plant)
WW-4	Reclaimed water revenues (King County)
Water Utility (Covington Water District) Benefits	
WU-1	Reclaimed water revenues (Covington Water District)
Self-Supplied Water User (Reclaimed Water End User) Benefits	
SS-1	Avoided groundwater pumping costs
General Public Benefits	
Environmental	
GP-1	Increased instream flows
GP-2	Savings in fertilizer usage
GP-3	Reduced greenhouse gas emissions
Recreational	
GP-4	Increased in-stream recreation (fishing)
GP-5	Increased near-stream recreation (wildlife viewing)
Qualitatively-Assessed Benefits	
Wastewater Utility (King County) Benefits	
WW-10	Increased flexibility in management of treated wastewater
WW-11	Avoided wastewater treatment capital costs related to nutrient removal (South Plant)
Water Utility (Covington Water District) Benefits	
WU-10	Protection of water source areas
Self-Supplied Water User (Reclaimed Water End User) Benefits	
SS-10	Increased water supply reliability
SS-11	Reduced risk of enforcement/litigation costs associated with water rights
General Public Benefits	
Environmental	
GP-10	Enhanced coastal ecosystems
GP-11	Improvements in in-stream water quality
GP-12	Reductions in risk associated with climate change
Societal	
GP-13	Increased economic growth
GP-14	Improved management of water resources
GP-15	Reinforced cultural/spiritual values
GP-16	Reinforced cultural values associated with a conservation ethic
GP-17	Enhanced aesthetic values
GP-18	Reductions in risk associated with population and economic growth
GP-19	Increased public education

It is important to note that the approach taken to evaluating benefits in this particular study (primarily with regard to distinguishing between those benefits that could be quantitatively analyzed versus those that could be qualitatively assessed) is specific to this analysis. A similar evaluation in another portion of King County will likely utilize different assumptions and approaches, due to differences in the nature of the study area relative to that in this study. For example, if a given study area is larger than that considered here (i.e., the District's service area), the quantitative analysis of more benefits may be warranted, due to larger impacts of benefits resulting from a larger scale study area. Furthermore, if more data exists that can be used to

monetize environmental benefits, then additional benefits may warrant quantitative analysis than are considered in this analysis.

The assumptions regarding how certain benefits were treated in this analysis is summarized below, depicted as key differences between the list of benefits included in this BCA model, compared to the initial list starting point.

Wastewater Utility Benefits

- Benefits WW-1 through WW-3 represent potential benefits to the wastewater utility, in the form of avoided capital costs. In the initial benefits list, these three items were rolled into one benefit (3.D.1). For transparency in the BCA calculation, these benefits have been broken out into three distinct items, to clearly capture significant benefits unique to this particular study.

- Benefit WW-11 is an addition to the list, and represents avoided capital costs related to potential future nutrient removal requirements at the South Treatment Plant. Through the workshop discussions, it was determined that this benefit could be significant and warrants mention, but that there is insufficient data currently available with which to quantify or monetize the benefit.

Water Utility Benefits

- Many of the water utility benefits present in the initial list were determined during the course of this work to be not applicable to the current analysis, primarily because implementation of a reclaimed water program in the District's service area would not alter or defer the District's present course of action relative to its exercise of its water supply portfolio during this time period.

Self-Supplied Water User Benefits

- Some water-side benefits (e.g., avoided groundwater pumping costs and increased water supply reliability) were determined to be applicable only to those water users that are currently self-supplied. As such, a distinct grouping of such benefits has been developed.

General Public Benefits

- Many of the general public benefits (i.e., environmental, societal, etc.) presented in the initial list were removed during this analysis. Similar to other benefits that were removed, this was due to them being either not applicable or of marginal impact due to the small scale of the study area.
- Some specific benefits were removed only after additional analysis was conducted to determine their relevancy. Key examples include:
    - Wetlands restoration. This benefit was removed since the alternatives being considered in this analysis do not involve beneficial reuse in the form of wetland restoration. Furthermore, review of the County's study *Identification of Wetlands*

Likely to Benefit from Additional Water Inputs (July 2009) indicates that there are few to no wetlands in the study area that would benefit from additional water.

- Reduced risks to threatened/endangered species other than salmon. A review by County staff of threatened/endangered species presence in the Covington area indicated that while there are some species whose presence is possible (e.g., Bald Eagle, Red-Tailed Hawk), in most instances the extent of that presence is unknown or undocumented. Furthermore, the likely impact of increased water flows upon species survival is difficult to characterize and is likely minimal in any event.
- Reduced risks to threatened/endangered species – Pacific Salmon. A review was conducted of available data regarding salmon presence in Covington and Soos Creeks, and an attempt to relate increases in instream flows to increased salmon production and species survival was made. The findings of this analysis are as follows:
    - This area provides spawning and year-round rearing habitat for Coho and Steelhead, and spawning habitat for Fall Chinook. Of these, Steelhead and Fall Chinook are listed as threatened species.
    - The amount of habitat utilized year-round by Steelhead in the study area is approximately 12 river miles (3 miles on Soos Creek and 9 miles on Covington Creek). Compared to the total habitat area utilized by Puget Sound Steelhead (thousands of river miles), the extent of area impacted by increased flows resulting from these reclaimed water alternatives is very minimal.
    - There have been no studies in the Soos Creek Basin that directly relate instream flows to available habitat and fish productivity. This, coupled with the small fraction of total Puget Sound Steelhead habitat represented by the study area, renders this benefit (which is characterized in the initial benefit list as the ability of a given project to increase total species population by 50%) unquantifiable. Even if it could be quantified with greater confidence, the impact would be negligible, relative to the entire Puget Sound Steelhead population.
    - Fall Chinook are not present in the study area during times of critical low-flow conditions. In addition, similar to Steelhead, the Soos Creek Basin represents a very small fraction of the total Puget Sound Fall Chinook habitat. Thus, this benefit does not warrant quantification relative to Fall Chinook.
    - Additional analysis was conducted to determine if any salmon production-related benefits could be realized by the Washington Department of Fish and Wildlife's (WDFW) Soos Creek Hatchery. Based upon discussions with hatchery managers, flow conditions in Soos Creek do not appear to be a limiting factor in the hatchery's operations. WDFW holds multiple water rights, some of which are associated with springs and not streamflow, which enable it to meet its water supply needs even when flows in Soos Creek decrease in late spring and summer.

- Increased commercial and recreational salmon harvest. As a result of the findings above regarding the limited benefits imparted to Puget Sound salmon with the increased flows provided to Covington and Soos Creeks, it was determined that it would be difficult to characterize with confidence the number of additional adult salmon that would be available for harvest in the basin. Regardless, the amount is anticipated to be minimal. Furthermore, another benefit remaining on the list (GP-4) captures the general increase in fishing-related recreation resulting from increased flows. Thus, an attempt to include a recreational salmon harvest benefit would likely constitute double-counting.

5.2 Quantitative Benefit Inputs

Additional information regarding the quantitatively-assessed benefits listed in Table 5-1 is provided in the narrative summaries below. Further details regarding the model calculations and input values for select benefits are provided in Appendix B.

In the benefit values depicted below, the "best estimate" is presented, followed by "low" and "high" values which are used to capture the uncertainty in the value. Unless otherwise noted, monetary values are expressed in July 2009 dollars (ENR CCI 8655).

Wastewater Utility Benefits

- WW-1: Avoided wastewater conveyance capital costs (Pump Station H).
  - *Description*. This benefit applies only to Alternative 1-B (a year-round satellite reclaimed water facility located in the Black Diamond area). It refers to the avoidance of needing to implement Project No. 25 of the County's Conveyance System Improvement (CSI) Program[8], which consists of construction of a wastewater pump station at Black Diamond and an associated trunk like. This avoidance occurs due to the reduction in wastewater flows being conveyed through the regional system as a result of the majority of flows generated in the southern portion of the Soos Creek Basin being captured, reclaimed, and beneficially reused in the upper portion of the study area.
  - *Value*.
    - *Best Estimate*. $48,010,000. This is the entire estimated cost of Project No. 25. The year in which this cost would have been expended is 2030.
    - *Low Estimate*. 70% of Best Estimate. This is predicated on a 30% contingency having been included in the original project cost estimate.
    - *High Estimate*. 120% of Best Estimate.
- WW-2: Avoided wastewater conveyance capital costs (Pump Station D).
  - *Description*. This benefit applies only to Alternatives 1-B and 2-B (the year-round satellite reclaimed water facility options). It refers to the reduction of costs

[8] King County Conveyance System Improvement Program Update, June 2007.

associated with Project No. 23 of the County's Conveyance System Improvement (CSI) Program, which consists of construction of a wastewater pump station at Black Diamond and an associated trunk like. While the reclaimed water options do not result in complete avoidance of implementation of this project, the reduced wastewater flows through the system will provide some cost savings.

- *Value*. For Alternative 1-B.
  - *Best Estimate*. $330,000. This alternative would result in approximately a 10% capacity reduction in Project No. 23. It is estimated that this would result in a 5% cost reduction of pertinent project components (i.e., pipeline materials and pump station equipment). This represents a small portion of the total project cost (approximately $42,500,000), since significant portions are associated with project elements that would not be impacted by capacity reductions (e.g., sitework related to the pipeline and pump station). This cost reduction would be realized in 2030.
  - *Low Estimate*. 70% of Best Estimate. This is predicated on a 30% contingency having been included in the original project cost estimate.
  - *High Estimate*. 120% of Best Estimate.
- *Value*. For Alternative 2-B.
  - *Best Estimate*. $940,000. This alternative would result in approximately a 28% capacity reduction in Project No. 23. It is estimated that this would result in a 14% cost reduction of pertinent project components (i.e., pipeline *materials* and pump station equipment). This represents a small portion of the total project cost (approximately $42,500,000), since significant portions are associated with project elements that would not be impacted by capacity reductions (e.g., sitework related to the pipeline and pump station). This cost reduction would be realized in 2030.
  - *Low Estimate*. 70% of Best Estimate. This is predicated on a 30% contingency having been included in the original project cost estimate.
  - *High Estimate*. 120% of Best Estimate.

- WW-3: Avoided wastewater treatment capital costs (South Plant).
  - *Description*. This benefit applies only to Alternatives 1-B and 2-B (the year-round satellite reclaimed water facility options). It refers to the reduction of costs associated with the County's planned capacity expansion of the South Treatment Plant[9]. In addition to reducing costs by a certain amount, the remaining capital costs would deferred by a matter of a few years.
  - *Value*. For Alternative 1-B.
    - *Best Estimate*. $4,375,000. This alternative would result in *approximately* a 16% capacity reduction in the South Treatment Plant Capacity upgrade project.

[9] As identified in the County's Regional Wastewater Services Plan, 1998.

Details regarding the cost estimate for the project were not readily available. However, it is unlikely that this amount of capacity reduction will have a significant bearing on cost savings. Therefore, it is estimated that this would result in only a 4% cost reduction of the overall project. This represents a small portion of the total project cost (approximately $110,000,000). This cost reduction would be realized in 2030. Deferral of the remaining project costs are from 2029 to 2030.

- *Low Estimate*. 70% of Best Estimate. This is predicated on an assumed 30% contingency having been included in the original project cost estimate.
- *High Estimate*. 120% of Best Estimate.

- *Value*. For Alternative 2-B.
  - *Best Estimate*. $25,160,000. This alternative would result in approximately a 46% capacity reduction in the South Treatment Plant Capacity upgrade project. Details regarding the cost estimate for the project were not readily available. However, this project generally consists of constructing new raw sewage pumps, sedimentation tanks, and aeration basins. Based upon preliminary project drawings, it appears that at least four treatment units are being added for each portion of the treatment train involved. Therefore, in the absence of more refined information, it is assumed than one treatment unit per train could be eliminated. Therefore, it is estimated that this would result in approximately a 23% cost reduction of the overall project. This cost reduction would be realized in 2033. Deferral of the remaining project costs are from 2030 to 2033.
  - *Low Estimate*. 70% of Best Estimate. This is predicated on an assumed 30% contingency having been included in the original project cost estimate.
  - *High Estimate*. 120% of Best Estimate.

- WW-4: Reclaimed water revenues (King County).
  - *Description*. This benefit refers to the revenues the County would realize by selling reclaimed water to the District, who in turn would distribute the resource to end users. (See Appendix B for details regarding the value calculation for this benefit.)
  - Value *Input A = Volume of Reclaimed Water Sold by County to District*.
    - *Best Estimate*. 69-239 mg/yr (dependent upon alternative and phase). Total volume of reclaimed water sold by the County to the District, includes water ultimately to be used by current District customers as well as self-*supplied* users who convert from their existing sources to reclaimed water. This is based upon the reclaimed water estimates generated in the Phase 1 work of this analysis, assuming customers come online in a phased approach over time. Therefore, this value varies by alternative and over time.
    - *Low Estimate*. 0% of Best Estimate. This assumes no reclaimed water is distributed by the District.
    - *High Estimate*. 110% of Best Estimate. This assumes the reclaimed water demand estimates for the District may be slightly underestimated.

- *Value Input B = County's Price of Reclaimed Water*.
  - *Best Estimate*. $1,893/mg. This is based upon 80% of Seattle Public Utility's (SPU) wholesale water rate (currently set at $1.77/ccf for peak usage under SPU "new [2001] contracts"), converted to million gallons (mg). This is based upon the County's current approach to reclaimed water pricing, as presented in the County document *Report on the Status of the Reclaimed Water Work Program* (June 1, 2009).
  - *Low Estimate*. 50% of SPU potable rate.
  - *High Estimate*. 100% of SPU potable rate.

Water Utility Benefits

- WU-1: Reclaimed water revenues (Covington Water District).
  - *Description*. This benefit refers to the revenues the District would realize by selling reclaimed water to current customers as wells as irrigation customers that currently utilize independent sources of supply. The magnitude of this benefit is reduced by the amount the District would pay the County for obtaining reclaimed water (i.e., as quantified in Benefit WW-4) and by the difference between potable and reclaimed water rates, as applied to current customers. (See Appendix B for details regarding the value calculation for this benefit.)
  - Value *Input A = Volume of Reclaimed Water Sold by District to Currently Self-Supplied Water Users*.
    - *Best Estimate*. 64-194 mg/yr (dependent upon alternative and phase). Volume of reclaimed water sold to potential future customers that are presently not customers of the District. This is based upon the reclaimed water estimates generated in the Phase 1 work of this analysis, assuming customers come online in a phased approach over time. Therefore, this value varies by alternative and over time.
    - *Low Estimate*. 0% of Best Estimate. This assumes none of the identified potential future customers considered in the Best Estimate become customers of the District (e.g., they elect to continue using their own sources of supply).
    - *High Estimate*. 110% of Best Estimate. This assumes the reclaimed water demand estimates for these potential customers may be slightly underestimated.
  - *Value Input B = District's Price of Reclaimed Water*.
    - *Best Estimate*. $6,877/mg. This is based upon 80% of the District's commercial irrigation rate (currently set at $6.43/ccf), converted to million gallons (mg).
    - *Low Estimate*. 50% of District potable rate.
    - *High Estimate*. 100% of District potable rate.
  - Value *Input C = Volume of Reclaimed Water Sold by County to District*.

- *Best Estimate*. 69-239 mg/yr (dependent upon alternative and phase). Total volume of reclaimed water sold by the County to the District, includes water ultimately to be used by current District customers as well as self-supplied users. This is based upon the reclaimed water estimates generated in the Phase 1 work of this analysis, assuming customers come online in a phased approach over time. Therefore, this value varies by alternative and over time.
- *Low Estimate*. 0% of Best Estimate. This assumes no reclaimed water is distributed by the District.
- *High Estimate*. 110% of Best Estimate. This assumes the reclaimed water demand estimates for the District may be slightly underestimated.

o Value *Input D = County's Price of Reclaimed Water*.

- *Best Estimate*. $1,893/mg. This is based upon 80% of Seattle Public Utility's (SPU) wholesale water rate (currently set at $1.77/ccf for peak usage under SPU "new [2001] contracts"), converted to million gallons (mg). This is based upon the County's current approach to reclaimed water pricing, as presented in the County document *Report on the Status of the Reclaimed Water Work Program* (June 1, 2009).
- *Low Estimate*. 50% of SPU potable rate.
- *High Estimate*. 100% of SPU potable rate.

o Value *Input E = Volume of Reclaimed Water Sold by District to Current/Future District Customers*.

- *Best Estimate*. 5-45 mg/yr (dependent upon alternative and phase). Volume of reclaimed water sold to existing water users that are current customers of the District, as well as water sold to future water users that are already planned to be customers of the District (e.g., future City of Covington parks). This is based upon the reclaimed water estimates generated in the Phase 1 work of this analysis, assuming customers come online in a phased approach over time. Therefore, this value varies by alternative and over time.
- *Low Estimate*. 50% of Best Estimate. This assumes only half of the customers considered in the Best Estimate become reclaimed water users.
- *High Estimate*. 110% of Best Estimate. This assumes the reclaimed water demand estimates for these customers may be slightly underestimated.

o *Value Input F = Difference between District's Potable Water Rate and Price of* Reclaimed *Water*.

- *Best Estimate*. $1,719/mg. This is based upon 20% of the District's commercial irrigation rate (i.e., inversely proportional to Value Input B).
- *Low Estimate*. 0% of District potable rate.
- *High Estimate*. 50% of District potable rate.

Self-Supplied Water User Benefits

- SS-1: Avoided groundwater pumping costs.
  - *Description*. This benefit refers to the savings the currently self-supplied water users considered in Benefit WU-1 would realize from ending the use of their own groundwater supplies. It is important to note that the most likely scenario within which this benefit would occur is if the State enforces the legal use of water rights and water right-exempt groundwater withdrawals in the basin, which would have the effect of forcing some of these water users to using alternative supplies such as reclaimed water. (See Appendix B for details regarding the value calculation for this benefit.)
  - Value *Input A = Price of Power*.
    - *Best Estimate*. $0.09/kW-hr. This is based upon PSE's approximate current rate for commercial customers.
    - *Low Estimate*. $0.07/kW-hr.
    - *High Estimate*. $0.11/kW-hr.
  - Value *Input B = Volume of Reclaimed Water*.
    - *Best Estimate*. 64-194 mg/yr (dependent upon alternative and phase). Volume of reclaimed water sold to potential future customers that are presently not customers of the District. This is based upon the reclaimed water estimates generated in the Phase 1 work of this analysis, assuming customers come online in a phased approach over time. Therefore, this value varies by alternative and over time.
    - *Low Estimate*. 0% of Best Estimate. This assumes none of the identified potential future customers considered in the Best Estimate become customers of the District.
    - *High Estimate*. 110% of Best Estimate. This assumes the reclaimed water demand estimates for these potential customers may be slightly underestimated.

General Public Benefits

- GP-1: Increased instream flows.
  - *Description*. This benefit refers to the enhancement of the ability of aquatic and streamside ecosystems to provide economically important goods and services for the general public, based upon the use of reclaimed water to augment instream flows. Based upon a review of available information, as summarized in the County's *Identification of Streams Likely to Benefit from Additional Water Inputs (July 2009)*, the Soos Creek Basin (and the Covington and Jenkins Creek Basins) have been identified as basins in King County that would benefit from additional water flow during summer low-flow periods. This is due to the basins having multiple lines of evidence suggesting low-flow problems. Furthermore, these basins rank high, when

compared with other basins in the County, as benefitting from additional water. (See Appendix B for details regarding the value calculation for this benefit.)

Original sources of data containing these findings include:

- Lombard, J., and D. Somers. 2004. *Central Puget Sound low flow survey.* Prepared for the Washington Department of Fish and Wildlife.
- Northwest Hydraulic Consultants, Inc. 2005. *Assessment of current water quantity conditions in the Green River basin.* Prepared for WRIA 9 Steering Committee. Northwest Hydraulic Consultants, Inc.: Seattle, WA.
- Timm, R., R. Jack, S. Lee, T. Mohamedali, C. Homan, and T. Swanson. 2008. *Soos Creek system temperature and dissolved oxygen total maximum daily load study, draft data summary report.* Washington Department of Ecology: Olympia, WA.
- Tributary Streamflow Technical Committee. 2006. *Final tributary streamflow report.* Prepared for the Regional Water Supply Planning Process. http://www.govlink.org/regional-water-planning/tech-committees/trib-streamflow/index.htm.

- Value *Input A = Unit Value of Additional Water Provided*.
  - *Best Estimate*. $37/acre-foot. This is based upon the summary of benefit valuations presented in the initial list (median value). See Appendix A for details.
  - *Low Estimate*. $3/acre-foot. This is the low end of the range identified in the initial list.
  - *High Estimate*. $300/acre-foot. This is the high end of the range identified in the initial list.
- *Value* Input *B = Volume of Reclaimed Water*.
  - *Best Estimate*. 197-3,880 acre-feet/yr (dependent upon alternative and phase). Volume of additional water input provided to the basin during low-flow summer periods. This includes the portion of reclaimed water used for environmental beneficial reuse (i.e., indirect stream flow augmentation via shallow groundwater recharge), as well as the portion of reclaimed water sold to potential future customers that are presently not customers of the District (which reduces shallow groundwater withdrawals that currently negatively impact stream flows). This is based upon the reclaimed water estimates generated in the Phase 1 work of this analysis, assuming a phased approach over time. Therefore, this value varies by alternative and over time.
  - *Low Estimate*. 25% of Best Estimate. This assumes that the realized instream flow input is significantly less than estimated, based on factors such as smaller-than-anticipated infiltration facilities are constructed, fewer-than-estimated potential irrigation customers are connected, etc.
  - *High Estimate*. 110% of Best Estimate. This assumes the reclaimed water demand estimates for these potential uses may be slightly underestimated.

- GP-2: Savings in fertilizer usage.
  - *Description*. This benefit refers to the reduction of fertilizer usage, based upon the use of reclaimed water for irrigation. (See Appendix B for details regarding the value calculation for this benefit.)
  - Value *Input A = Unit Value ($/acre-ft of reclaimed water used).*
    - *Best Estimate*. $42/acre-ft. This is based upon the summary of benefit valuations presented in the initial list. See Appendix A for details.
    - *Low Estimate*. 50% of Best Estimate.
    - *High Estimate*. 150% of Best Estimate.
  - Value *Input B = Volume of Reclaimed Water*.
    - *Best Estimate*. 211-735 acre-feet/yr (dependent upon alternative and phase). Volume of reclaimed water used for irrigation, and thereby imparting nutrients to the irrigated areas, reducing the need for fertilizer. This includes all reclaimed water used for irrigation, both for potential future customers that are existing District customers as well as those that are currently self-supplied. This is based upon the reclaimed water estimates generated in the Phase 1 work of this analysis, assuming a phased approach over time. Therefore, this value varies by alternative and over time.
    - *Low Estimate*. 25% of Best Estimate. This assumes that the estimated reclaimed water demand for irrigation is significantly less than projected.
    - *High Estimate*. 110% of Best Estimate. This assumes the reclaimed water demand estimates for these potential uses may be slightly underestimated.
- GP-3: Reduced greenhouse gas emissions.
  - *Description*. This benefit refers to the reduction of greenhouse gas emissions *associated* with fertilizer production, based upon the use of reclaimed water for irrigation. (See Appendix C for details regarding the value calculation for this benefit.)
  - *Value Input A = Unit Value ($/ton CO2).*
    - *Best Estimate*. $40/ton CO2. This is based upon the summary of benefit valuations presented in the initial list (median value). See Appendix A for details.
    - *Low Estimate*. $10/ton CO2. This is the low end of the range identified in the initial list, scaled to this particular project.
    - *High Estimate*. $70/ton CO2. This is the high end of the range identified in the initial list, scaled to this particular project.
  - *Value Input B = Conversion of volume of reclaimed water to CO2*.
    - *Best Estimate*. 0.2 ton CO2/acre-ft of reclaimed water. Based upon data presented in a University of Washington technical paper entitled *The Benefits of Wastewater Reclamation (2009)*, which is predicated on reclaimed water quality from the South Plant processes. Conversion to MBR-based effluent water quality

was made based upon 2008-2009 County data from the Carnation Reclaimed Water Facility. No range applied to this input value.

- *Value Input C = Volume of Reclaimed Water*.
  - *Best Estimate*. 211-735 acre-feet/yr (dependent upon alternative and phase). Volume of reclaimed water used for irrigation, and thereby imparting nutrients to the irrigated areas, reducing the need for fertilizer. This includes all reclaimed water used for irrigation, both for potential future customers that are existing District customers as well as those that are currently self-supplied. This is based upon the reclaimed water estimates generated in the Phase 1 work of this analysis, assuming a phased approach over time. Therefore, this value varies by alternative and over time.
  - *Low Estimate*. 25% of Best Estimate. This assumes that the estimated reclaimed water demand for irrigation is significantly less than projected.
  - *High Estimate*. 110% of Best Estimate. This assumes the reclaimed water demand estimates for these potential uses may be slightly underestimated.

- GP-4: Increased in-stream recreation (fishing).
  - *Description*. This benefit refers to the enhancement of the ability of aquatic ecosystems to support in-stream recreation in the form of fishing, based upon the use of reclaimed water to augment instream flows.
  - *Value Input A = Unit Value ($/visitor trips per year)*.
    - *Best Estimate*. $36.97. Based on USDA–Natural Resources Conservation Services data[10].
    - *Low Estimate*. $27.74. Based on USDA–Natural Resources Conservation Services data.
    - *High Estimate*. $39.22. Based on USDA–Natural Resources Conservation Services dat.
  - *Value Input B = Increase in visitor-trips per year*. Calculated as [Total Puget Sound Area Population, based on Puget Sound Regional Council forecasts[11]] x [Rate of Participation in Fishing, based on Washington State Parks and Recreation Data[12]] x [Percent Increase in Participation Resulting from Increased Flows]
    - *Best Estimate*. Assumed percent increase in participation is minimal, on the order of 1% for Alts 1-A and 2-A, and 3% for Alts 1-B and 2-B.
    - *Low Estimate*. Percent increase in participation = 0%.

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[10] USDA Natural Resource Conservation Service, 2005. "New Comparison Study of 1200 Recreational Studies by the Forest Service that has US and Regional Average User Day Values by type of activity." http://www.economics.nrcs.usda.gov/.

[11] Puget Sound Regional Council demographic forecasts (Released 2006, updated 2008). http://www.psrc.org/data/forecasts/saf/.

[12] US Census Bureau, "National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (FHWAR)." (Washington, 2006). http://www.census.gov/prod/www/abs/fishing.html.

        - *High Estimate*. Percent increase in participation = 5%.

- GP-5: Increased near-stream recreation (wildlife viewing).
    - *Description*. This benefit refers to the enhancement of the ability of aquatic and streamside ecosystems to support near-stream recreation in the form of wildlife *viewing*, based upon the use of reclaimed water to augment instream flows.
    - *Value Input A = Unit Value ($/visitor trips per year).*
        - *Best Estimate*. $29.74. Based on USDA–Natural Resources Conservation Services data.
        - *Low Estimate*. $27.03. Based on USDA–Natural Resources Conservation Services data.
        - *High Estimate*. $37.42. Based on USDA–Natural Resources Conservation Services data.
    - *Value Input B = Increase in visitor-trips per year*. Calculated as [Total Puget *Sound* Area Population, based on Puget Sound Regional Council forecasts] x [Rate of Participation in Wildlife Viewing, based on Washington State Parks and Recreation Data] x [Percent Increase in Participation Resulting from Increased Flows]
        - *Best Estimate*. Assumed percent increase in participation is minimal, on the order of 1% for Alts 1-A and 2-A, and 3% for Alts 1-B and 2-B.
        - *Low Estimate*. Percent increase in participation = 0%.
        - *High Estimate*. Percent increase in participation = 5%.

5.3 Qualitative Benefit Details

Descriptions of the qualitatively-assessed benefits listed in Table 5-1 are provided in the narrative summaries below, based primarily upon information presented in the County's *Identification of Potential Economic Benefits of Production and Use of Reclaimed Water (Draft, September 2009)*. Text in italics represents narrative extracted directly from this document.

Wastewater Utility Benefits

- WW-10: Increased flexibility in management of treated wastewater. *On-going environmental deterioration, population growth, climate change, and other factors are likely to put additional stress on water quality and quantity issues in Puget Sound. Increased production of reclaimed water would provide King County with another option for disposing of treated effluent*.
- WW-11: Avoided wastewater treatment capital costs related to nutrient removal (South Plant). This represents avoided capital costs related to potential future nutrient removal requirements at the South Treatment Plant. Through the workshop discussions, it was determined that this benefit could be significant and warrants mention, but that there is insufficient data currently available with which to quantify or monetize the benefit.

Water Utility Benefits

- WU-10: Protection of water source areas. *Increased use of reclaimed water as a substitute for water from natural sources would protect levels of source water availability for later use and decrease ecological disturbance of watersheds providing water for utilities and other purposes. Utilities and their customer/ratepayers would enjoy cost savings; the general public would enjoy environmental benefits.*

Self-Supplied Water User Benefits

- SS-10: Increased water supply reliability. If self-supplied water users that currently utilize water right-exempt wells converted to use of reclaimed water, this may result in increased supply reliability, in that the continued use of exempt wells may be subject to regulatory enforcement (if current uses are in excess of allowed amounts) and their use reduced or terminated.
- SS-11: Reduced risk of enforcement/litigation costs associated with water rights. Similar to the above benefit, self-supplied users may avoid costs associated with clarifying the boundaries of existing water rights and/or water supplies by utilizing reclaimed water.

General Public Benefits

Environmental

- GP-10: Enhanced coastal ecosystems. *Increased production of reclaimed water would decrease wastewater discharges, reducing pollutants which degrade the health and functions of coastal ecosystems that provide valuable goods and services to the general public*.
- GP-11: Improvements in in-stream water quality. *Increased production of reclaimed water would decrease discharge of wastewater pollutants in receiving water bodies. Increased direct or indirect use of reclaimed water to augment streamflows in impaired water bodies would dilute existing pollutants and improve water quality*.
- GP-12: Reductions in risk associated with climate change. *Increased production of reclaimed water would provide an additional source of water to meet demand in the face of potential water shortages associated with anticipated increases in the incidence of low stream flows during summer months and increased interannual variation in stream flows.*

Societal

- GP-13: Increased economic growth. *Increased production and use of reclaimed water would stimulate economic activity in related businesses. Increased availability of reclaimed water would support general economic growth insofar as it would relax constraints associated with the quantity, reliability, and environmental impacts of municipal-industrial water systems. General economic growth would yield financial benefits for growth-related businesses, property owners, and public services.*

- GP-14: Improved management of water resources. *Increased use of reclaimed water, displacing the use of potable water for customers and uses that don't require it, would increase the supply of potable water for other customers and uses, and decrease the local water utility's exposure to the decisions of environmental regulators, non-local water suppliers, and other external entities.*

- GP-15: Reinforced cultural/spiritual values. *Increased production and use of reclaimed water would enhance attributes of the environment having cultural/spiritual value.*

- GP-16: Reinforced cultural values associated with a conservation ethic. *Increased production and use of reclaimed water would respond to preferences of some individuals, businesses, and groups for diminishing the impacts on the environment.*

- GP-17: Enhanced aesthetic values. *Increased use of reclaimed water would lead to improvements in green space, instream water quality, reduced discharge of effluent in Puget Sound, and other natural-resource amenities from which people derive aesthetic value. The increase in value would affect the value of nearby properties, the level of activity in real-estate, tourism/recreation, and other industries, and the revenue public entities derived from the increases to support the provision of public services.*

- GP-18: Reductions in risk associated with population and economic growth. *Increased production and use of reclaimed water would provide an additional source of water to meet demands associated with population growth, resulting in less risk of water shortages and less cost associated with metering new water-supply demands.* In the Soos Creek Basin this is of particular significance, due to the basin's history of having development moratoriums imposed as a result of water supply constraints.

- GP-19: Increased public education. *Increased production and use of reclaimed water would generate opportunities to provide the public with information on the benefits of water reuse and conservation.*

Section 6.0 Results and Findings

The results from the quantitative benefit cost analysis and the qualitative benefit assessment are presented in this section, followed by a summary of key findings.

6.1 Results of Benefit Cost Analysis

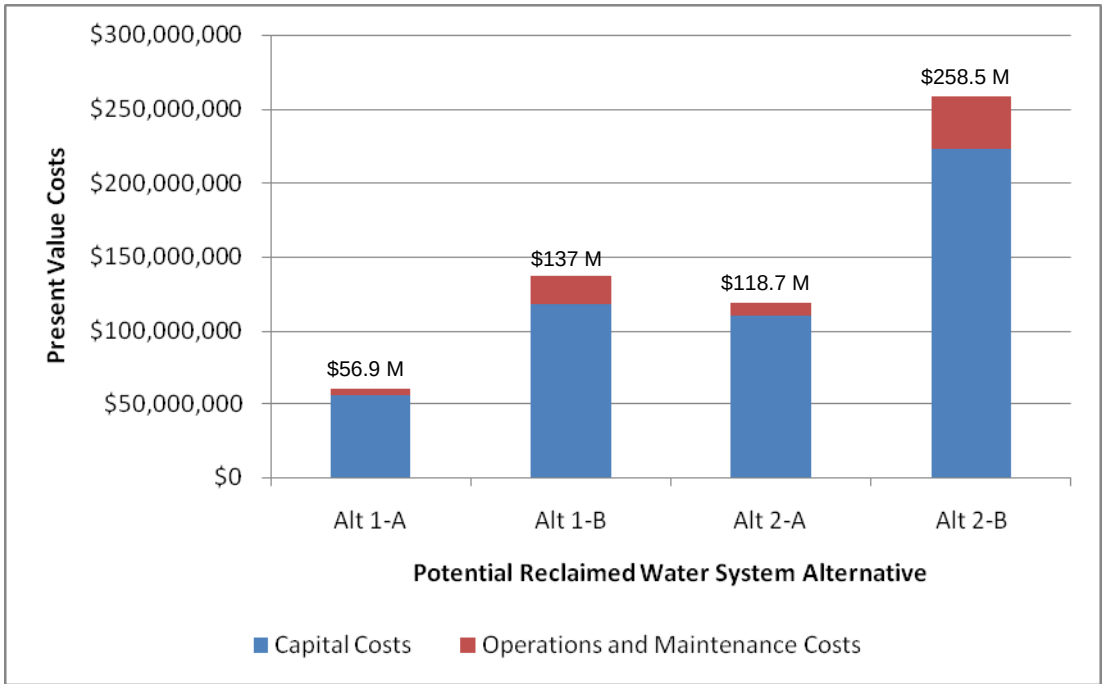
6.1.1 Present Value Summary of Project Costs

The present value cost for each alternative is summarized below in Table 6.1 and Figure 6.1, based upon the magnitude and timing of costs presented in Section 4. Alternative 2-B (Pump Station D Site, Year-Round Use) has the largest total present value cost at $258.5 million. Alternative 2-A (Pump Station D Site, Seasonal Use) is approximately one-half of this cost. Alternative 1-A (Black Diamond, Seasonal Use) is the least cost alternative at nearly one-third of the cost of Alternative 2-B at $59.6 million. The cost for Alternative 1-B (Black Diamond, Year-Round Use) is approximately $77 million greater than the cost Alternative 1-A.

Table 6-1. Summary of Present Value of Costs

	Alt 1-A	Alt 1-B	Alt 2-A	Alt 2-B
Capital Costs	$55,200,000	$117,800,000	$109,800,000	$222,800,000
Operations and Maintenance Costs	$4,400,000	$19,200,000	$8,900,000	$35,700,000
Total Costs	**$59,600,000**	**$137,000,000**	**$118,700,000**	**$258,500,000**

Figure 6-1. Comparison of Present Value of Costs



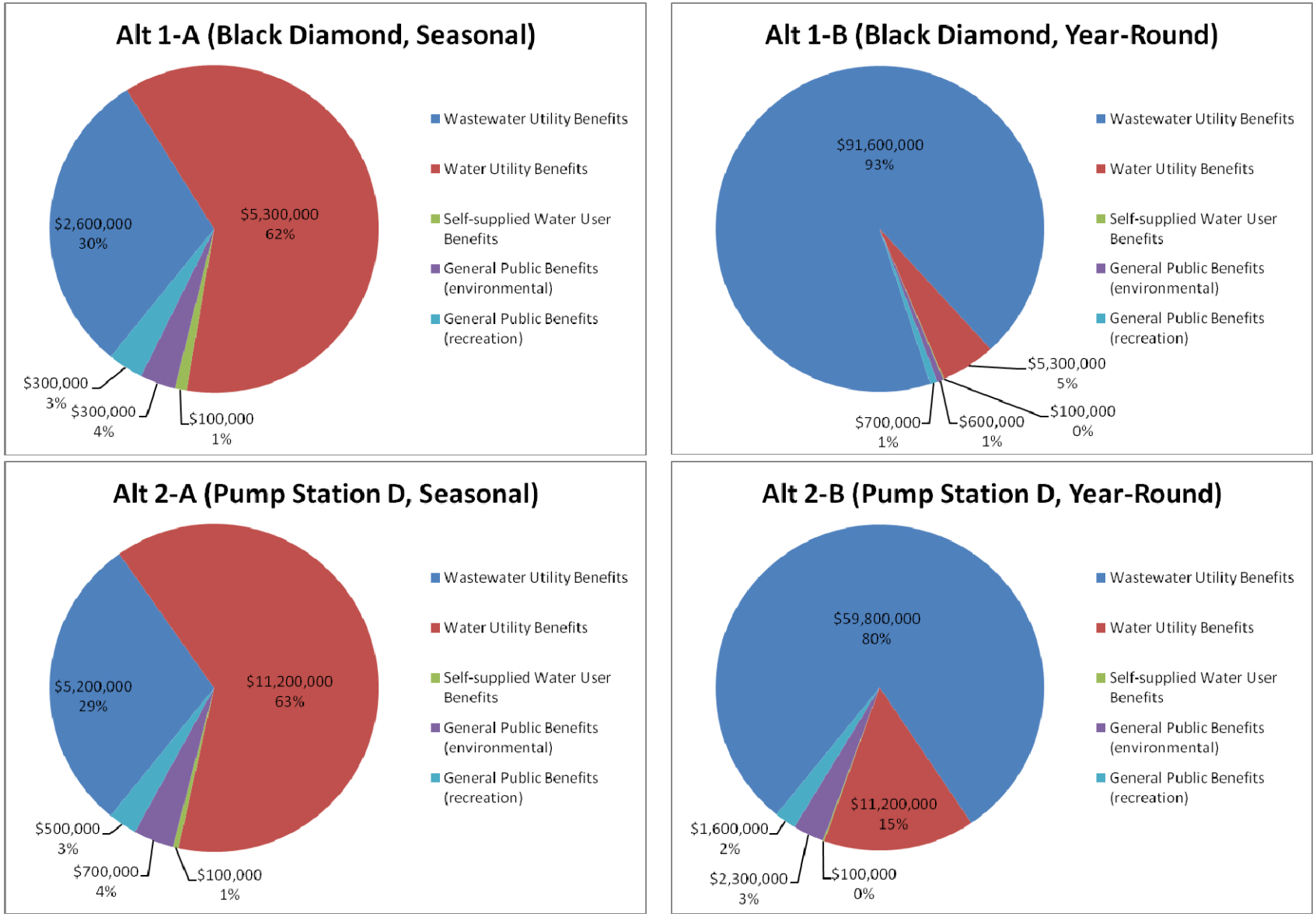
6.1.2 Present Value of Summary of Project Benefits

Table 6.2 and Figure 6.2 provide a summary of the composition of projected benefits for each alternative, based upon the calculation methodologies presented in Section 5. The total benefit present values range from $8.6 million (for Alternative 1-A) to $98.3 million (for Alternative 1-B). In the case of both the Black Diamond and Pump Station D locations, the year-round use alternatives have significantly higher benefit present values than their seasonal use counterparts. This is due to the impact of avoided and deferred wastewater utility benefits which are achieved only through the development of a year-round use reclaimed water system.

Table 6-2. Summary of Present Value of Benefits

	Alt 1-A	Alt 1-B	Alt 2-A	Alt 2-B
Wastewater Utility Benefits	$2,600,000	$91,600,000	$5,200,000	$59,800,000
Water Utility Benefits	$5,300,000	$5,300,000	$11,200,000	$11,200,000
Self-Supplied Water User Benefits	$100,000	$100,000	$100,000	$100,000
General Public Benefits (Environmental)	$300,000	$600,000	$700,000	$2,300,000
General Public Benefits (Recreational)	$300,000	$700,000	$500,000	$1,600,000
Total Benefits	**$8,600,000**	**$98,300,000**	**$17,700,000**	**$75,000,000**

Figure 6-2. Comparison of Present Value of Benefits



6.1.3 Net Benefits Results

The present value benefits and costs were used to calculate the net benefits[13] for each alternative. Table 6.3 summarizes the results. Based on the quantitative analysis, none of the alternatives provide positive net benefits within the 30 year period of analysis, when considering those benefits that could be monetized. The net benefits range between -$183.5 and -$38.8 million, when all benefits are considered. The net benefits are only minimally altered (less than 1% change) when the recreational benefits, which are based upon arguably the most far-reaching assumptions of all benefits, are excluded from the analysis, as summarized in Table 6.3. While a longer time period could yield more benefit, the discounting of future streams of benefits as well as the addition of future operations, maintenance and rehabilitation costs would likely offset those future year benefits.

Table 6-3. Summary of Net Monetized Benefits

	Alt 1-A (Black Diamond, Seasonal)	Alt 1-B (Black Diamond, Year-Round)	Alt 2-A (Pump Station D, Seasonal)	Alt 2-B (Pump Station D, Year-Round)
Benefits				
Wastewater Utility Benefits	$2,600,000	$91,600,000	$5,200,000	$59,800,000
Water Utility Benefits	$5,300,000	$5,300,000	$11,200,000	$11,200,000
Self-Supplied Water User Benefits (1)	$100,000	$100,000	$100,000	$100,000
General Public Benefits (Environmental)	$300,000	$600,000	$700,000	$2,300,000
General Public Benefits (Recreational)	$300,000	$700,000	$500,000	$1,600,000
Total Benefits	**$8,600,000**	**$98,300,000**	**$17,700,000**	**$75,000,000**
Costs				
Capital Costs	$55,200,000	$117,800,000	$109,800,000	$222,800,000
O&M Costs	$4,400,000	$19,200,000	$8,900,000	$35,700,000
Total Costs	**$59,600,000**	**$137,000,000**	**$118,700,000**	**$258,500,000**
Net Benefits (2)				
Considering All Benefits	**($51,000,000)**	**($38,800,000)**	**($100,900,000)**	**($183,500,000)**
Excluding Recreational Benefits	**($51,300,000)**	**($39,500,000)**	**($101,500,000)**	**($185,100,000)**

Notes:

(1) The values for these benefits range from $65,000 (Alts 1-A and 1-B) to $130,000 (Alts 2-A and 2-B). They appear equal in this summary due to rounding.

(2) These values represent the net benefits calculated based upon the expected values for the cost and benefit inputs to the BCA model. These values are depicted on Figure 6-4, in conjunction with their probability of occurrence within the context of the range of potential cost and benefit value inputs.

Analysis of the net benefits indicates the Black Diamond options generate the highest net benefits of the four alternatives. Specifically, Alternative 1-B, the Black Diamond year-round option, generates the best return. While this option is the second most costly alternative, it provides the largest return on investment out of the four alternatives mostly through large direct benefits to the wastewater and water utilities (i.e., avoided capital costs for expanded conveyance facilities, with regard to the County, and increased reclaimed water revenues, with regard to the District).

[13] The results of the calculation of a different, and less informative metric (the benefit-to-cost ratio), are summarized in Appendix C.

The Pump Station D alternatives fall significantly behind the Black Diamond alternatives when comparing the four. When compared to the benefits they generate, the costs are simply too large to arrive at net benefits similar to the Black Diamond options.

6.1.4 Risk and Uncertainty Analysis Results

A risk and uncertainty model was assembled using the ranges of values for costs and benefits discussed in Sections 4 and 5. The model was used to forecast the probability distribution of the net benefit results for each alternative, which are based upon the expected values of the cost and benefit inputs to the BCA model, given the established criteria set forth by the input value ranges. The results from this forecast are shown below in Figure 6.3 as probability density functions. These graphics show:

- The mean value of the net benefits represented by the peak of the curve;
- The frequency with which a net benefit value occurred in the analysis; and,
- The likely range within which 90% of the potential net benefits are captured.

Based on the analysis, the mean values for each alternative are slightly higher than the baseline net benefits values presented in section 6.1.3. Additionally the baseline values lie closer to the low end of the 90% range for net benefits. For Alternative 1-A, the mean value was approximately -$49 million. Approximately 90% of the net benefits values for Alternative 1-A range between -$53.7 and -$44.6 million. For Alternative 1-B, the mean value was -$37 million, again slightly improved from the baseline value. The range reflecting 90% of the potential value for Alternative 1-B occurs between -$49.4 and -$20.1 million.

Alternative 2-A has a mean value of -$98 million with a range between -$107.3 and -$88.0 million. Finally, Alternative 2-B exhibits a mean value of -$170 million, with a likely range between -$188.7 and -$149.7 million.

Figure 6-3. Net Benefit Probability Density Functions

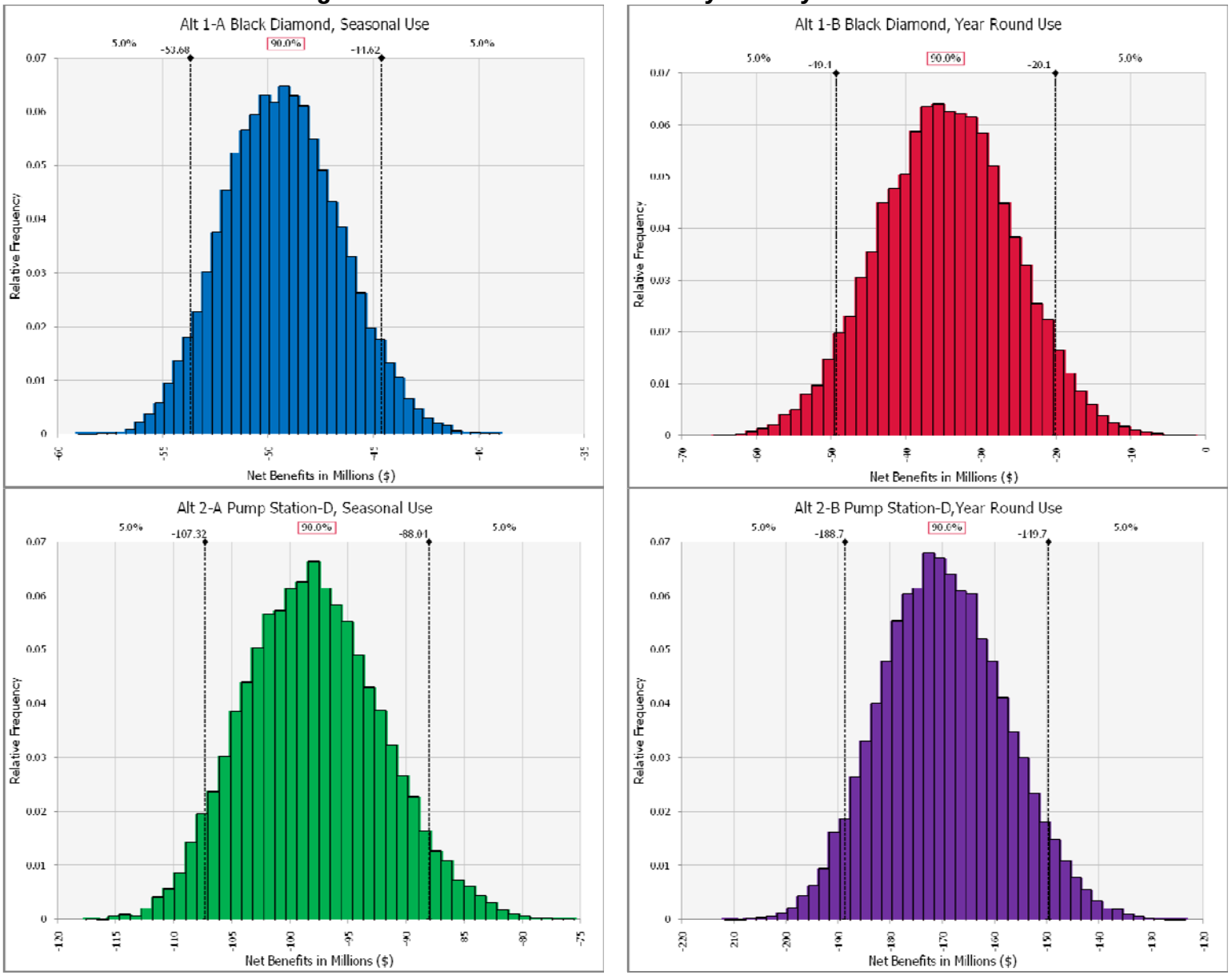
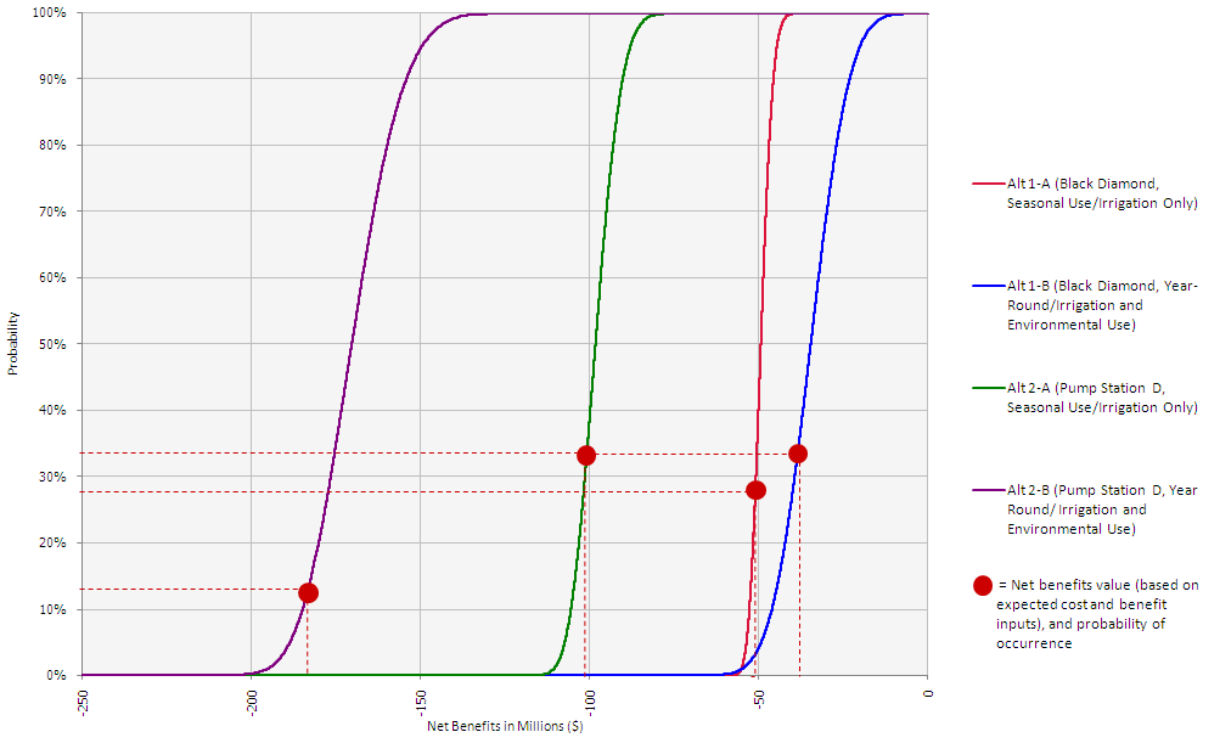


Figure 6.4 depicts the cumulative probability density functions of the net benefits for each alternative. These curves compare the alternatives against one another and demonstrate the likelihood of net benefits. The curves demonstrate a heavy presence of stochastic dominance for the Black Diamond alternatives over the Pump Station D alternatives. This means that for every possible combination of input values in the net benefits, the Black Diamond alternatives will always generate net benefits greater than those of the other two options.

Figure 6-4. Net Benefits Cumulative Probability Density Functions



As the figure also shows, the results of the net benefits calculation (i.e., the net benefits value based upon expected values for cost and benefit inputs) are also at the low end of the cumulative density functions. This indicates that from a standpoint of risk, each alternative presents a good chance of realizing higher net benefits than what the baseline net benefits results present. For example, for Alternative 1-B, there is a 33% probability that realized net benefits will be less than the result based upon expected input values, and a 77% probability that the net benefits would be greater than this baseline result.

6.2. Qualitative Benefit Evaluation

Supplemental comparative information about the alternatives, particularly with respect to one another, is provided in the qualitative benefit evaluation, the results of which are summarized in Table 6.4. Following the scoring methodology presented in Section 3, each alternative received a “relative magnitude” score, based upon the combination of a “relative impact” score multiplied by a “likelihood”. The maximum possible relative magnitude score to be achieved for each benefit by a given alternative is 5.0.

Based on the scoring, which was conducted in a workshop setting with District and County staff, Alternative 1-B received the highest score, followed by Alternatives 1-A and 2-B, which had similar total scores. Alternative 2-A scored the lowest.

The benefits that contribute most significantly to differentiating Alternative 1-B from the other options are:

- WW-10: Increased flexibility in management of treated wastewater. With respect to this benefit, the year-round use alternatives score significantly higher than the seasonal use alternatives, due to the ability of the year-round use alternatives to manage wet weather flows.
- GP-11: Improvements to instream water quality. Alternatives 1-A and 1-B score higher in regard to this benefit because of the more extensive length of stream reach potentially benefitted (i.e., due to reclaimed water use and streamflow enhancements higher in the watershed, both Covington and Soos Creeks may be benefitted, as opposed to just Soos Creek under Alternatives 2-A and 2-B).
- GP-12: Reductions in risk associated with climate change. The differentiation between scoring is due to the same effects noted for Benefit GP-11, related to stream lengths.

It is important to note that the scoring of these qualitatively-assessed benefits is specific to this analysis, and is largely a function of the relatively small size of the study area and the resultant minimal potential impact of the alternatives upon some benefits. For example, while benefit WW-11 (avoided costs related to nutrient removal at South Plant) shows a high likelihood of being realized via any of the alternatives, its impact score is 0 due to the very small volumes of reclaimed water produced and used under the alternatives, relative to the total volume of wastewater treated at South Plant.

Table 6-4. Qualitative Benefit Assessment Results

Benefit		Alt 1-A Black Diamond Seasonal Use			Alt 1-B Black Diamond Year-Round Use			Alt 2-A Pump Station D Seasonal Use			Alt 2-B Pump Station D Year-Round Use		
		I	L	M	I	L	M	I	L	M	I	L	M
WW-10	Increased flexibility in management of treated wastewater	1	75%	0.75	2	75%	1.50	1	75%	0.75	2	75%	1.50
WW-11	Avoided wastewater treatment capital costs related to nutrient removal (South Plant)	0	75%	0.00	1	75%	0.75	0	75%	0.00	1	75%	0.75
WU-10	Protection of water source areas	2	10%	0.20	2	10%	0.20	2	10%	0.20	2	10%	0.20
SS-10	Increased water supply reliability	2	25%	0.50	2	25%	0.50	2	25%	0.50	2	25%	0.50
SS-11	Reduced risk of enforcement/litigation costs associated with water rights	4	10%	0.40	4	10%	0.40	4	10%	0.40	4	10%	0.40
GP-10	Enhanced coastal ecosystems	1	10%	0.10	1	10%	0.10	1	10%	0.10	1	10%	0.10
GP-11	Improvements in in-stream water quality	2	50%	1.00	3	75%	2.25	1	10%	0.10	2	25%	0.50
GP-12	Reductions in risk associated with climate change	2	30%	0.60	3	50%	1.50	1	10%	0.10	2	20%	0.40
GP-13	Increased economic growth	1	10%	0.10	1	10%	0.10	1	10%	0.10	1	10%	0.10
GP-14	Improved management of water resources	1	10%	0.10	1	10%	0.10	1	10%	0.10	1	10%	0.10
GP-15	Reinforced cultural/spiritual values	4	75%	3.00	4	75%	3.00	3	75%	2.25	3	75%	2.25
GP-16	Reinforced cultural values associated with a conservation ethic	3	25%	0.75	3	25%	0.75	2	25%	0.50	2	25%	0.50
GP-17	Enhanced aesthetic values	1	10%	0.10	1	10%	0.10	1	10%	0.10	1	10%	0.10
GP-18	Reductions in risk associated with population and economic growth such as moratorium	3	20%	0.60	3	20%	0.60	3	20%	0.60	3	20%	0.60
GP-19	Increased public education	3	75%	2.25	3	75%	2.25	3	75%	2.25	3	75%	2.25
	Total Magnitude			**10.45**			**14.10**			**8.05**			**10.25**

Note: I = Impact Score (0-5); L = Likelihood (0-100%); M = Magnitude (I x L)

6.3 Key Findings

Key findings of the benefit cost analysis, considering the results of both the quantitative analysis and the qualitative assessment, are summarized below. While this summary of key findings is consistent with the methodology established in the WateReuse Foundation Economic Framework, the presentation of results varies slightly from the table templates presented in the Framework guidance document. This is due to the large list of benefits considered in this analysis (particularly with respect to the qualitatively-assessed benefits), and the lengthy tables that would be necessary if the detailed results from both the quantitative and qualitative components of the analysis were to be depicted together. As such, the summaries below serve as the most appropriate presentation of analysis results in this case.

1) The results of both the quantitative benefit cost analysis and the qualitative benefit assessment are provided below in Table 6.5, and indicate that the Black Diamond alternatives are clearly the top two alternatives. Alternative 1-B (Black Diamond, Year-Round Use) is the preferred reclaimed water system alternative amongst those options being considered in this analysis, while Alternative 1-A (Black Diamond, Seasonal Use) ranks second. The results are somewhat ambiguous with respect to the other two alternatives. Alternative 2-B (Pump Station D Site, Year-Round Use) presents a likely fourth place ranking in the quantitative analysis but third in the qualitative assessment, whereas Alternative 2-A (Pump Station D Site, Seasonal Use) has the opposite results.

Table 6-5. Summary of Alternative Rankings

Alternative	Quantitative Benefit Cost Analysis Ranking	Qualitative Benefit Assessment Ranking
Alt 1-A Black Diamond: Seasonal Use	2	2
Alt 1-B Black Diamond: Year-Round Use	1	1
Alt 2-A Pump Station D Site: Seasonal Use	3	4
Alt 2-B Pump Station D Site: Year-Round Use	4	3

2) Alternative 1-B (Black Diamond, Year-Round Use) has the highest net benefits than the other alternatives. This is because although it is the second most costly alternative, it provides by far the largest benefit due to avoided and deferred wastewater utility capital costs. Furthermore, this alternative, rather strongly also, received the highest ranking from the qualitative benefit assessment process with more than a two-point score difference from the other alternatives.

3) Based on the risk and uncertainty analysis, there is a good chance that the baseline values for the net benefits (i.e., those results based upon the expected cost and benefit inputs) for each alternative would be exceeded, given the potential range of input values.

4) The benefit split amongst beneficiaries, which could potentially be used to inform project cost allocations if a program were implemented, varies amongst the alternatives. For example, for Alternative 1-B (the highest ranking option) benefits that would be realized

by the County amount to 93% of those benefits that could be quantified and assigned dollar values. Benefits received by the District and the general public amount to approximately 5% and 2% of the total, respectively. By contrast, for the seasonal alternatives (regardless of location), the benefits realized by the District amount to slightly more than 60% of the total, while those realized by the County represent 30% of the total, with the remainder realized by the general public and self-supplied water users.

Section 7.0 Next Steps

Key future steps to be taken by the District and the County in advancing the planning of a potential reclaimed water program in this portion of the County include the following:

- Integration of this local level of reclaimed water planning with other concurrent efforts, such as the King County Reclaimed Water Comprehensive Plan, which is exploring reclaimed water alternatives at the regional level.

- Discussions and coordination with other local jurisdictions (e.g., municipalities and utility districts) so as to incorporate their needs and desires relative to reclaimed water in future planning stages. It is anticipated that new and/or modified reclaimed water system configurations may develop from this additional level of coordination. Furthermore, additional benefits may be identified which change the results of the benefit cost analysis presented herein.

- Updating of this benefit cost analysis if additional information comes to light which may have the potential to significantly alter the analysis outcomes. Potential items of significance include:
  - More definition regarding nutrient removal requirements at South Plant. Nutrient removal at South Plant is anticipated based on various discussions between the County, the Department of Ecology, and others regarding dissolved oxygen and nutrient levels in south Puget Sound. However, the nature, extent, and timing of potential nutrient removal requirements the County may have to meet in the future are uncertain at this time. As such requirements become better defined, this reclaimed water system benefit cost analysis could be revisited to examine if implementation of a reclaimed water program in the District's service area has the potential to reduce the magnitude of treatment plant upgrades at South Plant.
  - Increased State enforcement of potentially illegal water uses in the District's service area. There is great uncertainty in the probability of currently self-supplied water users in the basin to convert to reclaimed water or municipal water supplies. If more resources were used to ensure legal uses of water rights and water right-exempt sources, it is possible that the extent of reclaimed water use for non-potable purposes such as irrigation could increase. This analysis did not include any potential changes in law or enforcement relative to this issue. Therefore, the analysis could be revisited at the time when such changes are enacted, to determine if these increased benefits relative to water supply would lead to satellite reclaimed water program implementation becoming a more economically attractive strategy.

Appendices

Appendix A
"Initial List" of Benefits

[Excerpts of tables from *Identification of Potential Economic Benefits of Production and Use of Reclaimed Water - DRAFT* (King County, September 2009)]

Table 2. Potential Economic Benefits of Reclaimed Water (WateReuse Template 4, Summary Screening Analysis)

General Notes: *This table identifies potential economic benefits that might materialize as a result of developing and implementing the comprehensive plan. Individual items in the list were identified by applying the economic framework developed by the WateReuse Foundation (Raucher et al. 2006), consultation with staff from King County WTD, and our review of the relevant literature. We have taken a broad approach in identifying potential benefits, so that we provide a comprehensive synthesis of studies and data that might prove relevant as the comprehensive plan is completed and implemented. This approach necessarily means that we may have identified some potential benefits that will not materialize in actuality. It also means that we may have identified potential benefits as being distinct (because that is how they are reported in different studies) when, in actuality, they may prove to be one and the same. Completion of the plan should facilitate clarification of which benefits are likely to materialize in association with specific facilities, operational practices, water uses, etc., and this clarification should avoid double-counting. The final determination of actual benefits should be made as the plan is implemented and in the context of specific actions.*

Potential Benefits for Which It Appears There is Sufficient Information to Support Quantitative Valuation[1]	
3.D.1	Savings from using reclaimed water to avoid costs of wastewater treatment and conveyance
3.D.2	Reclaimed water-sales revenues
3.D.3	Avoided increases in groundwater-pumping costs
3.D.4	Energy savings from avoided pumping costs for importing water
3.D.5	Increased supply reliability (customer perspective)
3.D.6	Savings from using reclaimed water to avoid costs of developing/purchasing potable water supply
3.D.7	Savings from using reclaimed water to avoid costs of developing/purchasing water supply to recharge an aquifer
3.D.8	Savings from using reclaimed water to avoid costs of water supply treatment and transmission
3.E.1	Enhancement of downstream habitats
3.E.2	Enhanced environmental restoration, wetland restoration
3.E.3	Reduced risks to threatened or endangered species
3.E.4	Reduced risks to threatened or endangered species (Pacific Salmon)
3.E.5	Increased instream flows
3.E.6	Increased carbon sequestration and reduced greenhouse gas emissions
3.E.7	Increased nutrient cycling
3.R.1	Increased in-stream recreation, near-stream, and wetland recreation
3.R.2	Enhancement of green spaces for recreational use (e.g., golf courses, soccer fields, parks, etc.)
3.H.1	Reduced public health risk due as urban trees irrigated by reclaimed water remove pollutants from the air
3.ES.1	Increased property values (adjacent to suburban riparian greenways)
3.ES.2	Increased property values (adjacent to urban parks)
3.ES.3	Increased property values (adjacent to golf courses)
3.ES.4	Savings in fertilizer usage
3.ES.5	Commercial salmon harvest
3.ES.6	Recreational salmon harvest
3.ES.7	Flood Protection
3.ES.8	Avoided energy costs to businesses and local industry (electricity)
3.ES.9	Avoided energy costs to businesses and local industry (natural gas)
Potential Benefits for Which It Appears there Is Sufficient Information to Support Qualitative Assessment	
5.D.1	Increased flexibility regarding disposition of treated effluent
5.D.2	Increased water-supply flexibility and reliability
5.E.1	Reduced risk of subsidence resulting from declining groundwater levels
5.E.2	Enhanced coastal ecosystems

Table 2. Potential Economic Benefits of Reclaimed Water (WateReuse Template 4, Summary Screening Analysis)	
5.E.3	Enhanced protection for utilities' source-water areas
5.E.4	Improvements in water quality (e.g., temperature, toxic substances, sediment, etc.)
5.ES.1	Increased economic growth
5.ES.2	Increased ability for water projects to leverage other community projects
5.ES.3	Improved management of water resources
5.ES.4	Reinforced cultural/spiritual values
5.ES.5	Reinforced cultural values associated with a conservation ethic
5.ES.6	Enhanced aesthetic values
5.ES.7	Increased agricultural production
5.ES.8	Increased reliability of water supplies for agricultural irrigation
5.ES.9	Reductions in risks associated with population and economic growth
5.ES.10	Reductions in risk associated with climate change
5.ES.11	Increased public education
5.ES.12	Reduced risk of enforcement/litigation costs associated with water rights

Footnotes

[1] The heading in WateReuse Foundation's Template 4, on which we base this table, reads "Potential Benefits for Which there Appears To Be Sufficient Information To Support Full or Partial Valuation." At this time, it is premature to determine which benefits may be valued in full, and which may receive only partial valuation, given the current availability of relevant information.

Table 3. Potential Economic Benefits of Reclaimed Water that Can Be Described Quantitatively (WateReuse Templates 5 & 6, Detail on Benefit Value Derivation)

General Notes: *The intent of this table is to provide a broad array of potential benefits that may arise from a reclaimed water program in King County. The types of benefits listed below reflect a "menu" of possible benefits, only a subset of which will likely be relevant to any specific application of reclaimed water. In some instances, the list shows alternative ways of describing a particular type or potential benefit, reflecting different analytical approaches applied in past studies, but this overlap does not mean that the benefit should be double-counted. The values listed for each benefit represent a starting point for analysis; the actual value will depend on site- and action-specific factors and may be greater or less than the value shown.*

All unit values in 2008 dollars.

Benefit: 3.D.1 Savings from using reclaimed water to avoid costs of wastewater treatment and conveyance	
Description	Increased production of reclaimed water would enable King County WTD to avoid the capital and operating costs associated with new or upgraded conventional wastewater conveyance and treatment capabilities.
Key Beneficiaries	King County WTD Customers/ratepayers
Annual Quantity	*To be completed when specific project information becomes available.*
Unit Value	*Values to be provided by King County WTD.*
Comments on Unit Values	*We expect values will come directly from King County WTD's estimates of avoided capital costs for wastewater treatment and disposal using by using reclaimed water.*
Benefit: 3.D.2 Reclaimed water sales revenues	
Description	Revenue would be generated by sales of reclaimed water to water utilities, or directly to agricultural, industrial, commercial, or residential customers.
Key Beneficiaries	Reclaimed water utility[1] Customers/ratepayers
Annual Quantity	*To be completed when specific project information becomes available.*
Unit Value	*To be completed as values are determined during the planning process.*
Comments on Unit Values	*We expect values will be determined during the planning process.*
Benefit: 3.D.3 Avoided increases in groundwater-pumping costs	
Description	Reclaimed water may be used to recharge aquifers, raising the water table and reducing pumping costs. Pumping costs also can be avoided by substituting reclaimed water for water supplies obtained from groundwater.
Key Beneficiaries	Water utility using groundwater Self-supplied users of groundwater
Annual Quantity	*To be completed when specific project information becomes available.*
Unit Value	$0.08 per kWh (or current relevant electricity rate)
Comments on Unit Values	**Description and Source:** Value based on the current (Nov. 08) average electricity rate for large and small demand general service. Rates range from $0.06-$0.10 based on the timing and quantity of use. (Puget Sound Energy 2008a, Seattle City Light 2008) **Quality of Estimate and Applicability:** We anticipate estimating benefits directly using the avoided cost method.
Benefit: 3.D.4 Energy savings from avoided pumping costs for importing water	
Description	Augmenting local water supply with reclaimed water will decrease demand for imported water, lowering costs of pumping imported water.
Key Beneficiaries	Water utility using imported water Customers/ratepayers of water utility

Annual Quantity	*To be completed when specific project information becomes available.*
Unit Value	$0.08 per kWh (or current relevant electricity rate)
Comments on Unit Values	**Description and Source:** Value based on the current (Nov. 08) average electricity rate for large and small demand general service. Rates range from $0.06-$0.10 based on the timing and quantity of use. (Puget Sound Energy 2008a, Seattle City Light 2008) **Quality of Estimate and Applicability:** We anticipate estimating benefits directly using the avoided cost method.
Benefit: 3.D.5 Increased supply reliability (customer perspective)	
Description	Reclaimed water adds an additional source of water supply that is highly reliable, potentially increasing system-wide reliability should other water supplies become unavailable.
Key Beneficiaries	Customers of water utility Customers of reclaimed water utility
Annual Quantity	*To be completed when specific project information becomes available.*
Unit Value	**Residential:** $120-$275 per household per year (see scaling issues below) **Commercial:** See comment below
Comments on Unit Values	**Description and Source:** Residential value represents the amount water customers are willing to pay to eliminate future shortages. Based on contingent valuation studies that ask customers' willingness to pay to avoid different magnitudes and frequencies of water shortages. Willingness to pay increases as shortages become longer-lasting and more frequent. Studies generally show customers have a low threshold for shortages; customers are willing to pay to avoid even minor and infrequent shortages (e.g. a 10% reduction every 10 years). (Griffin and Mjelde 2000 and Barakat & Chamberlin Inc. 1994). For commercial customers, short-run willingness to pay is proportional to short-run reductions in output, which are proportional to reductions in water supply. (Chang 2003) Long-run willingness to pay is likely to be smaller. (Tierney 1997) Quality of Estimate and Applicability: MEDIUM-HIGH-Residential studies conducted in Texas and California, which may not represent willingness to pay in Puget Sound region. Both studies are generally consistent at the low estimate, however. Scaling Issues: Willingness to pay estimates are based on achieving 100 percent supply reliability. Values should be scaled to reflect the actual level of reliability enhanced by the reclaimed water program.
Benefit: 3.D.6 Savings from using reclaimed water to avoid costs of developing/purchasing potable water supply	
Description	Water utility would deliver reclaimed water to customers and uses that do not require potable water, allowing the utility to avoid costs of developing/purchasing more costly potable water and reducing rates for customers/ratepayers.
Key Beneficiaries	Water utility Customers/ratepayers
Annual Quantity	*To be completed when specific project information becomes available.*
Unit Value	*Value determined based on options for a specific location.*
Comments on Unit Values	*Where appropriate, value would be determined based on supply needs and options for specific water utilities or self-supported customers. See reclaimed water benefit no. 8 below if a water utility's planning provides for adequate supplies to meet its requirements over the next 30 to 50 years.*
Benefit: 3.D.7 Savings from using reclaimed water to avoid costs of developing/purchasing water supply to recharge an aquifer	
Description	Water utility would use reclaimed water to recharge its aquifer, avoid the costs of using more costly potable water and reduce rates for customers/ratepayers.
Key Beneficiaries	Water utility Customers/ratepayers
Annual Quantity	*To be completed when specific project information becomes available.*
Unit Value	*Value determined based on options for a specific location.*

Comments on Unit Values	*Where appropriate, value would be determined based on supply needs and options for specific water utilities or self-supported customers. See reclaimed water benefit no. 8 below if a water utility's planning provides for adequate supplies to meet its requirements over the next 30 to 50 years.*
Benefit: 3.D.8 Savings from using reclaimed water to avoid costs of water supply treatment and transmission	
Description	Water utility would deliver reclaimed water to customers and uses that do not require potable water. Diminished demand for potable water would allow the utility to avoid capital costs to expand its water-supply treatment and/or transmission capabilities and defer rate increases for customers/ratepayers.
Key Beneficiaries	Water utility Customers/ratepayers
Annual Quantity	*To be completed when specific project information becomes available.*
Unit Value	*Value determined based on options for a specific location.*
Comments on Unit Values	*Where appropriate, value would be determined based on supply needs and options for specific water utilities or self-supported customers. See reclaimed water benefit no. 8 below if a water utility's planning provides for adequate supplies to meet its requirements over the next 30 to 50 years.*
Benefit: 3.E.1 Enhancement of downstream habitats	
Description	Instream flows augmented by increased production of reclaimed water, or because increased use of reclaimed water would displace withdrawals from streams and provide environmental benefits for the general public. Increased production of reclaimed water rather than lower-quality wastewater would reduce the risk of environmental harm downstream from future spills.
Key Beneficiaries	Water utility Customers/ratepayers General public
Annual Quantity	*To be completed when specific project information becomes available.*
Unit Value	Approximately $40 per acre-foot per year
Comments on Unit Values	**Description and Source:** The median value of water for environmental purposes from a meta-analysis of water transactions in Washington between 1990 and 2003. Range of market prices for water purchased for environmental purposes in Washington is $3-$300. Median value was $37. (Brown 2004) **Quality of Estimate and Applicability: MEDIUM-LOW**-Represents recent transactions in Washington state, but not necessarily the Puget Sound region. Also, analysis is based on a small number of transactions, and study authors indicate a high level of uncertainty in drawing conclusions from these data. **Omissions, Biases, and Uncertainties:** Values reflect price of water under past conditions. As water demand increases and supply becomes more scarce we would expect the value of water to increase in the future. Value may underestimate the total value of ecosystem goods and services produced by enhancing downstream habitats by increasing instream flows, perhaps considerably.
Benefit: 3.E.2 Enhanced environmental restoration, wetland restoration	
Description	Increased use of reclaimed water to augment instream flows and restore wetlands would increase the ecosystem's ability to produce fish habitat and other goods and services economically important to the general public. Increased production of reclaimed water rather than lower-quality wastewater would reduce the risk of environmental harm downstream from future spills.
Key Beneficiaries	General public
Annual Quantity	*To be completed when specific project information becomes available.*
Unit Value	$100–$500 per acre per year

Comments on Unit Values	**Description and Source:** Values highly variable depending on the ecosystem restored and the degree of restoration. A meta-analysis of wetland valuation studies found that the value of most wetland ecosystem goods and services are in the range of $100-$500 per acre. (Woodward and Wui 2001) Depending on the type of ecosystem, its functions, location, and context within the larger environment, values in Puget Sound could be considerably higher or lower. **Quality of Estimate and Applicability: MEDIUM-LOW-**Values come from studies conducted across the country. Not specific to Puget Sound. Values represent wetland habitats, and may not apply to other kinds of habitats. **Omissions, Biases, and Uncertainties:** This value may be an overestimate or an underestimate of the actual value of environmental restoration. Studies show that values for natural ecosystems, including wetlands near urban areas, increase with population growth and growth in per capita GDP (Brander et al. 2006), so we would expect the per-unit value to increase over time.
Benefit: 3.E.3 Reduced risks to threatened or endangered species	
Description	Increased use of reclaimed water to augment instream flows and restore wetlands would increase the ecosystem's ability to produce habitat for at-risk species.
Key Beneficiaries	General public
Annual Quantity	*To be completed when specific project information becomes available.*
Unit Value	$64–$138 per household per year (see scaling issues)
Comments on Unit Values	**Description and Source:** Value represents the willingness to pay by Washington and U.S. households to ensure the survival of the Northern spotted owl, from two contingent valuation studies. (Rubin 1991 and Hagen et al. 1992 in Richardson and Loomis 2008) Research on the spotted owl provides an indication of the value of impacts on other at-risk species. **Quality of Estimate and Applicability: MEDIUM-HIGH-**Lower value from study of households in Washington, higher value from a survey of all U.S. households; value is dated. **Scaling Issues:** Value represents households' willingness to pay to avoid a 100 percent loss of the species. It would need to be scaled to reflect the extent to which a particular reclaimed water application would improve the survival of the species. In most cases, applications would have a very small effect on species survival as a whole. Must also determine the appropriate geography of households to consider (e.g., Puget Sound, statewide, national). **Omissions, Biases, and Uncertainties:** Value may overestimate or underestimate the actual willingness to pay to ensure the continued survival of the species. Considerable uncertainty will surround the appropriate scaling factor of any project, leading to greater uncertainty in the total value of this benefit.
Benefit: 3.E.4 Reduced risks to threatened or endangered species (Pacific salmon)	
Description	Increased use of reclaimed water to augment instream flows and restore wetlands would increase the ecosystem's ability to produce habitat for at-risk fish and other species. Increased production of reclaimed water, rather than lower-quality wastewater would reduce the discharge of effluent potentially harmful to species near the outfall in Puget Sound and reduce the risk of harm to at-risk species from future spills.
Key Beneficiaries	General public
Annual Quantity	*To be completed when specific project information becomes available.*
Unit Value	$156–$326 per household per year, depending on fish run (see scaling issues)
Comments on Unit Values	**Description and Source:** Value represents the willingness to pay by households in Washington for salmon recovery efforts that increase fish populations by 50 percent. (Layton, Brown, and Plummer 2001 in Richardson and Loomis 2008) **Quality of Estimate and Applicability: MEDIUM-HIGH-**Value from study of salmon recovery efforts in the Pacific Northwest, for Columbia Basin and Puget Sound salmon runs. **Scaling Issues:** Value represents households' willingness to pay for species recovery It would need to be scaled to reflect the extent to which a particular reclaimed water application would improve the survival of the species. In most cases, applications would have a very small effect on species survival as a whole. **Omissions, Biases, and Uncertainties:** Value may overestimate or underestimate the real willingness to pay to ensure the survival of the species. Considerable uncertainty will surround the appropriate scaling factor of any project, leading to greater uncertainty in the total value of this benefit.
Benefit: 3.E.5 Increased instream flows	

Description	Increased use of reclaimed water to augment stream flows or to displace the withdrawal of water from streams would enhance the ability of aquatic and streamside ecosystems to provide economically important goods and services, such as recreational opportunities, for the general public, and diminish the likelihood that a water utility would experience curtailment of its ability to withdraw water.
Key Beneficiaries	General public
Annual Quantity	*To be completed when specific project information becomes available.*
Unit Value	Approximately $40 per acre-foot per year
Comments on Unit Values	**Description and Source:** The median value of water for environmental purposes from a meta-analysis of water transactions in Washington between 1990 and 2003. Range of market prices for water purchased for environmental purposes in Washington is $3-$300. Median value was $37. (Brown 2004) **Quality of Estimate and Applicability: MEDIUM-LOW-**Represents recent transactions in Washington state, but not necessarily the Puget Sound region. Also, analysis is based on a small number of transactions, and study authors indicate a high level of uncertainty in drawing conclusions from these data. **Omissions, Biases, and Uncertainties:** Values reflect price of water under past conditions. As water demand increases and supply becomes more scarce we would expect the value of water to increase in the future. Value may underestimate the total value of ecosystem goods and services produced by enhancing downstream habitats by increasing instream flows, perhaps considerably.
Benefit: 3.E.6 Increased carbon sequestration and reduced greenhouse gas emissions	
Description	Increased use of reclaimed water to improve the health and functions of aquatic and streamside ecosystems would expand the ability of plants and trees to sequester carbon and dampen the anticipated adverse effects of climate change. Increased production of reclaimed water would increase the supply of biosolids available to supplant the use of fertilizers derived from fossil fuels. Reduced energy use from pumping groundwater or imported water reduces the emissions of greenhouse gases.
Key Beneficiaries	General public
Annual Quantity	*To be completed when specific project information becomes available.*
Unit Value	$40 per ton of carbon dioxide or carbon dioxide equivalent
Comments on Unit Values	**Description and Source:** Median value based on a range ($10 to $70) of the potential future price of carbon dioxide emissions, estimated by a consortium of western electric utilities. (Western Regional Transmission Expansion Partnership Economic Analysis Subcommittee 2007) **Quality of Estimate and Applicability: HIGH-**Represents a reasonable potential value of the price of carbon dioxide on national and global markets should carbon emissions become regulated. Similar prices are found in Europe, which is already regulating carbon emissions. **Omissions, Biases, and Uncertainty:** If current predictions of the impacts of climate change or the degree to which greenhouse gases must be controlled are underestimated, which seems likely (see Adam 2008) the price per ton of carbon dioxide could be substantially higher.
Benefit: 3.E.7 Increased nutrient cycling	
Description	Increased production of reclaimed water would increase the supply of biosolid fertilizer for use by agricultural and other users. King County WTD would enjoy additional revenue from the sale of the fertilizer, generating financial benefits for reclaimed water customers and ratepayers.
Key Beneficiaries	Agricultural and other users of biosolid nutrients King County WTD Customers/ratepayers
Annual Quantity	*To be completed when specific project information becomes available.*
Unit Value	*Values to be provided by King County WTD*
Comments on Unit Values	*We expect values will come directly from King County WTD's current prices for the sale of biosolids.*
Benefit: 3.R.1 Increased in-stream, near-stream, and wetland recreation	

Description	Increased use of reclaimed water to increase streamflows and streamside ecosystems directly or indirectly would enhance instream recreational opportunities, especially during the summer when flows are low. Boaters and other recreationists would derive benefits from the increased recreational opportunities, businesses selling recreation-related goods or services would experience increased sales, and nearby property values would increase.
Key Beneficiaries	Consumers of instream, near-stream, and wetland recreation opportunities Businesses that support recreation Owners of property near enhanced recreational opportunities Beneficiaries of the increase in the property-tax base
Annual Quantity	*To be completed when specific project information becomes available.*
Unit Value	Approximately $36 per person per day
Comments on Unit Values	**Description and Source:** Represents the net economic value associated with general recreation activities in the Pacific Northwest, per person per day from a meta-analysis of recreation valuation studies. (Loomis 2005) **Quality of Estimate and Applicability: MEDIUM-HIGH**-Represents a general value for recreation in the Puget Sound region. Values for specific kinds of recreation are available and may be considerably higher or lower than this value. **Omissions, Biases, and Uncertainty**: Value may underestimate or overestimate the actual value of recreation at a specific location. Studies show that the value people place on recreational opportunities increases with per-capita GDP, so this value could increase in the future.
Benefit: 3.R.2 Enhancement of green spaces for recreational use (e.g., golf courses, soccer fields, parks, etc.)	
Description	Increased use of reclaimed water for irrigation would facilitate the establishment of new green spaces and allow existing green spaces to be kept greener longer during the dry months. The additional amenities would benefit users, passers-by, and nearby residents. The (public or private) entities responsible for producing the green spaces would enjoy savings from lower irrigation costs. Businesses selling related goods and services (golf equipment, picnic baskets, etc.) would realize increased revenues from higher demand for their products.
Key Beneficiaries	Producers and consumers of goods and services of parks, golf courses, soccer fields, etc. Businesses selling goods and services associated with green spaces Owners of nearby properties
Annual Quantity	*To be completed when specific project information becomes available.*
Unit Value	Approximately $5 per person per day (see scaling issues) 2%–13% increase in property values (see scaling issues)
Comments on Unit Values	**Description and Source:** Represents the net economic value associated with recreation at a riparian-area urban park in Portland, Oregon. (David Evans and Associates Inc., and ECONorthwest 2004); Represents the increase in value of property within 1,500 feet of an urban park (low estimate) or golf course (high estimate), as measured in a hedonic study conducted in Portland, Oregon. (Lutzenhiser and Netusil 2001) **Quality of Estimate and Applicability: MEDIUM-HIGH**-Represents a recent valuation of specific recreation opportunities provided by enhanced greenspace in an urban setting in the Pacific Northwest**; MEDIUM-HIGH-**Value based on empirical data on property values gathered in in Portland, OR, a region with similar characteristics to Puget Sound. **Scaling Issues:** If a particular park already exists but is enhanced by the addition of reclaimed water, the change in recreational value or property value will likely be smaller than this estimate but may still be positive, assuming environmental quality is enhanced. **Omissions, Biases, and Uncertainty:** Value may underestimate or overestimate the actual value of recreation or increase in property values at a specific location. Specific recreation activities, such as golf, may have values considerably higher than this.
Benefit: 3.H.1 Reduced public health risk as urban trees irrigated by reclaimed water remove pollutants from the air	
Description	Increased use of reclaimed water to irrigate trees in urban areas would improve air quality insofar as the additional trees would filter toxins from the air.
Key Beneficiaries	General public
Annual Quantity	*To be completed when specific project information becomes available.*

Unit Value	Approximately $740 per ton CO Approximately $1,500 per ton NOx Approximately $2,500 per ton SO2 Approximately $4,000 per ton PM10 Approximately $2,000 per ton VOC
Comments on Unit Values	**Description and Source:** Represents median values from a meta-analysis of social damage estimates from air emissions, including the costs of health care associated with health impacts from pollutants. (Matthews and Lave 2000) **Quality of Estimate and Applicability:** We anticipate estimating benefits directly using the avoided-cost method. An assessment of reclaimed water uses incorporating this benefit would include the cost of a tree planting program. **Scaling Issues:** To the extent that trees in urban areas already exist, but are enhanced by the addition of reclaimed water, the improvement in air quality and public health will likely be smaller than this estimate, but positive. **Omissions, Biases, and Uncertainty:** Considerable uncertainty surrounds the underlying damage functions and chemical modeling used to calculate the social damage estimates for each of the studies included in the meta-analysis. These values may underestimate or overestimate the actual value of removing the pollutants.
Benefit: 3.ES.1 Increased property values (adjacent to suburban riparian greenways)	
Description	Increased use of reclaimed water to provide green space, improve instream water quality, or provide other environmental improvements would increase the value of nearby properties. Increased use of reclaimed water to increase the supply and/or reliability of water for municipal-industrial uses would stimulate economic growth and increase growth-related values of property in areas where tight supplies and/or restricted reliability would curtail growth.
Key Beneficiaries	General public
Annual Quantity	*To be completed when specific project information becomes available.*
Unit Value	10%–15% increase in property value (see scaling issues)
Comments on Unit Values	Description and Source: Represents the increase in value of property adjacent to riparian suburban greenways, as measured in a hedonic study conducted in British Columbia. (Quayle and Hamilton 1999) This is consistent with the findings of studies completed in the U.S. (Palone 1997, Mason 2001) **Quality of Estimate and Applicability: MEDIUM-HIGH-**Value based on empirical data gathered in British Columbia, a region with similar characteristics to Puget Sound. **Scaling Issues:** If riparian greenways already exist, but are enhanced by the addition of reclaimed water, the change in property value will likely be smaller than this estimate but positive, assuming environmental quality is enhanced. **Omissions, Biases, and Uncertainty:** This may overestimate or underestimate the actual effect on values of any specific project using reclaimed water.
Benefit: 3.ES.2 Increased property values (adjacent to urban parks)	
Description	Increased use of reclaimed water to provide green space, improve instream water quality, or provide other environmental improvements would increase the value of nearby properties. Increased use of reclaimed water to increase the supply and/or reliability of water for municipal-industrial uses would stimulate economic growth and increase growth-related values of property in areas where tight supplies and/or restricted reliability would curtail growth.
Key Beneficiaries	Property owners adjacent to urban parks Consumers of public services dependent on growth-related tax revenue
Annual Quantity	*To be completed when specific project information becomes available.*
Unit Value	Approximately 2% increase in property value (see scaling issues)

Comments on Unit Values	**Description and Source:** Represents the increase in value of property within 1,500 feet of an urban park, as measured in a hedonic study conducted in Portland, Oregon. (Lutzenhiser and Netusil 2001) **Quality of Estimate and Applicability: MEDIUM-HIGH-**Value based on empirical data gathered in in Portland, OR, a region with similar characteristics to Puget Sound. **Scaling Issues:** If a particular park already exists but is enhanced by the addition of reclaimed water, the change in property value will likely be smaller than this estimate but may still be positive, assuming environmental quality is enhanced. **Omissions, Biases, and Uncertainty:** This may overestimate or underestimate the actual effect on values of any specific project using reclaimed water.
Benefit: 3.ES.3 Increased property values (adjacent to golf courses)	
Description	Increased use of reclaimed water to provide green space, improve instream water quality, or provide other environmental improvements would increase the value of nearby properties. Increased use of reclaimed water to increase the supply and/or reliability of water for municipal-industrial uses would stimulate economic growth and increase growth-related values of property in areas where tight supplies and/or restricted reliability would curtail growth.
Key Beneficiaries	Property owners adjacent to golf courses Consumers of public services dependent on growth-related tax revenue
Annual Quantity	*To be completed when specific project information becomes available.*
Unit Value	Approximately 13% increase in property value (see scaling issues)
Comments on Unit Values	**Description and Source:** Represents the increase in value of property within 1,500 feet of a golf course, as measured in a hedonic study conducted in Portland, Oregon. (Lutzenhiser and Netusil 2001) **Quality of Estimate and Applicability: MEDIUM-HIGH-**Value based on empirical data gathered in in Portland, OR, a region with similar characteristics to Puget Sound. **Scaling Issues:** If a golf course already exists but is enhanced by the addition of reclaimed water, the change in property value will likely be smaller than this estimate but may still be positive, assuming environmental quality is enhanced. **Omissions, Biases, and Uncertainty:** This may overestimate or underestimate the actual effect on values of any specific project using reclaimed water.
Benefit: 3.ES.4 Savings in fertilizer usage	
Description	Residual nutrients in reclaimed water would fertilize land where used for irrigation, decreasing the amount and cost of additional fertilizer applications.
Key Beneficiaries	Agricultural producers Consumers of agricultural products General public
Annual Quantity	*To be completed when specific project information becomes available.*
Unit Value	Approximately $42 per acre-foot of water applied
Comments on Unit Values	**Description and Source:** Represents the value of offset fertilizer use per acre-foot of water applied in agricultural and landscaping purposes that would otherwise require other sources of fertilizer. (King County WTD 2008) **Quality of Estimate and Applicability:** We anticipate estimating benefits directly using the avoided cost method.
Benefit: 3.ES.5 Commercial salmon harvest	
Description	Increased production and use of reclaimed water would result in improved aquatic and marine habitat for salmon. Larger salmon populations would increase the catch available to the commercial salmon industry. The increased supply of wild salmon would lower prices for consumers; increased salmon consumption would have health benefits for consumers.
Key Beneficiaries	Commercial salmon industry Consumers of wild salmon
Annual Quantity	*To be completed when specific project information becomes available.*
Unit Value	Approximately $7 million per year (see scaling issues)

Comments on Unit Values	**Description and Source:** Value based on the average annual value of the commercial salmon harvest in Puget Sound. (Industrial Economics 2006) **Quality of Estimate and Applicability: HIGH-**Value estimated recently in Puget Sound. **Scaling Issues:** Represents total value of the commercial salmon harvest each year. It would need to be scaled to reflect the extent to which a particular reclaimed water application would affect the value (e.g., total catch, per-unit price, etc.). In most cases, applications would have a very small effect. **Omissions, Biases, and Uncertainty:** Actual value of commercial salmon harvest may vary sometimes considerably, from year to year.
Benefit: 3.ES.6 Recreational salmon harvest	
Description	Increased production and use of reclaimed water would result in improved aquatic and marine habitat for salmon. Larger salmon populations would increase the catch available to the salmon anglers, and generate additional demand for related businesses. The increased catch and consumption of salmon would have health benefits for consumers.
Key Beneficiaries	Salmon anglers Businesses in the recreational fishing industry Consumers of wild salmon
Annual Quantity	*To be completed when specific project information becomes available.*
Unit Value	Approximately $4 per additional fish caught
Comments on Unit Values	**Description and Source:** Represents the willingness to pay for catching an additional fish by recreational salmon anglers on the Willamette and Clackamas Rivers in northwestern Oregon. (Berrens, Berland, and Adams 1993) **Quality of Estimate and Applicability: MEDIUM**-Represents the value of catching an additional fish to salmon anglers in the Pacific Northwest. Conditions and characteristics of anglers, and hence the value they place on catching a fish, may be considerably different between the rivers in the study and the Puget Sound. Value is also somewhat dated. **Omissions, Biases, and Uncertainty:** Value may overestimate or underestimate the value of enhancing the recreational salmon harvest in Puget Sound. Value measured in a river environment, so may not accurately represent values for marine angling.
Benefit: 3.ES.7 Flood protection	
Description	Increased use of reclaimed water to expand existing wetlands and create new ones could expand their ability, under some conditions, to absorb water, retard water flows, and diminish downstream flooding.
Key Beneficiaries	General public
Annual Quantity	*To be completed when specific project information becomes available.*
Unit Value	Approximately $40,000 per acre (a one-time benefit)
Comments on Unit Values	**Description and Source:** Median value of flood protection provided by restored wetlands in Lynnwood and Renton, Washington. Study based on substitution costs of constructed flood storage for storage provided by existing wetlands. (Leschine 1997) **Quality of Estimate and Applicability: MEDIUM-**Represents the value of flood storage provided by wetlands in two watersheds in Puget Sound for specific storm events. Transferring this value to other wetlands depends on the similarity of the flood storage provided by other wetlands, the relevant storm size, and potentially other factors. An assessment of reclaimed water uses incorporating this benefit would include the cost of creating the flood retention area or wetland. **Omissions, Biases, and Uncertainty:** Value may overestimate or underestimate the actual value of flood protection provided by wetlands.
Benefit: 3.ES.8 Avoided energy costs to businesses and local industry (electricity)	
Description	Increased use of reclaimed water to heat and/or cool buildings would lower energy costs.
Key Beneficiaries	Building owners Customers
Annual Quantity	*To be completed when specific project information becomes available.*
Unit Value	$0.08 per kWh (or current relevant electricity rate)

Comments on Unit Values	**Description and Source:** Value based on the current (Nov. 08) average electricity rate for large and small demand general service. Rates range from $0.06-$0.10 based on the timing and quantity of use. (Puget Sound Energy 2008a, Seattle City Light 2008) **Quality of Estimate and Applicability:** We anticipate estimating benefits directly using the avoided cost method.

Benefit: 3.ES.9 Avoided energy costs to businesses and local industry (natural gas)	
Description	Increased use of reclaimed water to heat and/or cool buildings would lower energy costs.
Key Beneficiaries	Building owners Customers
Annual Quantity	*To be completed when specific project information becomes available.*
Unit Value	$1.20 per therm (or current relevant natural gas rate)
Comments on Unit Values	**Description and Source:** Value based on the current (November 2008) natural gas rate for commercial and industrial. (Puget Sound Energy 2008b) **Quality of Estimate and Applicability:** We anticipate estimating benefits directly using the avoided cost method.

Footnotes

[1] We use the term "reclaimed water utility" as a shorthand to facilitate our reference to expected situations where King County WTD would deliver RH20 to a water utility, which would distribute it.

Table 4. Potential Economic Benefits of Reclaimed Water that Can Be Described Qualitatively (WateReuse Template 7, Qualitative Benefits Description)	
General Notes: *The intent of this table is to describe potential benefits that may arise from expansion of the reclaimed water program in King County. Only a subset of these likely will be relevant to any specific action. In some instances, the table includes alternative descriptions of a potential benefit; these should not be used to double-count the benefit.*	
Benefit: 5.D.1 Increased flexibility regarding disposition of treated effluent	
Description	On-going environmental deterioration, population growth, climate change, and other factors are likely to put additional stress on water quality and quantity issues in Puget Sound. Increased production of reclaimed water would provide King County with another option for disposing of treated effluent. The level of benefit resulting from increased flexibility regarding disposition of treated effluent would be case-specific.
Key Beneficiaries	King County WTD Customers/ratepayers
Relative Importance	*To be completed when specific project information becomes available.*
Benefit: 5.D.2 Increased water-supply flexibility and reliability	
Description	Increased supply of reclaimed water would supplement other water supplies available to water utilities, giving them more options for meeting customers' demands at lower cost, increasing service reliability, and deferring rate increases. The level of benefit resulting from increased water-supply flexibility and reliability from using reclaimed water would be case-specific.
Key Beneficiaries	Water utility Customers/ratepayers Reclaimed water utility[1]
Relative Importance	*To be completed when specific project information becomes available.*
Benefit: 5.E.1 Reduced risk of subsidence resulting from declining groundwater levels	
Description	Increased use of reclaimed water to recharge aquifers or substitute for water that otherwise would be pumped from aquifers would raise groundwater levels and reduce subsidence risk. The level of benefit resulting from reduced risk of subsidence from using reclaimed water would be case-specific.
Key Beneficiaries	General public, especially those affected by subsidence from declining groundwater levels
Relative Importance	*To be completed when specific project information becomes available.*
Benefit: 5.E.2 Enhanced coastal ecosystems	
Description	Increased production of reclaimed water would decrease wastewater discharges, reducing pollutants which degrade the health and functions of coastal ecosystems that provide valuable goods and services to the general public. The level of benefit resulting from enhanced coastal ecosystems from a particular application of reclaimed water would be case-specific.
Key Beneficiaries	General public
Relative Importance	*To be completed when specific project information becomes available.*
Benefit: 5.E.3 Enhanced protection for utilities' source-water areas	
Description	Increased use of reclaimed water as a substitute for water from natural sources would protect levels of source water available for later use and decrease ecological disturbance of watersheds providing water for utilities and other purposes. Utilities and their customer/ratepayers would enjoy cost savings; the general public would enjoy environmental benefits. The level of benefit resulting from enhanced protection for utilities' source-water areas from using reclaimed water would be case-specific.
Key Beneficiaries	Water utility Customers/ratepayers General public

Relative Importance	*To be completed when specific project information becomes available.*

Benefit: 5.E.4 Improvements in water quality (e.g., temperature, toxic substances, sediment, etc.)

Description	Increased production of reclaimed water would decrease discharge of wastewater pollutants in receiving water bodies. Increased direct or indirect use of reclaimed water to augment streamflows in impaired water bodies would dilute existing pollutants and improve water quality. The level of benefit resulting from improvements in water quality from a particular application of reclaimed water would be case-specific.
Key Beneficiaries	General public
Relative Importance	*To be completed when specific project information becomes available.*

Benefit: 5.ES.1 Increased economic growth

Description	Increased production and use of reclaimed water would stimulate economic activity in related businesses. Increased availability of reclaimed water would support general economic growth insofar as it would relax constraints associated with the quantity, reliability, and environmental impacts of municipal-industrial water systems. General economic growth would yield financial benefits for growth-relate businesses, property owners, and public services. Increased economic growth related to a particular application of reclaimed water would be case-specific. Effects from increased economic growth may include changes in expenditures, changes in the supply of goods and services, changes in amenities and quality of life, and changes in the cost of doing business. Changes in jobs and incomes resulting from increased production of reclaimed water are not the same as the changes in the supply of goods and services resulting from the reclaimed water comprehensive plan. First-order impacts would be offset, more or less, by second-order effects that would materialize if, for example, new jobs drew resources away from jobs elsewhere in the county. If net expenditures or employment increase however, a project would provide a net stimulus.
Key Beneficiaries	Reclaimed water-related businesses Growth-related businesses Owners of property that experiences growth-related increases in value Consumers of public services dependent on growth-related tax revenues
Relative Importance	*To be completed when specific project information becomes available.*

Benefit: 5.ES.2 Increased ability for water projects to leverage other community projects

Description	Increased use of reclaimed water would enable the development of community projects that otherwise would not be possible due to water supply constraints, or a lack of an affordable, reliable supply of water in an appropriate location. The level of benefit resulting from leveraging other community projects with a particular application of reclaimed water would be case-specific.
Key Beneficiaries	Reclaimed water-related businesses Growth-related businesses Owners of property that experiences growth-related increases in value Consumers of public services dependent on growth-related tax revenues
Relative Importance	*To be completed when specific project information becomes available.*

Benefit: 5.ES.3 Improved management of water resources

Description	Increased use of reclaimed water, displacing the use of potable water for customers and uses that don't require it, would increase the supply of potable water for other customers and uses, and decrease the local water utility's exposure to the decisions of environmental regulators, non-local water suppliers, and other external entities. If a project decreases the likelihood that other water users with senior rights outside of King County's jurisdiction will capture flows that could be put to beneficial use by King County, the project provides a valuable benefit. Water utilities elsewhere that do not have primacy for their entire water supply have made major and costly capital investments in the form of pipelines, reservoirs, desalination plants, and water reuse purely to meet this benefit. These costs represent at a minimum, the benefit of local control. If King County is able to avoid such a situation with a project, the project will provide an equivalent benefit.
Key Beneficiaries	Water utilities Reclaimed water utilities General public

Relative Importance	*To be completed when specific project information becomes available.*
Benefit: 5.ES.4 Reinforced cultural/spiritual values	
Description	Increased production and use of reclaimed water would enhance attributes of the environment having cultural/spiritual value. The level of benefit related to reinforced cultural/spiritual values resulting from a particular application of reclaimed water would be case-specific.
Key Beneficiaries	Individuals who derive cultural/spiritual value from environmental resources enhanced by the use of reclaimed water
Relative Importance	*To be completed when specific project information becomes available.*
Benefit: 5.ES.5 Reinforced cultural values associated with a conservation ethic	
Description	Increased production and use of reclaimed water would respond to preferences of some individuals, businesses, and groups for diminishing impacts on the environment. The level of benefit related to reinforced cultural values associated with a conservation ethic resulting from a particular application of reclaimed water would be case-specific.
Key Beneficiaries	Individuals who derive value from actions that promote natural-resource conservation
Relative Importance	*To be completed when specific project information becomes available.*
Benefit: 5.ES.6 Enhanced aesthetic values	
Description	Increased use of reclaimed water would lead to improvements in green space, instream water quality, reduced discharge of effluent in Puget Sound, and other natural-resource amenities from which people derive aesthetic value. The increase in value would affect the value of nearby properties, the level of activity in real-estate, tourism/recreation, and other industries, and the revenue public entities derived from the increases to support the provision of public services. The level of benefit related to enhanced aesthetic values resulting from a particular application of reclaimed water would be case-specific.
Key Beneficiaries	Consumers of natural-resource amenities enhanced by reclaimed water Owners of properties near the enhanced amenities Businesses associated with the enhanced amenities Consumers of public services dependent on values and activities derived from the enhanced amenities
Relative Importance	*To be completed when specific project information becomes available.*
Benefit: 5.ES.7 Increased agricultural production	
Description	Increased use of reclaimed water for irrigation at prices lower than alternative supplies (if available) would increase the supply of locally produced agricultural supplies available to consumers, increase farmers' net revenues, and reinforce efforts to prevent farmland from being converted to other uses. The level of benefit arising from increased agricultural production related to a particular application of reclaimed water would be case-specific.
Key Beneficiaries	Agricultural producers Consumers of agricultural products General public
Relative Importance	*To be completed when specific project information becomes available.*
Benefit: 5.ES.8 Increased reliability of water supplies for agricultural irrigation	
Description	Increased access to reclaimed water for irrigation would induce farmers to undertake production of higher-value crops requiring reliable source of irrigation water. The level of benefit arising from increased reliability of water supplies for agricultural production would be case-specific.
Key Beneficiaries	Agricultural producers Consumers of agricultural products General public

Relative Importance	*To be completed when specific project information becomes available.*

Benefit: 5.ES.9 Reductions in risks associated with population and economic growth

Description	Increased production and use of reclaimed water would provide an additional source of water to meet demands associated with population growth, resulting in less risk of water shortages and less cost associated with meeting new water-supply demands. The level of decreased risk associated with the potential impacts on water supply, ecosystem goods and services, and demand for water resources from increased population and economic growth in the region, would be case-specific.
Key Beneficiaries	General public
Relative Importance	*To be completed when specific project information becomes available.*

Benefit: 5.ES.10 Reductions in risk associated with climate change

Description	Increased production and use of reclaimed water would provide an additional source of water to meet demand in the face of potential water shortages associated with anticipated increases in the incidence of low stream flows during summer months and increased interannual variation in stream flows. The level of decreased risk associated with reductions in impacts of climate change directly, such as changes in ecosystem functions, increased insect and disease outbreaks, and increased fire, drought, and other events, as well as changes in society's response to climate change, including implementation of regulation to control greenhouse gas emissions and other adaptation and mitigation measures, would be case-specific
Key Beneficiaries	General public
Relative Importance	*To be completed when specific project information becomes available.*

Benefit: 5.ES.11 Increased public education

Description	Increased production and use of reclaimed water would generate opportunities to provide the public with information on the benefits of water reuse and conservation. The level of benefit of public education resulting from a particular application of reclaimed water would be case-specific.
Key Beneficiaries	General public
Relative Importance	*To be completed when specific project information becomes available.*

Benefit: 5.ES.12 Reduced risk of enforcement/litigation costs associated with water rights

Description	Increased use of reclaimed water, by displacing the use of water from a stream or aquifer, would allow a water utility or industrial water user to avoid bumping against the limits of its existing water rights and incurring costs to develop additional water rights. The state and interested third parties would avoid costs associated with clarifying the boundaries of existing water rights or evaluating an application for new water rights. Enforcement/litigation costs avoided by the use of reclaimed water would be case-specific.
Key Beneficiaries	General public Water utility Customers/ratepayers Taxpayers
Relative Importance	*To be completed when specific project information becomes available.*

Footnotes

[1] We use the term "reclaimed water utility" as a shorthand to facilitate our reference to expected situations where King County WTD would deliver RH20 to a water utility, which would distribute it.

Appendix B
Quantitative Benefit Calculation Details

Benefit WW-4: Reclaimed water revenues (King County)

Calculation algorithm:

[A] x [B]; where:
[A] = reclaimed water volume sold (by King County to District), varies through time and by alternative
[B] = reclaimed water price = percentage of SPU wholesale rate

Inputs (Best Guess, BG, listed first):

[A] = RW Use Categories 1 + 2 (table below, green highlighted + yellow highlighted); Low Value = 0% of BG; High Value = 110% of BG

[B] = $1,893/mg (based on 80%); Low Value = $1,183/mg (based on 50%); High Value = $2,366/mg (based on 100%)

		RW Alternative 1-A						RW Alternative 1-B						RW Alternative 2-A						RW Alternative 2-B					
		RW Use Category 1		RW Use Category 2		RW Use Category 3		RW Use Category 1		RW Use Category 2		RW Use Category 3		RW Use Category 1		RW Use Category 2		RW Use Category 3		RW Use Category 1		RW Use Category 2		RW Use Category 3	
Year	Note About Key Years	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)
2020	Phase 1 Design Point	5	14	64	197	0	0	5	14	64	197	536	1,646	13	40	164	505	0	0	13	40	164	505	1,483	4,553
2021		5	14	64	197	0	0	5	14	64	197	536	1,646	13	40	164	505	0	0	13	40	164	505	1,483	4,553
2022		5	14	64	197	0	0	5	14	64	197	536	1,646	13	40	164	505	0	0	13	40	164	505	1,483	4,553
2023		5	14	64	197	0	0	5	14	64	197	536	1,646	13	40	164	505	0	0	13	40	164	505	1,483	4,553
2024		5	14	64	197	0	0	5	14	64	197	536	1,646	13	40	164	505	0	0	13	40	164	505	1,483	4,553
2025		5	14	64	197	0	0	5	14	64	197	536	1,646	13	40	164	505	0	0	13	40	164	505	1,483	4,553
2026		5	14	64	197	0	0	5	14	64	197	536	1,646	13	40	164	505	0	0	13	40	164	505	1,483	4,553
2027		5	14	64	197	0	0	5	14	64	197	536	1,646	13	40	164	505	0	0	13	40	164	505	1,483	4,553
2028		5	14	64	197	0	0	5	14	64	197	536	1,646	13	40	164	505	0	0	13	40	164	505	1,483	4,553
2029		5	14	64	197	0	0	5	14	64	197	536	1,646	13	40	164	505	0	0	13	40	164	505	1,483	4,553
2030		15	45	92	282	0	0	15	45	92	282	553	1,698	24	73	174	535	0	0	24	73	174	535	1,871	5,744
2031		15	45	92	282	0	0	15	45	92	282	553	1,698	24	73	174	535	0	0	24	73	174	535	1,871	5,744
2032		15	45	92	282	0	0	15	45	92	282	553	1,698	24	73	174	535	0	0	24	73	174	535	1,871	5,744
2033		15	45	92	282	0	0	15	45	92	282	553	1,698	24	73	174	535	0	0	24	73	174	535	1,871	5,744
2034		15	45	92	282	0	0	15	45	92	282	553	1,698	24	73	174	535	0	0	24	73	174	535	1,871	5,744
2035		15	45	92	282	0	0	15	45	92	282	553	1,698	24	73	174	535	0	0	24	73	174	535	1,871	5,744
2036		15	45	92	282	0	0	15	45	92	282	553	1,698	24	73	174	535	0	0	24	73	174	535	1,871	5,744
2037		15	45	92	282	0	0	15	45	92	282	553	1,698	24	73	174	535	0	0	24	73	174	535	1,871	5,744
2038		15	45	92	282	0	0	15	45	92	282	553	1,698	24	73	174	535	0	0	24	73	174	535	1,871	5,744
2039		15	45	92	282	0	0	15	45	92	282	553	1,698	24	73	174	535	0	0	24	73	174	535	1,871	5,744
2040		25	76	119	367	0	0	25	76	119	367	570	1,750	35	106	184	566	0	0	35	106	184	566	2,259	6,935
2041		25	76	119	367	0	0	25	76	119	367	570	1,750	35	106	184	566	0	0	35	106	184	566	2,259	6,935
2042		25	76	119	367	0	0	25	76	119	367	570	1,750	35	106	184	566	0	0	35	106	184	566	2,259	6,935
2043		25	76	119	367	0	0	25	76	119	367	570	1,750	35	106	184	566	0	0	35	106	184	566	2,259	6,935
2044		25	76	119	367	0	0	25	76	119	367	570	1,750	35	106	184	566	0	0	35	106	184	566	2,259	6,935
2045		25	76	119	367	0	0	25	76	119	367	570	1,750	35	106	184	566	0	0	35	106	184	566	2,259	6,935
2046		25	76	119	367	0	0	25	76	119	367	570	1,750	35	106	184	566	0	0	35	106	184	566	2,259	6,935
2047		25	76	119	367	0	0	25	76	119	367	570	1,750	35	106	184	566	0	0	35	106	184	566	2,259	6,935
2048		25	76	119	367	0	0	25	76	119	367	570	1,750	35	106	184	566	0	0	35	106	184	566	2,259	6,935
2049		25	76	119	367	0	0	25	76	119	367	570	1,750	35	106	184	566	0	0	35	106	184	566	2,259	6,935
2050	Phase 2 Design Point	35	107	147	451	0	0	35	107	147	451	587	1,802	45	139	194	597	0	0	45	139	194	597	2,647	8,126

Benefit WU-1: Reclaimed water revenues (Covington Water District)

Calculation algorithm:

([A] x [B]) - ([C] x [D]) - ([E] x [F]); where:
[A] = reclaimed water volume sold (only to current non-District customers), varies through time and by alternative
[B] = reclaimed water price (that District charges customers) = percentage of District potable irrigation rate
[C] = reclaimed water volume sold (by King County to District), varies through time and by alternative
[D] = reclaimed water price (that County charges District) = percentage of SPU wholesale rate
[E] = reclaimed water volume sold to current District customers (that switch from potable to reclaim), varies through time and by alternative; this reflects a potential loss in revenue from these customers
[F] = portion of revenue lost on unit basis = percentage of District potable irrigation rate (inversely proportional to percentage of potable rate that defines reclaimed water charge)

Inputs (Best Guess, BG, listed first):

[A] = RW Use Category 2 (table below, yellow highlighted); Low Value = 0% of BG; High Value = 110% of BG

[B] = $6,877/mg (based on 80%); Low Value = $4,298/mg (based on 50%); High Value = $8,596/mg (based on 100%)

[C] = RW Use Categories 1 + 2 (table below, green highlighted + yellow highlighted); Low Value = 0% of BG; High Value = 110% of BG

[D] = $1,893/mg (based on 80% of SPU); Low Value = $1,183/mg (based on 50%); High Value = $2,366/mg (based on 100%)

[E] = RW Use Category 1 (table below, green highlighted); Low Value = 50% of BG; High Value = 110% of BG

[F] = $1,719/mg (based on 20% of potable); Low Value = $0/mg (based on 0%); High Value = $4,298/mg (based on 50%)

Breakdown of Annual Reclaimed Water Uses, by Alternative, Category, and Time

Reclaimed Water Alternatives:
1-A: Black Diamond (Seasonal)
1-B: Black Diamond (Year-Round)
2-A: Pump Station D (Seasonal)
2-B: Pump Station D (Year-Round)

Reclaimed Water Use Categories:
1: Offset Covington Water District Potable Water Demand
2: Offset Non-District Potable Water Demand
3: Environmental Enhancement (Infiltration)

		RW Alternative 1-A						RW Alternative 1-B						RW Alternative 2-A						RW Alternative 2-B					
		RW Use Category 1		RW Use Category 2		RW Use Category 3		RW Use Category 1		RW Use Category 2		RW Use Category 3		RW Use Category 1		RW Use Category 2		RW Use Category 3		RW Use Category 1		RW Use Category 2		RW Use Category 3	
Year	Note About Key Years	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)
2020	Phase 1 Design Point	5	14	64	197	0	0	5	14	64	197	536	1,646	13	40	164	505	0	0	13	40	164	505	1,483	4,553
2021		5	14	64	197	0	0	5	14	64	197	536	1,646	13	40	164	505	0	0	13	40	164	505	1,483	4,553
2022		5	14	64	197	0	0	5	14	64	197	536	1,646	13	40	164	505	0	0	13	40	164	505	1,483	4,553
2023		5	14	64	197	0	0	5	14	64	197	536	1,646	13	40	164	505	0	0	13	40	164	505	1,483	4,553
2024		5	14	64	197	0	0	5	14	64	197	536	1,646	13	40	164	505	0	0	13	40	164	505	1,483	4,553
2025		5	14	64	197	0	0	5	14	64	197	536	1,646	13	40	164	505	0	0	13	40	164	505	1,483	4,553
2026		5	14	64	197	0	0	5	14	64	197	536	1,646	13	40	164	505	0	0	13	40	164	505	1,483	4,553
2027		5	14	64	197	0	0	5	14	64	197	536	1,646	13	40	164	505	0	0	13	40	164	505	1,483	4,553
2028		5	14	64	197	0	0	5	14	64	197	536	1,646	13	40	164	505	0	0	13	40	164	505	1,483	4,553
2029		5	14	64	197	0	0	5	14	64	197	536	1,646	13	40	164	505	0	0	13	40	164	505	1,483	4,553
2030		15	45	92	282	0	0	15	45	92	282	553	1,698	24	73	174	535	0	0	24	73	174	535	1,871	5,744
2031		15	45	92	282	0	0	15	45	92	282	553	1,698	24	73	174	535	0	0	24	73	174	535	1,871	5,744
2032		15	45	92	282	0	0	15	45	92	282	553	1,698	24	73	174	535	0	0	24	73	174	535	1,871	5,744
2033		15	45	92	282	0	0	15	45	92	282	553	1,698	24	73	174	535	0	0	24	73	174	535	1,871	5,744
2034		15	45	92	282	0	0	15	45	92	282	553	1,698	24	73	174	535	0	0	24	73	174	535	1,871	5,744
2035		15	45	92	282	0	0	15	45	92	282	553	1,698	24	73	174	535	0	0	24	73	174	535	1,871	5,744
2036		15	45	92	282	0	0	15	45	92	282	553	1,698	24	73	174	535	0	0	24	73	174	535	1,871	5,744
2037		15	45	92	282	0	0	15	45	92	282	553	1,698	24	73	174	535	0	0	24	73	174	535	1,871	5,744
2038		15	45	92	282	0	0	15	45	92	282	553	1,698	24	73	174	535	0	0	24	73	174	535	1,871	5,744
2039		15	45	92	282	0	0	15	45	92	282	553	1,698	24	73	174	535	0	0	24	73	174	535	1,871	5,744
2040		25	76	119	367	0	0	25	76	119	367	570	1,750	35	106	184	566	0	0	35	106	184	566	2,259	6,935
2041		25	76	119	367	0	0	25	76	119	367	570	1,750	35	106	184	566	0	0	35	106	184	566	2,259	6,935
2042		25	76	119	367	0	0	25	76	119	367	570	1,750	35	106	184	566	0	0	35	106	184	566	2,259	6,935
2043		25	76	119	367	0	0	25	76	119	367	570	1,750	35	106	184	566	0	0	35	106	184	566	2,259	6,935
2044		25	76	119	367	0	0	25	76	119	367	570	1,750	35	106	184	566	0	0	35	106	184	566	2,259	6,935
2045		25	76	119	367	0	0	25	76	119	367	570	1,750	35	106	184	566	0	0	35	106	184	566	2,259	6,935
2046		25	76	119	367	0	0	25	76	119	367	570	1,750	35	106	184	566	0	0	35	106	184	566	2,259	6,935
2047		25	76	119	367	0	0	25	76	119	367	570	1,750	35	106	184	566	0	0	35	106	184	566	2,259	6,935
2048		25	76	119	367	0	0	25	76	119	367	570	1,750	35	106	184	566	0	0	35	106	184	566	2,259	6,935
2049		25	76	119	367	0	0	25	76	119	367	570	1,750	35	106	184	566	0	0	35	106	184	566	2,259	6,935
2050	Phase 2 Design Point	35	107	147	451	0	0	35	107	147	451	587	1,802	45	139	194	597	0	0	45	139	194	597	2,647	8,126

Benefit SS-1: Avoided groundwater pumping costs

Calculation algorithm:

[A] x [B] x [factor]; where:
[A] = price of power (in $/kW-hr)
[B] = volume of self-supplied user water replaced with reclaimed water
[factor] = calculation constant = 602

Inputs (Best Guess, BG, listed first):

[A] = $0.09/kW-hr (based on approx current PSE rate); Low Value = $0.07/kW-hr; High Value = $0.11/kW-hr

[B] = "RW Use Category 2" column in table below (table below, yellow highlighted); Low Value = 0% of BG; High Value = 110% of BG

		RW Alternative 1-A						RW Alternative 1-B						RW Alternative 2-A						RW Alternative 2-B					
		RW Use Category 1		RW Use Category 2		RW Use Category 3		RW Use Category 1		RW Use Category 2		RW Use Category 3		RW Use Category 1		RW Use Category 2		RW Use Category 3		RW Use Category 1		RW Use Category 2		RW Use Category 3	
Year	Note About Key Years	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)
2020	Phase 1 Design Point	5	14	64	197	0	0	5	14	64	197	536	1,646	13	40	164	505	0	0	13	40	164	505	1,483	4,553
2021		5	14	64	197	0	0	5	14	64	197	536	1,646	13	40	164	505	0	0	13	40	164	505	1,483	4,553
2022		5	14	64	197	0	0	5	14	64	197	536	1,646	13	40	164	505	0	0	13	40	164	505	1,483	4,553
2023		5	14	64	197	0	0	5	14	64	197	536	1,646	13	40	164	505	0	0	13	40	164	505	1,483	4,553
2024		5	14	64	197	0	0	5	14	64	197	536	1,646	13	40	164	505	0	0	13	40	164	505	1,483	4,553
2025		5	14	64	197	0	0	5	14	64	197	536	1,646	13	40	164	505	0	0	13	40	164	505	1,483	4,553
2026		5	14	64	197	0	0	5	14	64	197	536	1,646	13	40	164	505	0	0	13	40	164	505	1,483	4,553
2027		5	14	64	197	0	0	5	14	64	197	536	1,646	13	40	164	505	0	0	13	40	164	505	1,483	4,553
2028		5	14	64	197	0	0	5	14	64	197	536	1,646	13	40	164	505	0	0	13	40	164	505	1,483	4,553
2029		5	14	64	197	0	0	5	14	64	197	536	1,646	13	40	164	505	0	0	13	40	164	505	1,483	4,553
2030		15	45	92	282	0	0	15	45	92	282	553	1,698	24	73	174	535	0	0	24	73	174	535	1,871	5,744
2031		15	45	92	282	0	0	15	45	92	282	553	1,698	24	73	174	535	0	0	24	73	174	535	1,871	5,744
2032		15	45	92	282	0	0	15	45	92	282	553	1,698	24	73	174	535	0	0	24	73	174	535	1,871	5,744
2033		15	45	92	282	0	0	15	45	92	282	553	1,698	24	73	174	535	0	0	24	73	174	535	1,871	5,744
2034		15	45	92	282	0	0	15	45	92	282	553	1,698	24	73	174	535	0	0	24	73	174	535	1,871	5,744
2035		15	45	92	282	0	0	15	45	92	282	553	1,698	24	73	174	535	0	0	24	73	174	535	1,871	5,744
2036		15	45	92	282	0	0	15	45	92	282	553	1,698	24	73	174	535	0	0	24	73	174	535	1,871	5,744
2037		15	45	92	282	0	0	15	45	92	282	553	1,698	24	73	174	535	0	0	24	73	174	535	1,871	5,744
2038		15	45	92	282	0	0	15	45	92	282	553	1,698	24	73	174	535	0	0	24	73	174	535	1,871	5,744
2039		15	45	92	282	0	0	15	45	92	282	553	1,698	24	73	174	535	0	0	24	73	174	535	1,871	5,744
2040		25	76	119	367	0	0	25	76	119	367	570	1,750	35	106	184	566	0	0	35	106	184	566	2,259	6,935
2041		25	76	119	367	0	0	25	76	119	367	570	1,750	35	106	184	566	0	0	35	106	184	566	2,259	6,935
2042		25	76	119	367	0	0	25	76	119	367	570	1,750	35	106	184	566	0	0	35	106	184	566	2,259	6,935
2043		25	76	119	367	0	0	25	76	119	367	570	1,750	35	106	184	566	0	0	35	106	184	566	2,259	6,935
2044		25	76	119	367	0	0	25	76	119	367	570	1,750	35	106	184	566	0	0	35	106	184	566	2,259	6,935
2045		25	76	119	367	0	0	25	76	119	367	570	1,750	35	106	184	566	0	0	35	106	184	566	2,259	6,935
2046		25	76	119	367	0	0	25	76	119	367	570	1,750	35	106	184	566	0	0	35	106	184	566	2,259	6,935
2047		25	76	119	367	0	0	25	76	119	367	570	1,750	35	106	184	566	0	0	35	106	184	566	2,259	6,935
2048		25	76	119	367	0	0	25	76	119	367	570	1,750	35	106	184	566	0	0	35	106	184	566	2,259	6,935
2049		25	76	119	367	0	0	25	76	119	367	570	1,750	35	106	184	566	0	0	35	106	184	566	2,259	6,935
2050	Phase 2 Design Point	35	107	147	451	0	0	35	107	147	451	587	1,802	45	139	194	597	0	0	45	139	194	597	2,647	8,126

Benefit GP-1: Instream flows

Calculation algorithm:

[A] x [B]; where:
[A] = reclaimed water used to increase instream flows (directly through enviro enhancement and indirectly through source substitution), varies through time and by alternative
[B] = unit value (from County benefits work, "initial list")

Inputs (Best Guess, BG, listed first):

[A] = "SUBTOTAL" column in table below (RW Use Category 2 + RW Use Category 3 (June-Oct only) (table below, yellow highlighted); Low Value = 25% of BG; High Value = 110% of BG

[B] = $37/acre-foot (based on median); Low Value = $3/acre-foot (based on range); High Value = $300/acre-foot (based on range)

	RW Alternative 1-A							
	RW Use Category 1		RW Use Category 2		RW Use Category 3		SUBTOTAL	
Year Note About Key Years	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)
2020 Phase 1 Design Point	5	14	64	197	0	0	64	197
2021	5	14	64	197	0	0	64	197
2022	5	14	64	197	0	0	64	197
2023	5	14	64	197	0	0	64	197
2024	5	14	64	197	0	0	64	197
2025	5	14	64	197	0	0	64	197
2026	5	14	64	197	0	0	64	197
2027	5	14	64	197	0	0	64	197
2028	5	14	64	197	0	0	64	197
2029	5	14	64	197	0	0	64	197
2030	15	45	92	282	0	0	92	282
2031	15	45	92	282	0	0	92	282
2032	15	45	92	282	0	0	92	282
2033	15	45	92	282	0	0	92	282
2034	15	45	92	282	0	0	92	282
2035	15	45	92	282	0	0	92	282
2036	15	45	92	282	0	0	92	282
2037	15	45	92	282	0	0	92	282
2038	15	45	92	282	0	0	92	282
2039	15	45	92	282	0	0	92	282
2040	25	76	119	367	0	0	119	367
2041	25	76	119	367	0	0	119	367
2042	25	76	119	367	0	0	119	367
2043	25	76	119	367	0	0	119	367
2044	25	76	119	367	0	0	119	367
2045	25	76	119	367	0	0	119	367
2046	25	76	119	367	0	0	119	367
2047	25	76	119	367	0	0	119	367
2048	25	76	119	367	0	0	119	367
2049	25	76	119	367	0	0	119	367
2050 Phase 2 Design Point	35	107	147	451	0	0	147	451

	RW Alternative 1-B									
	RW Use Category 1		RW Use Category 2		RW Use Category 3		ADWF	ADWF for 5 mos	RW Cat 3 Modified to Reflect Summer Low Flows	SUBTOTAL
Year Note About Key Years	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mgd)	(mg)	(mg)	(mg) (afy)
2020 Phase 1 Design Point	5	14	64	197	536	1,646	1.58	241.13	172.43	236.63 726.45
2021	5	14	64	197	536	1,646	1.58	242.32	173.62	237.82 730.11
2022	5	14	64	197	536	1,646	1.59	243.51	174.81	239.01 733.78
2023	5	14	64	197	536	1,646	1.60	244.71	176.01	240.21 737.44
2024	5	14	64	197	536	1,646	1.61	245.90	177.20	241.40 741.10
2025	5	14	64	197	536	1,646	1.62	247.10	178.40	242.60 744.77
2026	5	14	64	197	536	1,646	1.62	248.29	179.59	243.79 748.43
2027	5	14	64	197	536	1,646	1.63	249.48	180.78	244.98 752.09
2028	5	14	64	197	536	1,646	1.64	250.68	181.98	246.18 755.76
2029	5	14	64	197	536	1,646	1.65	251.87	183.17	247.37 759.42
2030	15	45	92	282	553	1,698	1.65	253.06	146.66	238.46 732.06
2031	15	45	92	282	553	1,698	1.66	254.73	148.32	240.12 737.18
2032	15	45	92	282	553	1,698	1.68	256.40	149.99	241.79 742.30
2033	15	45	92	282	553	1,698	1.69	258.07	151.66	243.46 747.42
2034	15	45	92	282	553	1,698	1.70	259.73	153.33	245.13 752.54
2035	15	45	92	282	553	1,698	1.71	261.40	154.99	246.79 757.66
2036	15	45	92	282	553	1,698	1.72	263.07	156.66	248.46 762.78
2037	15	45	92	282	553	1,698	1.73	264.74	158.33	250.13 767.90
2038	15	45	92	282	553	1,698	1.74	266.40	160.00	251.80 773.02
2039	15	45	92	282	553	1,698	1.75	268.07	161.66	253.46 778.14
2040	25	76	119	367	570	1,750	1.76	269.74	125.63	245.03 752.23
2041	25	76	119	367	570	1,750	1.78	271.65	127.54	246.94 758.10
2042	25	76	119	367	570	1,750	1.79	273.56	129.45	248.85 763.97
2043	25	76	119	367	570	1,750	1.80	275.48	131.36	250.76 769.84
2044	25	76	119	367	570	1,750	1.81	277.39	133.28	252.68 775.71
2045	25	76	119	367	570	1,750	1.83	279.30	135.19	254.59 781.59
2046	25	76	119	367	570	1,750	1.84	281.21	137.10	256.50 787.46
2047	25	76	119	367	570	1,750	1.85	283.13	139.01	258.41 793.33
2048	25	76	119	367	570	1,750	1.86	285.04	140.93	260.33 799.20
2049	25	76	119	367	570	1,750	1.88	286.95	142.84	262.24 805.07
2050 Phase 2 Design Point	35	107	147	451	587	1,802	1.89	288.86	107.04	254.04 779.92

	RW Alternative 2-A							
	RW Use Category 1		RW Use Category 2		RW Use Category 3		SUBTOTAL	
Year Note About Key Years	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)
2020 Phase 1 Design Point	13	40	164	505	0	0	164	505
2021	13	40	164	505	0	0	164	505
2022	13	40	164	505	0	0	164	505
2023	13	40	164	505	0	0	164	505
2024	13	40	164	505	0	0	164	505
2025	13	40	164	505	0	0	164	505
2026	13	40	164	505	0	0	164	505
2027	13	40	164	505	0	0	164	505
2028	13	40	164	505	0	0	164	505
2029	13	40	164	505	0	0	164	505
2030	24	73	174	535	0	0	174	535
2031	24	73	174	535	0	0	174	535
2032	24	73	174	535	0	0	174	535
2033	24	73	174	535	0	0	174	535
2034	24	73	174	535	0	0	174	535
2035	24	73	174	535	0	0	174	535
2036	24	73	174	535	0	0	174	535
2037	24	73	174	535	0	0	174	535
2038	24	73	174	535	0	0	174	535
2039	24	73	174	535	0	0	174	535
2040	35	106	184	566	0	0	184	566
2041	35	106	184	566	0	0	184	566
2042	35	106	184	566	0	0	184	566
2043	35	106	184	566	0	0	184	566
2044	35	106	184	566	0	0	184	566
2045	35	106	184	566	0	0	184	566
2046	35	106	184	566	0	0	184	566
2047	35	106	184	566	0	0	184	566
2048	35	106	184	566	0	0	184	566
2049	35	106	184	566	0	0	184	566
2050 Phase 2 Design Point	45	139	194	597	0	0	194	597

	RW Alternative 2-B									
	RW Use Category 1		RW Use Category 2		RW Use Category 3		ADWF	ADWF for 5 mos	RW Cat 3 Modified to Reflect Summer Low Flows	SUBTOTAL
Year Note About Key Years	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)				(mg) (afy)
2020 Phase 1 Design Point	13	40	164	505	1,483	4,553	6.66	1,018.37	841.07	1,005.47 3,086.79
2021	13	40	164	505	1,483	4,553	6.76	1,033.64	856.34	1,020.74 3,133.66
2022	13	40	164	505	1,483	4,553	6.86	1,048.91	871.61	1,036.01 3,180.54
2023	13	40	164	505	1,483	4,553	6.96	1,064.18	886.88	1,051.28 3,227.42
2024	13	40	164	505	1,483	4,553	7.06	1,079.45	902.15	1,066.55 3,274.29
2025	13	40	164	505	1,483	4,553	7.16	1,094.72	917.42	1,081.82 3,321.17
2026	13	40	164	505	1,483	4,553	7.25	1,109.98	932.68	1,097.08 3,368.05
2027	13	40	164	505	1,483	4,553	7.35	1,125.25	947.95	1,112.35 3,414.93
2028	13	40	164	505	1,483	4,553	7.45	1,140.52	963.22	1,127.62 3,461.80
2029	13	40	164	505	1,483	4,553	7.55	1,155.79	978.49	1,142.89 3,508.68
2030	24	73	174	535	1,871	5,744	7.65	1,171.06	972.96	1,147.36 3,522.40
2031	24	73	174	535	1,871	5,744	7.70	1,178.70	980.60	1,155.00 3,545.84
2032	24	73	174	535	1,871	5,744	7.75	1,186.33	988.23	1,162.63 3,569.28
2033	24	73	174	535	1,871	5,744	7.80	1,193.97	995.87	1,170.27 3,592.72
2034	24	73	174	535	1,871	5,744	7.85	1,201.60	1,003.50	1,177.90 3,616.16
2035	24	73	174	535	1,871	5,744	7.90	1,209.24	1,011.14	1,185.54 3,639.59
2036	24	73	174	535	1,871	5,744	7.95	1,216.87	1,018.77	1,193.17 3,663.03
2037	24	73	174	535	1,871	5,744	8.00	1,224.50	1,026.40	1,200.80 3,686.47
2038	24	73	174	535	1,871	5,744	8.05	1,232.14	1,034.04	1,208.44 3,709.91
2039	24	73	174	535	1,871	5,744	8.10	1,239.77	1,041.67	1,216.07 3,733.35
2040	35	106	184	566	2,259	6,935	8.15	1,247.41	1,028.51	1,212.91 3,723.63
2041	35	106	184	566	2,259	6,935	8.19	1,253.61	1,034.71	1,219.11 3,742.65
2042	35	106	184	566	2,259	6,935	8.23	1,259.80	1,040.90	1,225.30 3,761.68
2043	35	106	184	566	2,259	6,935	8.27	1,266.00	1,047.10	1,231.50 3,780.70
2044	35	106	184	566	2,259	6,935	8.32	1,272.20	1,053.30	1,237.70 3,799.72
2045	35	106	184	566	2,259	6,935	8.36	1,278.39	1,059.49	1,243.89 3,818.75
2046	35	106	184	566	2,259	6,935	8.40	1,284.59	1,065.69	1,250.09 3,837.77
2047	35	106	184	566	2,259	6,935	8.44	1,290.78	1,071.88	1,256.28 3,856.79
2048	35	106	184	566	2,259	6,935	8.48	1,296.98	1,078.08	1,262.48 3,875.82
2049	35	106	184	566	2,259	6,935	8.52	1,303.18	1,084.28	1,268.68 3,894.84
2050 Phase 2 Design Point	45	139	194	597	2,647	8,126	8.56	1,309.37	1,069.67	1,264.07 3,880.71

Benefit GP-2: Savings in fertilizer usage

Calculation algorithm:

[A] x [B]; where:
[A] = reclaimed water used for irrigation, varies through time and by alternative
[B] = unit value (from County benefits work, "initial list")

Inputs (Best Guess, BG, listed first):

[A] = "SUBTOTAL" column in table below (RW Use Category 1 + RW Use Category 2); Low Value = 25% of BG; High Value = 110% of BG

[B] = $42/acre-foot (based on values in "initial list"); Low Value = $21/acre-foot (based on 50% of BG); High Value = $63/acre-foot (based on 150% of BG)

		RW Alternative 1-A								RW Alternative 1-B								RW Alternative 2-A								RW Alternative 2-B							
		RW Use Category 1		RW Use Category 2		RW Use Category 3		SUBTOTAL		RW Use Category 1		RW Use Category 2		RW Use Category 3		SUBTOTAL		RW Use Category 1		RW Use Category 2		RW Use Category 3		SUBTOTAL		RW Use Category 1		RW Use Category 2		RW Use Category 3		SUBTOTAL	
Year	Note About Key Years	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)
2020	Phase 1 Design Point	5	14	64	197	0	0		211	5	14	64	197	536	1,646		210.91	13	40	164	505	0	0		544	13	40	164	505	1,483	4,553		544.31
2021		5	14	64	197	0	0		211	5	14	64	197	536	1,646		210.91	13	40	164	505	0	0		544	13	40	164	505	1,483	4,553		544.31
2022		5	14	64	197	0	0		211	5	14	64	197	536	1,646		210.91	13	40	164	505	0	0		544	13	40	164	505	1,483	4,553		544.31
2023		5	14	64	197	0	0		211	5	14	64	197	536	1,646		210.91	13	40	164	505	0	0		544	13	40	164	505	1,483	4,553		544.31
2024		5	14	64	197	0	0		211	5	14	64	197	536	1,646		210.91	13	40	164	505	0	0		544	13	40	164	505	1,483	4,553		544.31
2025		5	14	64	197	0	0		211	5	14	64	197	536	1,646		210.91	13	40	164	505	0	0		544	13	40	164	505	1,483	4,553		544.31
2026		5	14	64	197	0	0		211	5	14	64	197	536	1,646		210.91	13	40	164	505	0	0		544	13	40	164	505	1,483	4,553		544.31
2027		5	14	64	197	0	0		211	5	14	64	197	536	1,646		210.91	13	40	164	505	0	0		544	13	40	164	505	1,483	4,553		544.31
2028		5	14	64	197	0	0		211	5	14	64	197	536	1,646		210.91	13	40	164	505	0	0		544	13	40	164	505	1,483	4,553		544.31
2029		5	14	64	197	0	0		211	5	14	64	197	536	1,646		210.91	13	40	164	505	0	0		544	13	40	164	505	1,483	4,553		544.31
2030		15	45	92	282	0	0		327	15	45	92	282	553	1,698		326.67	24	73	174	535	0	0		608	24	73	174	535	1,871	5,744		608.17
2031		15	45	92	282	0	0		327	15	45	92	282	553	1,698		326.67	24	73	174	535	0	0		608	24	73	174	535	1,871	5,744		608.17
2032		15	45	92	282	0	0		327	15	45	92	282	553	1,698		326.67	24	73	174	535	0	0		608	24	73	174	535	1,871	5,744		608.17
2033		15	45	92	282	0	0		327	15	45	92	282	553	1,698		326.67	24	73	174	535	0	0		608	24	73	174	535	1,871	5,744		608.17
2034		15	45	92	282	0	0		327	15	45	92	282	553	1,698		326.67	24	73	174	535	0	0		608	24	73	174	535	1,871	5,744		608.17
2035		15	45	92	282	0	0		327	15	45	92	282	553	1,698		326.67	24	73	174	535	0	0		608	24	73	174	535	1,871	5,744		608.17
2036		15	45	92	282	0	0		327	15	45	92	282	553	1,698		326.67	24	73	174	535	0	0		608	24	73	174	535	1,871	5,744		608.17
2037		15	45	92	282	0	0		327	15	45	92	282	553	1,698		326.67	24	73	174	535	0	0		608	24	73	174	535	1,871	5,744		608.17
2038		15	45	92	282	0	0		327	15	45	92	282	553	1,698		326.67	24	73	174	535	0	0		608	24	73	174	535	1,871	5,744		608.17
2039		15	45	92	282	0	0		327	15	45	92	282	553	1,698		326.67	24	73	174	535	0	0		608	24	73	174	535	1,871	5,744		608.17
2040		25	76	119	367	0	0		442	25	76	119	367	570	1,750		442.43	35	106	184	566	0	0		672	35	106	184	566	2,259	6,935		672.02
2041		25	76	119	367	0	0		442	25	76	119	367	570	1,750		442.43	35	106	184	566	0	0		672	35	106	184	566	2,259	6,935		672.02
2042		25	76	119	367	0	0		442	25	76	119	367	570	1,750		442.43	35	106	184	566	0	0		672	35	106	184	566	2,259	6,935		672.02
2043		25	76	119	367	0	0		442	25	76	119	367	570	1,750		442.43	35	106	184	566	0	0		672	35	106	184	566	2,259	6,935		672.02
2044		25	76	119	367	0	0		442	25	76	119	367	570	1,750		442.43	35	106	184	566	0	0		672	35	106	184	566	2,259	6,935		672.02
2045		25	76	119	367	0	0		442	25	76	119	367	570	1,750		442.43	35	106	184	566	0	0		672	35	106	184	566	2,259	6,935		672.02
2046		25	76	119	367	0	0		442	25	76	119	367	570	1,750		442.43	35	106	184	566	0	0		672	35	106	184	566	2,259	6,935		672.02
2047		25	76	119	367	0	0		442	25	76	119	367	570	1,750		442.43	35	106	184	566	0	0		672	35	106	184	566	2,259	6,935		672.02
2048		25	76	119	367	0	0		442	25	76	119	367	570	1,750		442.43	35	106	184	566	0	0		672	35	106	184	566	2,259	6,935		672.02
2049		25	76	119	367	0	0		442	25	76	119	367	570	1,750		442.43	35	106	184	566	0	0		672	35	106	184	566	2,259	6,935		672.02
2050	Phase 2 Design Point	35	107	147	451	0	0		558	35	107	147	451	587	1,802		558.19	45	139	194	597	0	0		736	45	139	194	597	2,647	8,126		735.88

Benefit GP-3: Reduced greenhouse gas emissions

Calculation algorithm:

[A] x [B] x [C]; where:
[A] = reclaimed water used for irrigation, varies through time and by alternative
[B] = conversion of volume of reclaimed water (acre-feet) to tons of CO2
[C] = unit value (from County benefit work, "initial list")

Inputs (Best Guess, BG, listed first):

[A] = "SUBTOTAL" column in table below (RW Use Category 1 + RW Use Category 2); Low Value = 25% of BG; High Value = 110% of BG

[B] = 0.2 tons CO2 per acre-ft of reclaimed water

[C] = $40/ton of CO2 (based on values in "initial list"); Low Value = $10/ton (based on range); High Value = $70/ton (based on range)

Breakdown of Annual Reclaimed Water Uses, by Alternative, Category, and Time

Reclaimed Water Alternatives:
1-A: Black Diamond (Seasonal)
1-B: Black Diamond (Year-Round)
2-A: Pump Station D (Seasonal)
2-B: Pump Station D (Year-Round)

Reclaimed Water Use Categories:
1: Offset Covington Water District Potable Water Demand
2: Offset Non-District Potable Water Demand
3: Environmental Enhancement (Infiltration)

		RW Alternative 1-A								RW Alternative 1-B												RW Alternative 2-A								RW Alternative 2-B											
		RW Use Category 1		RW Use Category 2		RW Use Category 3		SUBTOTAL		RW Use Category 1		RW Use Category 2		RW Use Category 3		ADWF	IWF for 5 mW Cat 3 mc		SUBTOTAL			RW Use Category 1		RW Use Category 2		RW Use Category 3		SUBTOTAL		RW Use Category 1		RW Use Category 2		RW Use Category 3		ADWF	IWF for 5 mW Cat 3 mc		SUBTOTAL	
Year	Note About Key Years	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)				(mg)	(afy)		(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)	(mg)	(afy)				(mg)	(afy)
2020	Phase 1 Design Point	5	14	64	197	0	0		211	5	14	64	197	536	1,646	1.58	241.13	172.43		210.91		13	40	164	505	0	0		544	13	40	164	505	1,483	4,553	6.66	1,018.37	841.07		544.31
2021		5	14	64	197	0	0		211	5	14	64	197	536	1,646	1.58	242.32	173.62		210.91		13	40	164	505	0	0		544	13	40	164	505	1,483	4,553	6.76	1,033.64	856.34		544.31
2022		5	14	64	197	0	0		211	5	14	64	197	536	1,646	1.59	243.51	174.81		210.91		13	40	164	505	0	0		544	13	40	164	505	1,483	4,553	6.86	1,048.91	871.61		544.31
2023		5	14	64	197	0	0		211	5	14	64	197	536	1,646	1.60	244.71	176.01		210.91		13	40	164	505	0	0		544	13	40	164	505	1,483	4,553	6.96	1,064.18	886.88		544.31
2024		5	14	64	197	0	0		211	5	14	64	197	536	1,646	1.61	245.90	177.20		210.91		13	40	164	505	0	0		544	13	40	164	505	1,483	4,553	7.06	1,079.45	902.15		544.31
2025		5	14	64	197	0	0		211	5	14	64	197	536	1,646	1.62	247.10	178.40		210.91		13	40	164	505	0	0		544	13	40	164	505	1,483	4,553	7.16	1,094.72	917.42		544.31
2026		5	14	64	197	0	0		211	5	14	64	197	536	1,646	1.62	248.29	179.59		210.91		13	40	164	505	0	0		544	13	40	164	505	1,483	4,553	7.25	1,109.98	932.68		544.31
2027		5	14	64	197	0	0		211	5	14	64	197	536	1,646	1.63	249.48	180.78		210.91		13	40	164	505	0	0		544	13	40	164	505	1,483	4,553	7.35	1,125.25	947.95		544.31
2028		5	14	64	197	0	0		211	5	14	64	197	536	1,646	1.64	250.68	181.98		210.91		13	40	164	505	0	0		544	13	40	164	505	1,483	4,553	7.45	1,140.52	963.22		544.31
2029		5	14	64	197	0	0		211	5	14	64	197	536	1,646	1.65	251.87	183.17		210.91		13	40	164	505	0	0		544	13	40	164	505	1,483	4,553	7.55	1,155.79	978.49		544.31
2030		15	45	92	282	0	0		327	15	45	92	282	553	1,698	1.65	253.06	146.66		326.67		24	73	174	535	0	0		608	24	73	174	535	1,871	5,744	7.65	1,171.06	972.96		608.17
2031		15	45	92	282	0	0		327	15	45	92	282	553	1,698	1.66	254.73	148.32		326.67		24	73	174	535	0	0		608	24	73	174	535	1,871	5,744	7.70	1,178.70	980.60		608.17
2032		15	45	92	282	0	0		327	15	45	92	282	553	1,698	1.68	256.40	149.99		326.67		24	73	174	535	0	0		608	24	73	174	535	1,871	5,744	7.75	1,186.33	988.23		608.17
2033		15	45	92	282	0	0		327	15	45	92	282	553	1,698	1.69	258.07	151.66		326.67		24	73	174	535	0	0		608	24	73	174	535	1,871	5,744	7.80	1,193.97	995.87		608.17
2034		15	45	92	282	0	0		327	15	45	92	282	553	1,698	1.70	259.73	153.33		326.67		24	73	174	535	0	0		608	24	73	174	535	1,871	5,744	7.85	1,201.60	1,003.50		608.17
2035		15	45	92	282	0	0		327	15	45	92	282	553	1,698	1.71	261.40	154.99		326.67		24	73	174	535	0	0		608	24	73	174	535	1,871	5,744	7.90	1,209.24	1,011.14		608.17
2036		15	45	92	282	0	0		327	15	45	92	282	553	1,698	1.72	263.07	156.66		326.67		24	73	174	535	0	0		608	24	73	174	535	1,871	5,744	7.95	1,216.87	1,018.77		608.17
2037		15	45	92	282	0	0		327	15	45	92	282	553	1,698	1.73	264.74	158.33		326.67		24	73	174	535	0	0		608	24	73	174	535	1,871	5,744	8.00	1,224.50	1,026.40		608.17
2038		15	45	92	282	0	0		327	15	45	92	282	553	1,698	1.74	266.40	160.00		326.67		24	73	174	535	0	0		608	24	73	174	535	1,871	5,744	8.05	1,232.14	1,034.04		608.17
2039		15	45	92	282	0	0		327	15	45	92	282	553	1,698	1.75	268.07	161.66		326.67		24	73	174	535	0	0		608	24	73	174	535	1,871	5,744	8.10	1,239.77	1,041.67		608.17
2040		25	76	119	367	0	0		442	25	76	119	367	570	1,750	1.76	269.74	125.63		442.43		35	106	184	566	0	0		672	35	106	184	566	2,259	6,935	8.15	1,247.41	1,028.51		672.02
2041		25	76	119	367	0	0		442	25	76	119	367	570	1,750	1.78	271.65	127.54		442.43		35	106	184	566	0	0		672	35	106	184	566	2,259	6,935	8.19	1,253.61	1,034.71		672.02
2042		25	76	119	367	0	0		442	25	76	119	367	570	1,750	1.79	273.56	129.45		442.43		35	106	184	566	0	0		672	35	106	184	566	2,259	6,935	8.23	1,259.80	1,040.90		672.02
2043		25	76	119	367	0	0		442	25	76	119	367	570	1,750	1.80	275.48	131.36		442.43		35	106	184	566	0	0		672	35	106	184	566	2,259	6,935	8.27	1,266.00	1,047.10		672.02
2044		25	76	119	367	0	0		442	25	76	119	367	570	1,750	1.81	277.39	133.28		442.43		35	106	184	566	0	0		672	35	106	184	566	2,259	6,935	8.32	1,272.20	1,053.30		672.02
2045		25	76	119	367	0	0		442	25	76	119	367	570	1,750	1.83	279.30	135.19		442.43		35	106	184	566	0	0		672	35	106	184	566	2,259	6,935	8.36	1,278.39	1,059.49		672.02
2046		25	76	119	367	0	0		442	25	76	119	367	570	1,750	1.84	281.21	137.10		442.43		35	106	184	566	0	0		672	35	106	184	566	2,259	6,935	8.40	1,284.59	1,065.69		672.02
2047		25	76	119	367	0	0		442	25	76	119	367	570	1,750	1.85	283.13	139.01		442.43		35	106	184	566	0	0		672	35	106	184	566	2,259	6,935	8.44	1,290.78	1,071.88		672.02
2048		25	76	119	367	0	0		442	25	76	119	367	570	1,750	1.86	285.04	140.93		442.43		35	106	184	566	0	0		672	35	106	184	566	2,259	6,935	8.48	1,296.98	1,078.08		672.02
2049		25	76	119	367	0	0		442	25	76	119	367	570	1,750	1.88	286.95	142.84		442.43		35	106	184	566	0	0		672	35	106	184	566	2,259	6,935	8.52	1,303.18	1,084.28		672.02
2050	Phase 2 Design Point	35	107	147	451	0	0		558	35	107	147	451	587	1,802	1.89	288.86	107.04		558.19		45	139	194	597	0	0		736	45	139	194	597	2,647	8,126	8.56	1,309.37	1,069.67		735.88

Appendix C
Benefit-to-Cost (B/C) Ratio Results

(Note: This appendix provides the results of the calculation of a metric different than the Net Benefits metric focused upon in the body of the report. Here, a Benefit-to-Cost Ratio metric is discussed.)

Benefit Cost Ratio Results

The present value benefits and costs were used to calculate a benefit-to-cost (B/C) ratio for each alternative. Table 1 summarizes the results. Based on the quantitative analysis, none of the alternatives provide a return greater than one over the 30 year period of analysis. The B/C ratios range from 0.14 to 0.72, when all benefits are considered. The ratios are only minimally altered when the recreational benefits, which are arguably based upon the most far-reaching assumptions of all benefits, are excluded from the analysis, as summarized in Table 1. While a longer time period could yield more benefit, the discounting of future streams of benefits as well as the addition of future operations, maintenance and rehabilitation costs would likely offset those future year benefits.

Table 1. Summary of Benefit/Cost Ratio Calculations

	Alt 1-A (Black Diamond, Seasonal)	Alt 1-B (Black Diamond, Year-Round)	Alt 2-A (Pump Station D, Seasonal)	Alt 2-B (Pump Station D, Year-Round)
Benefits				
Wastewater Utility Benefits	$2,600,000	$91,600,000	$5,200,000	$59,800,000
Water Utility Benefits	$5,300,000	$5,300,000	$11,200,000	$11,200,000
Self-Supplied Water User Benefits	$100,000	$100,000	$100,000	$100,000
General Public Benefits (Environmental)	$300,000	$600,000	$700,000	$2,300,000
General Public Benefits (Recreational)	$300,000	$700,000	$500,000	$1,600,000
Total Benefits	$8,600,000	$98,300,000	$17,700,000	$75,000,000
Costs				
Capital Costs	$55,200,000	$117,800,000	$109,800,000	$222,800,000
O&M Costs	$4,400,000	$19,200,000	$8,900,000	$35,700,000
Total Costs	$59,600,000	$137,000,000	$118,700,000	$258,500,000
Benefit/Cost Ratios				
Considering All Benefits	**0.14**	**0.72**	**0.15**	**0.29**
Excluding Recreational Benefits	**0.14**	**0.71**	**0.15**	**0.28**

Comparison of the B/C ratios indicates that the seasonal alternatives have the smallest returns on their initial investments. Alternative 1-A costs the least amount; however, this option only returns $6.1 million in benefits over 30 years. Alternative 2-A costs twice as much as Alternative 1-A and doubles the benefits to $12.6 million; however, the larger relative cost of construction generates an almost equivalent return as Alternative 1-A.

Alternative 2-B (the year-round Pump Station D alternative) costs the most and generates wastewater utility benefits from deferred and avoided capital costs. However, the large investment in capital required for this alternative significantly outweighs the benefits it provides resulting in a B/C ratio that is equal to only $0.16 per dollar invested better than Alternative 2-A (the seasonal option for Pump Station D).

The option that offers the greatest return is Alternative 1-B (year-round use at the Black Diamond site). This option generates nearly $0.53 more per dollar invested than Alternative 2-B. Still the B/C ratio for this alternative is less than 1, for a return of $0.70 for every dollar invested.

Risk and Uncertainty Analysis for Benefit Cost Ratios

A risk and uncertainty model was assembled using the ranges of values for costs and benefits discussed in Sections 4 and 5. The risk model was used to forecast the probability distribution of the expected B/C ratios (i.e., those ratios based on expected cost and benefit inputs) for each alternative given the established criteria set forth by the input value ranges. The results from this forecast are shown below in Figure 1 as probability density functions. These graphics show:

- The mean value of the B/C ratio represented by the peak of the curve;
- the frequency with which a B/C ratio occurred in the analysis; and,
- the likely range within which 90% of the potential B/C ratios are captured.

For Alternative 1-A, the mean value was between 0.10 and 0.12 (lower than the expected value of 0.14) with 90% of the values ranging between 0.07 and 0.16. Alternative 2-A has very similar results to those of Alternative 1-A. Alternative 2-A has a mean value between 0.70 and 0.75, approximately the same as the expected value. The range for 90% of the values is between 0.63 and 0.84. Finally Alternative 2-B has a mean value of 0.30 which is slightly higher than the expected value, with 90% occurring between 0.25 and 0.34.

Figure 1. B/C Ratio Probability Density Functions

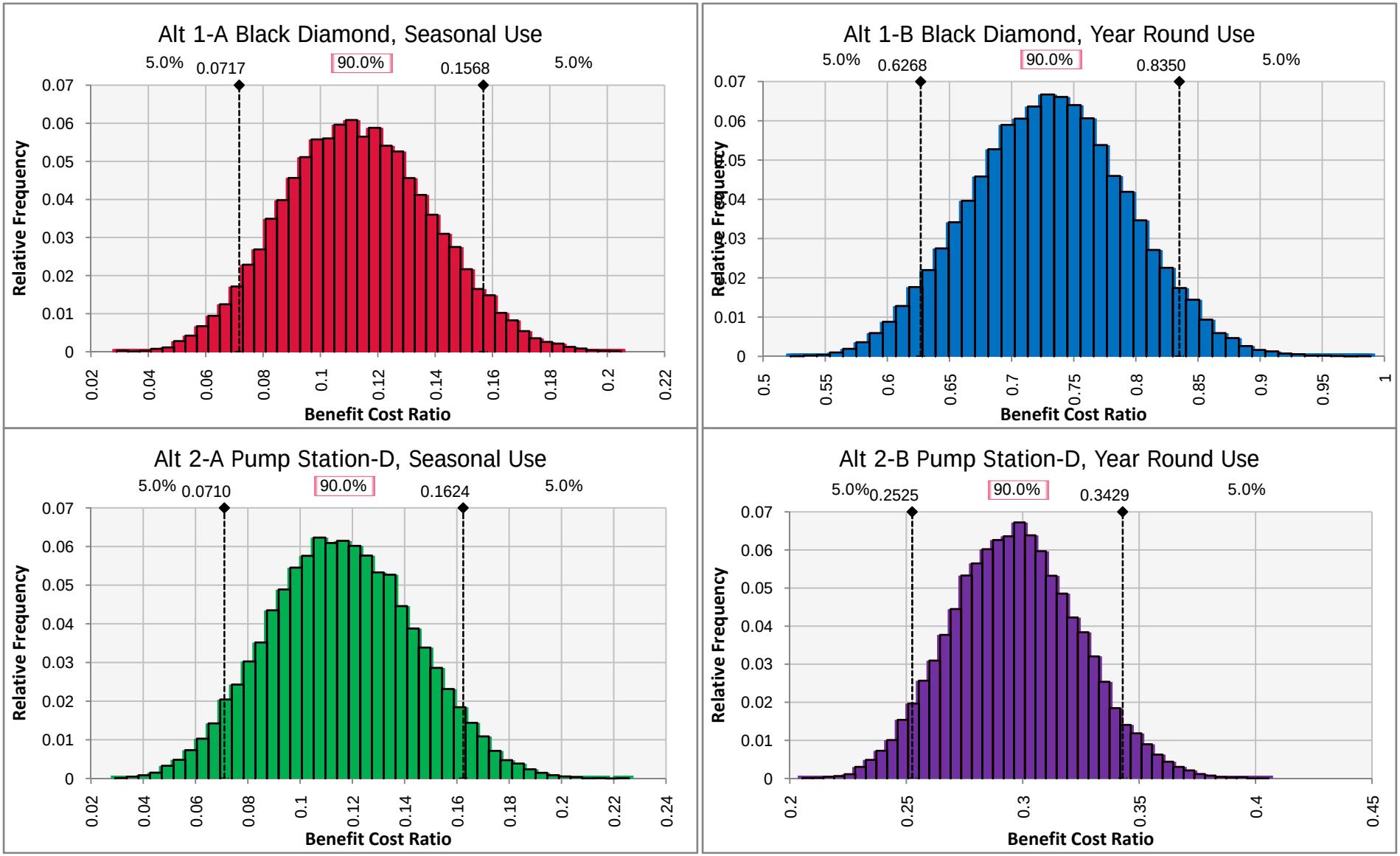
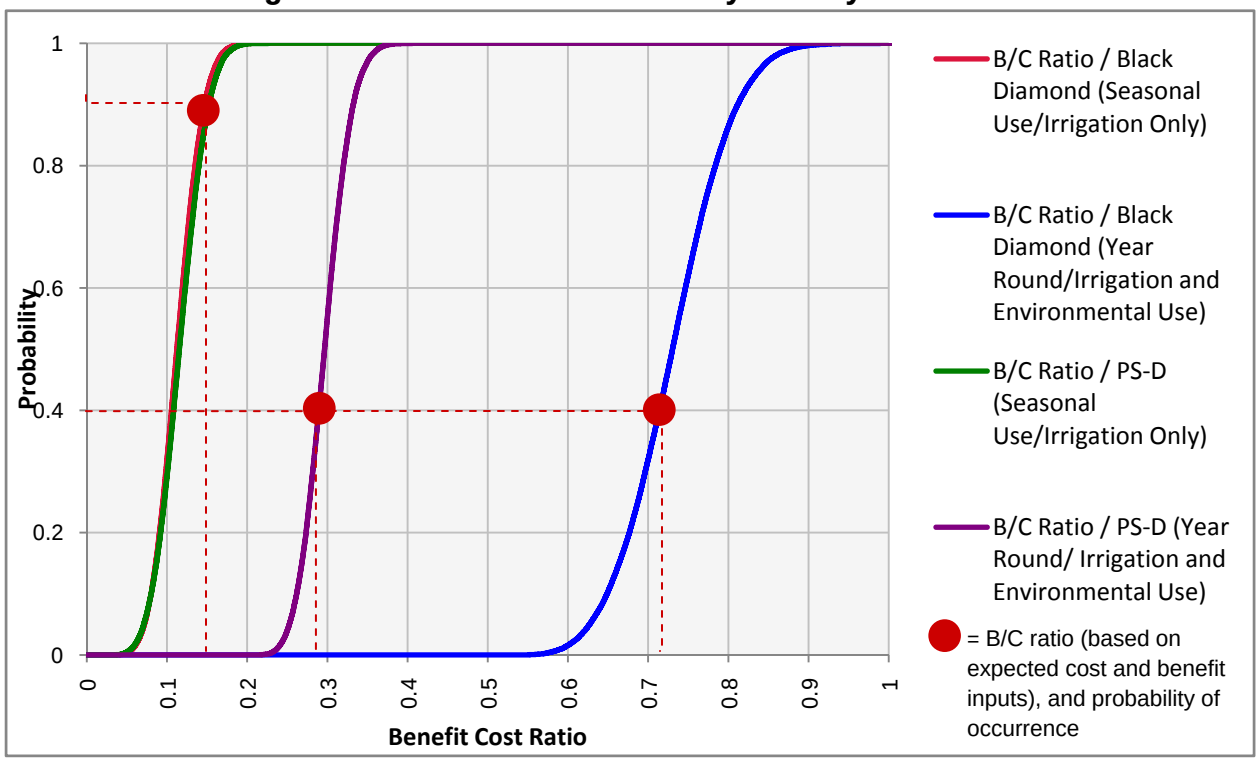


Figure 2 depicts the cumulative density functions of the B/C ratios for each alternative. These curves compare the alternatives against one another and demonstrate what the likelihood of the expected B/C ratios are. The seasonal use options (Alternatives 1-A and 2-A) both have B/C ratios of approximately 0.15 and a 90% chance that the B/C ratio could be smaller than 0.15. By comparison, the year round options (Alternatives 1-B and 2-B) have baseline values occurring with only a 40% chance that the B/C ratio would be smaller than the expected values. Thus, with the seasonal use alternatives there is a sizeable chance that the B/C ratio will be smaller than the expected value, while with the year round alternatives there is a good chance (approximately 60%) that the B/C ratio will be larger than the expected value.

Figure 2. B/C Ratio Probability Density Functions



It should also be noted, that with respect to Alternative 1-B, as compared to the other options, there is heavy presence of stochastic dominance. Meaning that for every possible combination of input values in the B/C ratios, Alternative 1-B will always have a B/C ratio greater than that of the other options.