

COMMISSIONING ALTERNATIVES

BRIGHTWATER WASTEWATER TREATMENT PLANT

March 2010



King County

A report to the King County Council
by the
Wastewater Treatment Division
King County Department of Natural Resources and Parks

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COMMISSIONING ALTERNATIVES

BRIGHTWATER WASTEWATER TREATMENT PLANT

Executive Summary

The Brightwater Treatment Program was planned and designed to deliver the coordinated construction and commissioning of two separate, but dependant infrastructure facilities: the Wastewater Treatment Plant (the Plant) and the Conveyance System. The Plant is being constructed under two general construction contracts: Liquids and Solids. The Conveyance System is being constructed through three tunnel contracts, one Marine Outfall contract, and one Influent Pump Station (IPS) contract. Additionally, the Conveyance System includes several smaller contracts for reclaimed water distribution and pump station upgrades.

The Plant construction is currently on schedule to achieve substantial completion in February 2011 and wastewater treatment commissioning in August 2011. Most elements of the Conveyance System are either complete (the Marine Outfall) or on schedule to be complete without impacting the scheduled commissioning of the Plant.

The one critical exception is the Central Tunnel contract. The delay in completion of the Central Tunnels delays Conveyance System completion, and the date when treated wastewater can be discharged to Puget Sound through the new outfall. Because the Central Tunnel timing remains uncertain, commissioning alternatives have been developed to address various risks and mitigate the cost impacts of delays.

This Commissioning Alternatives report lists and discusses decisions to be made in the not too distant future and outlines the commissioning alternatives. Alternatives are discussed in detail and are presented in terms of overall costs, including capital and operating, as well as rate considerations. This report describes the methodology used to develop operating cost projections for the Brightwater system and verifies the reasonableness of the operating costs during the Plant commissioning phase, prior to completion of the Conveyance System, and after system completion when the Plant is in full operation. However, due to timing of the county's rate setting schedule, any potential operating savings may not be reflected in the monthly sewer rate until 2013. This is because the monthly sewer rate is proposed and adopted the year before it is levied. For example, the sewer rate for 2011 will be adopted in June 2010. Additionally, the Wastewater Treatment Division (WTD) follows the policy of supporting multiple year rates whenever prudent. This means the next adopted sewer rate may be intended to remain stable for 2011 and 2012. Therefore, the next opportunity to adjust the monthly sewer rate could be 2013.

The four alternatives are:

Alternative	Primary Considerations
Alternative 1 , Extend Liquids and Solids Contracts – King County and Contractors Perform Commissioning	<ul style="list-style-type: none"> • Optimizes commissioning phase by maintaining contractor involvement during commissioning • Least risk
Alternative 2 , Do Not Extend Liquids and Solids Contract – King County Performs Commissioning without Contractor Assistance	<ul style="list-style-type: none"> • Eliminates contractor assistance during commissioning • Increased risk
Alternative 3 , Do Not Extend Liquids and Solids Contract - Delay Commissioning until Conveyance is Complete – King County Performs Commissioning	<ul style="list-style-type: none"> • Eliminates contractor assistance during commissioning • Interim maintenance plan required • Most risk
Alternative 4 , Extend Liquids and Solids Contracts, Place Plant on Standby once Commissioning is Complete. King County Restarts Plant	<ul style="list-style-type: none"> • Maintains contractor involvement in commissioning • Requires complete facility de-commissioning and re-commissioning • Higher risk compared to Alternative 1, but lower risk compared to Alternative 2 & 3

At this time, it is not necessary to make a decision. The following key decision points can be made at the following intervals when more information is known about the date the Conveyance System will be completed.

1. September 2010

Decide whether to commission the Plant beginning in August 2011, at a later date, or when the Conveyance System is completed. The timing of this decision is established by the progress in completion of the section of tunnel between the Influent Pump Station (IPS) and the North Kenmore Portal (BT-2). If BT-2 falls farther behind schedule, it affects the schedule for installation of piping at the IPS which will be used for sewage recirculation. This piping is necessary for the early commissioning Alternatives 1, 2, and 4 to proceed.

2. October 2010

Decide if contract extensions will be negotiated with the Plant contractors to support commissioning, or if the county commissions the Plant without the contractors present. The timing of this decision is established by the need to amend the Plant construction contracts.

3. November 2011 (If commissioning is to occur in 2011)

Decide whether to place the Plant in standby mode after commissioning. It is not necessary to make this decision until the schedule for conveyance completion is more certain and the progress in achieving commissioning objectives is known.





These alternatives have differing profiles of operating costs and capital costs, as well as different amounts and types of risk. Costs were estimated for three completion dates and are presented in Table 1 on the following page, shown as deviations from a base case.

Rate equivalencies, shown in Table 1, are shown as dollars per Residential Customer Equivalent (RCE) per month on the monthly sewer rate. The most substantive impact on rates is from Alternatives 3 and 4, if the Conveyance System is further delayed. As shown in the table, the maximum estimated rate impact is slightly below one percent of the current monthly rate.

The majority (over 90 percent) of the rate equivalency impact is because of operational cost considerations. Capital cost considerations do not influence the rate equivalency figures substantially because they are amortized, and therefore distributed over a 35-year period. Additionally, capital cost increases would be factored into future capacity charge calculations, as they are substantially recovered through capacity charges.

Table 1.
Brightwater Treatment Plant Commissioning Outcomes
Summary of Annual Rate Equivalents* Associated with Capital and Operating Cost (2011 - 2013)

Difference from Alternative 1, System Completion October 2012

Outcomes	Early System Completion April 2012	System Completion October 2012	Late System Completion June 2013	Risk Exposure**			
	Monthly Sewer Rate	Monthly Sewer Rate	Monthly Sewer Rate	Amount (Million\$)	Rate \$/RCE/Month	Level	
Alternative 1, Extend Liquids and Solids Contracts – King County and Contractors Perform Commissioning	(\$0.01)	\$0.00	\$0.01	\$2.8	\$0.00	Low	
Alternative 2, Do Not Extend Liquids and Solids Contract – King County Performs Commissioning without Contractor Assistance	(\$0.01)	\$0.00	\$0.01	\$6.0	\$0.03	Medium-High	
Alternative 3, Do Not Extend Liquids and Solids Contract - Delay Commissioning until Conveyance is Complete – King County Performs Commissioning	(\$0.11)	(\$0.19)	(\$0.30)	\$8.1	\$0.04	High	
Alternative 4, Extend Liquids and Solids Contracts, Place Plant on Standby once Commissioning is Complete. King County Restarts Plant	(\$0.01)	(\$0.08)	(\$0.23)	\$3.6	\$0.01	Medium	

*Annual Residential Customer Equivalent rate is the effect of the indicated scenario and alternative on the monthly sewer rate for 2011-13 relative to the baseline.

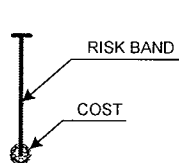
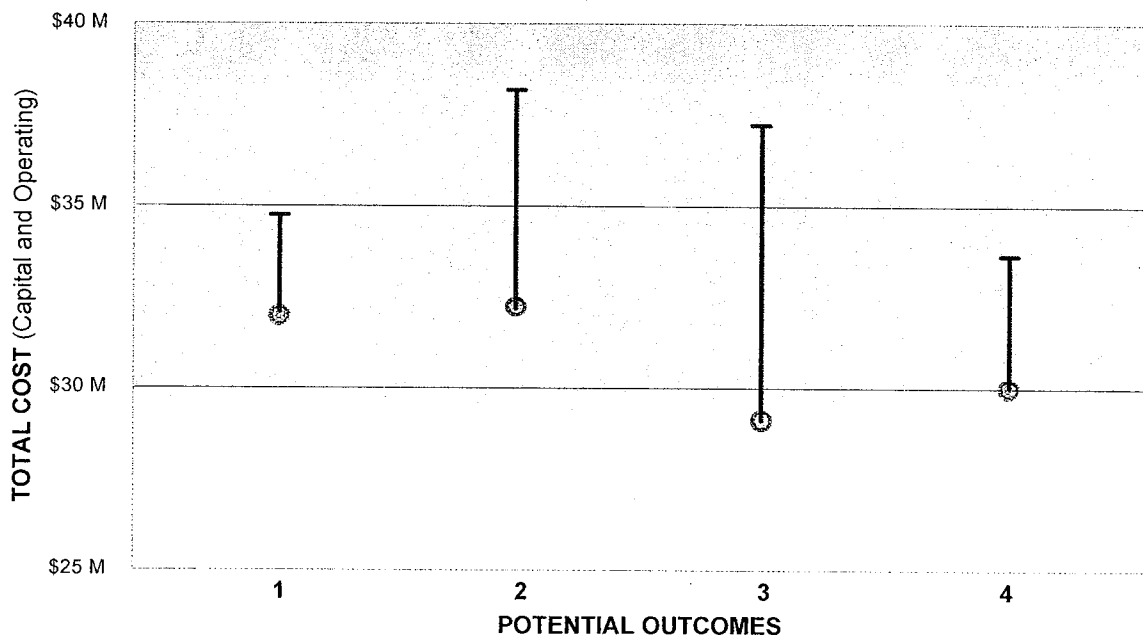
** Risk contingency reflects differences in risk relative to Alternative 1.

Note:

1. Operating costs are combined for years 2011, 2012, and 2013 to provide a comparable time period for comparison of alternatives.
2. Operating costs include operational labor, energy, chemicals, and utilities for the Brightwater Treatment Plant and Influent Pump Station.
3. Potential exposure to risk from contractor claims and correcting defective work is addressed in the risk exposure and not included in the rate equivalent figures.
4. Alternatives 3 and 4 transfer 13 operations and maintenance personnel to South Treatment and West Point Treatment Plants for maintenance activities for the interval that Brightwater is not fully operational.
5. Risk exposure is quantified in Appendix B. Quantified risks include exposure to cost impacts associated with correcting defective work, project delays, and extended warranty protection. Risk exposure levels are relative based on the potential capital cost impact associated with each alternative.

To verify the reasonableness of the operating cost projections, a cost model was developed to improve the accuracy of cost predictions to operate the Plant and the IPS during commissioning and operations. Operating costs were developed to analyze different alternatives for plant commissioning, including placing the Plant on standby until Conveyance System completion. The operating costs developed in Section 5 are deemed reasonable because they are based on the specific equipment and systems that will be operated at the Plant for a given flow volume, including seasonal variations. The cost model is specific to the Plant, and cost parameters are derived from our large wastewater treatment and conveyance system operating experience to date. Expenditures for labor, chemicals, and energy are predictable although they will be informed by actual operating expenses once the Plant is up and running. The timing for when the operating expenditures take effect is explored in detail in Section 5 of this report.

Figure 1
 POTENTIAL OUTCOMES – ESTIMATED TOTAL COSTS & RISK
 SYSTEM COMPLETION OCTOBER 2012



	COST (\$M)	RISK (\$M)
Alternative 1	32.0	2.8
Alternative 2	32.2	6.0
Alternative 3	29.1	8.1
Alternative 4	30.0	3.6

The figure above displays the total cost of each alternative, and the relative risk exposure or potential cost impact if the risk materializes: Risk exposure for each alternative is quantified in Appendix B, and is shown in Figure 1 as a “band” or potential range of exposure to risk. For instance, Alternative 3 has a lower cost but a higher exposure to risk relative to Alternative 2.

Quantified risks include exposure to cost impacts associated with correcting defective work, project delays, and extended warranty protection.

Alternatives 2 and 3 are riskier because under these alternatives, the county could be exposed to additional cost increases as a result of correcting defective work. In both of these alternatives, test responsibilities are effectively completed and the contractors are demobilized before commissioning begins and any opportunity for assistance from them to correct any defective work diminishes. As a result, the county may have to pay a separate contractor to repair any defective work. The current Plant construction contractors also contribute to the personnel continuity that has contributed to the success of the project thus far. Interrupting this continuity will increase the county's risk.

Alternative 3 has the highest risk because increasing the interval between construction and commissioning increases the potential for defective work to go undetected until after warranties expire, long after the contractor has demobilized. The discovery of any defective work at a later date when equipment is not under warranty and a substantial period of time has lapsed increases the difficulty and expense of correcting the problems. There has been a significant investment in staff, consultant, and contractor knowledge of the facility design, construction, and operation, and a high level of personnel continuity. The interruption of this continuity and loss of institutional knowledge presents a risk to future operation of the facility and may result in difficulties resolving problems encountered during commissioning and startup.

Alternatives 3 and 4 have the lowest costs, particularly if the Conveyance System is delayed substantially. This is because operating costs are delayed when the project is delayed. Alternative 3 carries a substantial amount of risk and has the highest potential to delay completion of the Brightwater system with potential regulatory implications. For that reason, Alternative 3 is not recommended.

In making its decisions, WTD will balance the potential risks of each alternative against the capital and operating cost impacts. WTD will continue to monitor the following parameters as it reaches these decision points shown above:

- Construction schedules and projected substantial completion dates. Most significantly, the interval between the Plant and conveyance completion. This determines the length of time Brightwater could be put in standby mode.
- Progress of change order and/or contract negotiations that influence the cost estimates of these alternatives.

This report does not address the potential change in tunneling contractors outlined in the County Executive's February 18, 2010, Emergency Declaration. Any changes that result from this declaration would be considered at the decision points mentioned above.

Introduction

1.1 Purpose

This document provides information and analysis from King County's Wastewater Treatment Division (WTD) in response to a proviso in WTD's 2010 operating budget (contained in Proviso 2 Section 105 of Ordinance 16717), which reads as follows:

A. Of this appropriation, \$100,000 may not be expended or encumbered until the Executive has collaborated with the Brightwater Oversight Management Consultant and the King County Auditor's office capital projects oversight program and submitted a report for council acceptance by motion, regarding: (1) an analysis and verification that the Wastewater Treatment Division's projected, as of December 31, 2009, operating costs for the Brightwater Treatment System are reasonable: (a) during the early post-commissioning phase when Brightwater effluent will be conveyed to other treatment plants for discharge; and (b) when fully operational and discharging effluent via the Brightwater conveyance system. If any portion of the Wastewater Treatment Division's projected operating costs are not reasonable, then the report should indicate what elements should be adjusted and provide a reasonable estimate for those elements; and (2) building on the verified and, if necessary, adjusted estimate of operating costs for the Brightwater Treatment System developed under item (1) of this Subsection A. of this proviso, the results of the collaborative efforts in developing potentials to maximize operational savings before and during the commissioning of the Brightwater Treatment System. The report and motion shall be transmitted by April 2, 2010.

B. For the verification of Wastewater Treatment Division projected operational costs analysis, the report shall examine, but not be limited to, the following: (1) a breakdown of the anticipated operating expenses associated with the early post-commissioning period and a breakdown of operating expenses when fully operational; (2) startup plans and necessary staffing; and (3) anticipated consultants or other resources that will be needed and the costs associated. Based on the verification of Wastewater Treatment Division projected operational costs analysis, the report shall also specifically identify options for reducing operating costs and make recommendations for a cost-effective startup; as well as development of opportunities for operational saving.

C. Any report or motion required to be submitted by this proviso must be filed in the form of a paper original and an electronic copy with the clerk of the council, who shall retain the original and provide an electronic copy to all council members and to the committee coordinator for the government and accountability committee and the regional water quality committee or their successors.

Separate sections of this report address each of the elements of the proviso:

- Section 1 presents the proviso information addressed by this report as well as a summary introduction of the current status of the Brightwater Treatment Program.

- Section 2 provides a background discussion and commissioning challenges for the Brightwater Treatment Plant. These challenges have a direct bearing on the capital and operating cost for startup and commissioning the Plant, which are addressed in Section 5.
- Section 3 presents four contracting alternatives, with a timeline representing each alternative. The contracting alternatives have varying levels of risk that affect the magnitude and timing of the capital and operating expenditures.
- Section 4 discusses steps being taken to manage and contain risk as well as identification of issues that affect recommendations. Identification and management of risk and associated costs impacts have a direct bearing on when the Plant can be placed in operation and the magnitude and timing of capital and operational expenditures.
- Section 5 presents the methodology for development of operating costs for each alternative and includes the estimated operating, capital, and total costs for early, scheduled, and late system completion. Section 5 includes discussion of the steps evaluated to mitigate operating cost increases, and includes discussion of why the operating costs estimates are considered reasonable.
- Section 6 includes a discussion of the alternatives, including the risk and comparative costs of potential outcomes.
- Section 7 closes this report with recommendations and a discussion of when decisions need to be made.

1.2 Introduction

The Brightwater Treatment Program was planned and designed to deliver the coordinated construction and commissioning of two separate, but dependant infrastructure facilities: the Plant and the Conveyance System. The Plant is being constructed under two general construction contracts: Liquids and Solids. The Conveyance System is being constructed through three tunnel contracts, one Marine Outfall contract, and one Influent Pump Station contract. Additionally, the Conveyance System includes several smaller contracts for reclaimed water distribution and pump station upgrades.

The Plant construction is currently on schedule to achieve substantial completion in February 2011, and wastewater treatment commissioning in August 2011. Most elements of the Conveyance System are either complete (the Marine Outfall) or on schedule to be complete without impacting the scheduled commissioning of the Plant. The one critical exception is the Central Tunnel contract. Conveyance System contracts are progressing in a manner supporting treatment plant completion with the exception being the Central Tunnel contract. The two tunnel boring machines (TBMs) have experienced extensive rim bar wear on the machines' rotating face. This wear was discovered in May 2009 and required that both machines undergo extensive underground repairs. The difficulty of this repair work was compounded by high ground pressure requiring extensive dewatering and compressed air work. Planning, designing, and executing repairs has been time consuming and has resulted in significant delays in the completion of the Central Tunnels which in turn delays completion of the Conveyance System, and the date when treated wastewater can be discharged to Puget Sound through the new outfall. As an interim measure, a modification to piping at the IPS will facilitate a temporary diversion of

treated wastewater from the Plant to discharge into the existing conveyance lines for conveyance to either the West Point or South Treatment Plants.

This delay to the Conveyance System can impact the wastewater commissioning schedule of the Plant. The effect of this delay would have broad implications on the closeout of the Plant construction contracts, interim management of facilities, warranties, and continuity of contractor's personnel for later commissioning, among many other issues.

Specifically, this report responds to the following key questions:

1. What options for delayed commissioning best mitigate operational cost impacts? What are the potential costs and risks?
2. What is the best contracting strategy for the Plant commissioning given the costs and risks of commissioning with and without the contractor present?
3. What are the risks the county faces resulting from commissioning the Plant under various delay scenarios?
4. What are the benefits of commissioning and operating the Plant prior to completion of the Conveyance System relative to the capital and operating costs incurred? What are the costs and risks of placing the Plant on standby, once commissioning is completed?
5. Once commissioning with sewage is completed and the Plant is in operation, what is the optimal flow rate to send through the Plant to maintain operations and its attendant benefits relative to the operating costs?
6. Are the operating costs reasonable? How do these alternatives affect sewer rates?

This report is intended to evaluate the potential outcome of tunnel delays and to serve as a guide on how to proceed with the myriad of issues and decisions to be made while the Central Tunnels are completed. This report analyzes alternatives and discusses strategies to optimize plant operation and minimize risk, while minimizing cost impacts. This report also describes the methodology used to develop operating cost projections for the Brightwater system and verifies the reasonableness of the operating costs during the Plant commissioning phase, prior to completion of the Conveyance System, and after system completion when the Plant is in full operation. It must be recognized that this document will focus on the most probable path forward in terms of potential scenarios on both the Plant and Conveyance System projects, but must be flexible to accommodate changes that evolve until the entire Brightwater system is complete and operating.

This report does not specifically factor in any potential changes in contracting strategies for completion of the remaining section of tunnel between the North Kenmore Portal and the Lake Ballinger Portal (BT-3) that were the subject of the County Executive's February 18, 2010, Emergency Declaration. However, the sensitivity of costs to the conveyance completion schedule described in this report is still applicable should changes be made that impact the project schedule.

2.0 Background

2.1 Definitions

Brightwater Wastewater Treatment System - the Wastewater Treatment Plant, the Conveyance System, and modifications to existing pump stations and infrastructure to reroute wastewater from existing facilities to Brightwater.

Central Tunnel(s) – consisting of the tunnels extending from the North Kenmore Portal to the Influent Pumping Station (BT-2) and from North Kenmore to the Ballinger Way Portal (BT-3).

Conveyance System - the tunnel extending from the Plant site near Woodinville to Puget Sound, influent and effluent piping encased in the tunnel, the Influent Pump Station and Influent Structure (IS), and the Marine Outfall in Puget Sound.

The Plant - the process treatment facilities being constructed by two general construction contractors (Liquids and Solids).

Liquids: screening, grit removal, primary settling, aeration, membrane bioreactors, and disinfection.

Solids: thickening, digestion, dewatering, and odor control.

North Creek Pump Station – (NCPS) available to provide wastewater to and accept treated wastewater from the IS.

Substantial Completion - defined by the contracts as contractor completion of facility construction including the successful completion of clean water testing and being ready for commissioning with wastewater.

Final Acceptance – defined by the contracts as completion of all contractual requirements, including sewage commissioning.

Commissioning - Plant operational performance demonstration, using wastewater routed from the NCPS through the Influent Structure and the IPS. Commissioning will be achieved using flows less than the design flow rate. The Plant Liquids and Solids contracts specify that the process operate for a continuous 30-day period without any shutdowns attributable to the contractor. Although the process is operated by WTD staff, the contractor must have a presence and correct problems.

Plant Shutdown - emptying, cleaning and maintaining the Plant following commissioning while waiting for completion of the Conveyance System.

2.2 Discussion

The Plant is currently scheduled to reach substantial completion in February 2011.

The Brightwater program schedule, as originally developed in multiple contracts, provided for a coordinated startup and clean water testing between the IPS and the Plant following substantial completion of the Plant in January 2011. Clean water would be circulated from the IPS through

the East Tunnel to the Plant and then back through the East Tunnel to the IPS. Once performance tests had been completed between the IPS and the Plant using clean water, sewage commissioning was intended to immediately follow. Commissioning support is included in the two plant construction contracts. Commissioning support requires the contractor to be present and to assist in correcting any problems that impact the ability of the Plant to operate continuously.

Early during plant construction, management recognized the benefit of providing a means to internally recirculate water for testing to avoid reliance on completion of the IPS for clean water recirculation within the Plant. A modification to the design was installed allowing the Plant clean water testing to proceed without the support of the IPS. An estimated seven million gallons per day (mgd) will be recirculated within the Plant, enabling testing and greater confidence of the performance of plant systems.

Due to the delay of the Central Tunnels, a design modification to the Influent Structure at the IPS is being implemented which modifies construction sequencing to allow for extraction of the tunnel boring machine and separation of work between the IPS and Central Tunnel contract. One benefit of this work around is that it allows piping to be installed for the IPS to recirculate clean water to and from the Plant, and to pump sewage to the Plant prior to completion of the Central Tunnel (**Figure 2**). The IPS is scheduled to be available to recirculate clean water to the Plant by mid-May 2011. From May 2011 through August 2011, a 90-day test period is built into the schedule for recirculation of water from the IPS to the Plant. Once the recirculation testing is complete in August 2011, wastewater will be pumped to the Plant to start the commissioning period.

The current and anticipated Plant substantial completion and commissioning status is:

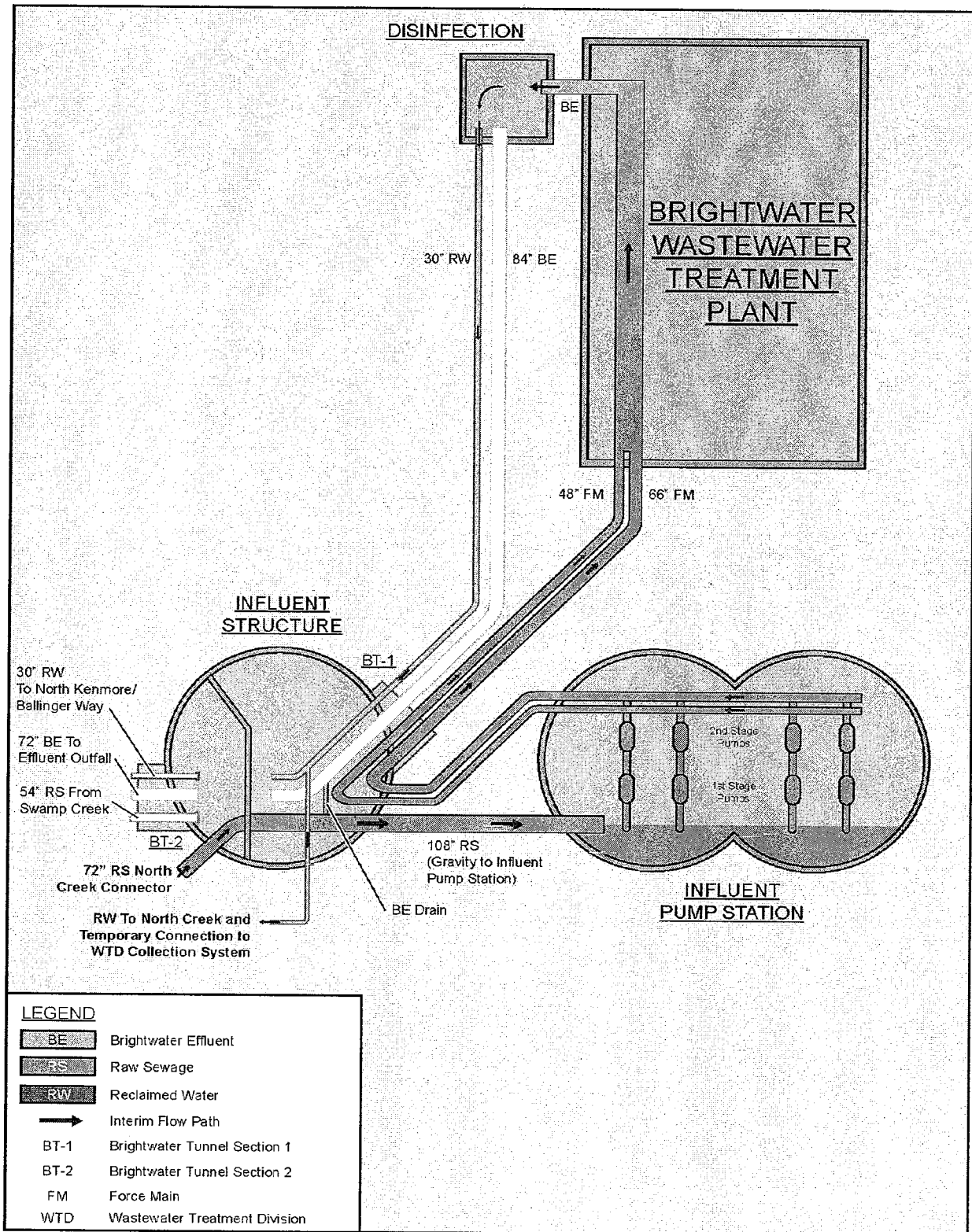
- A piping modification implemented at the Plant provides for internal recirculation of clean water without support from the IPS, allowing the Plant to achieve substantial completion in February 2011.
- Both Liquids and Solids contracts are on the same schedule for completion at this time, however, weather delays or other factors may contribute to substantial completion extending beyond February 2011.
- The IPS is scheduled for partial completion by mid-May 2011, allowing the pumps to recirculate clean water to the Plant and back to the IPS. A 90-day checkout period for the pumps, which will recirculate water to and through the Plant at higher flow rates, is currently scheduled.
- A modification at the IPS is being planned to allow wastewater influent to be conveyed from NCPS to the IPS, where it will be pumped to the Plant for treatment. Treated effluent will be discharged into the King County Conveyance System and will be conveyed to either the West Point or South Treatment Plants until the Brightwater system is complete.
- A six-month commissioning period is planned for the Plant, beginning in August 2011 and extending to mid-February 2012. This commissioning period is based on the commissioning period for the Zenon membranes. The membranes provide the filtration

necessary to produce a high quality effluent for water reuse and discharge to Puget Sound. The county manages the Zenon contract, and is responsible for evaluating performance testing.

- Completion of Liquids and Solids contracts commissioning can be achieved in less than six months, or whenever they successfully complete a 30-day performance test required by the contract.

The wastewater currently planned for commissioning use will flow from the NCPS via the Influent Structure to the IPS, where it will be pumped to the Plant (**Figure 2**). It will then be treated at the Plant and discharged through the reclaimed water line and NCPS back into the collection system to one of the two existing WTD facilities. This plan results in the wastewater being treated twice.

Figure 2
Interim Commissioning Flow Path



Department of Natural Resources & Parks
Brightwater Treatment Plant

2.3 Commissioning Challenges

Clean water testing will provide significant confidence in the integrity of portions of the Plant and assurance that some of the Plant is operating per design. **Table 2** highlights the level of integrity and functionality demonstrated by clean water testing. However, for much of the Plant, a comprehensive demonstration of equipment functionality during commissioning is only possible using wastewater.

Table 2. Clean Water Testing Results

Contract	Building / Function	System Integrity	System Function	
Liquids	Headworks	Yes	Yes	
	Headworks Truck Loadout	No ¹	No ¹	
	Grit Removal	Yes	No ¹	
	Primary Clarifiers	Yes	No ²	
	Primary Effluent Screens	Yes	No ²	
	Aeration Basins	Yes	No ²	
	Membrane Feed Pumps/Equipment	Yes	Yes	
	Membrane Basins	Yes	No ²	
	Disinfection	Yes	No ²	
	Alkaline Chemical Storage	Yes	Yes	
	Effluent Drop Structure	Yes	Yes	
	Solids	Boilers	Yes	No ³
		Digesters	Yes	No ³
Gravity Belt Thickeners		Yes	No ³	
Centrifuges		Yes	No ³	
Chemical System		Yes	No ³	
Conveyors		No ³	No ³	
Truck Loadout		No ³	No ³	
Acid Chemical Storage		Yes	No ³	
Odor Control Facilities (3 each)	Yes	No ³		

¹ Requires wastewater inorganic solids

² Requires wastewater flow

³ Requires wastewater biosolids

During the sewage commissioning period, operation of the Plant and equipment is turned over to county operations staff as they are trained and licensed to operate treatment processes. The scope of the contractor's responsibilities during commissioning requires them to be present and to assist, if problems or issues arise. The county does not grant acceptance of contractor commissioning until the process has been operated for 30 days continuously. The contractor is not physically responsible for operating the process facilities, but it is in their interest to assist in problem identification and resolution in order to complete the 30-day continuous performance test as soon as possible.

At this time, it is the county's intention to move forward to substantial completion on both plant contracts without delay. On the Liquids side, clean water testing on most equipment and facilities can be performed to achieve substantial completion. One notable exception is the Zenon membrane equipment. The membranes are shipped in a glycerin bath and once installed are required to be left in water and periodically disinfected. The warranty period begins on the membranes when they are installed, now scheduled for January 2011. If the membranes are left in the packaging for an extended period, the glycerin bath needs to be recharged at substantial expense. Staff are in discussions with Zenon regarding proper handling and costs for recharging membranes to maintain service life.

The Solids equipment cannot be conclusively commissioned with water since equipment like the gravity belt thickeners and centrifuges require biosolids to confirm operability and performance. Grit and screenings equipment also requires wastewater solids to demonstrate proper function. Chemical storage, batching and feed equipment will also present challenges during startup and testing. Odor control equipment can be operated; however, the biofilters require a food source normally provided by the air from the wastewater process. All Plant wastewater treatment systems will be placed in standby mode beginning February 23, 2011, until the IPS is available to recirculate clean water in May 2011.

The option of hauling solids from another county facility to perform preliminary commissioning of the Solids facilities was evaluated and eliminated from consideration. The benefit of preliminary commissioning is it permits equipment and systems to operate under design conditions, demonstrates their ability to properly function and process wastewater, and could allow the county to close out the Solids contractor's contract under actual operating conditions. However, only a portion of the equipment and facilities could be tested, and substantial uncertainty would remain regarding the commissioning of other equipment. Temporary odor control measures would need to be implemented to allow for the temporary transfer of biosolids. Extensive cleaning of equipment and facilities would also need to be performed upon completion of the testing to properly maintain the equipment and limit odors. Accordingly, this option is not recommended and will not be pursued further.

3.0 Contracting Alternatives Evaluated

Four commissioning alternatives (**Figure 3**) were developed to evaluate the costs and risks of commissioning delay. A discussion of the four alternatives, with advantages and disadvantages of each, are presented in **Appendix A**. Risks associated with each of the four alternatives are discussed in **Section 4** and **Appendix B**.

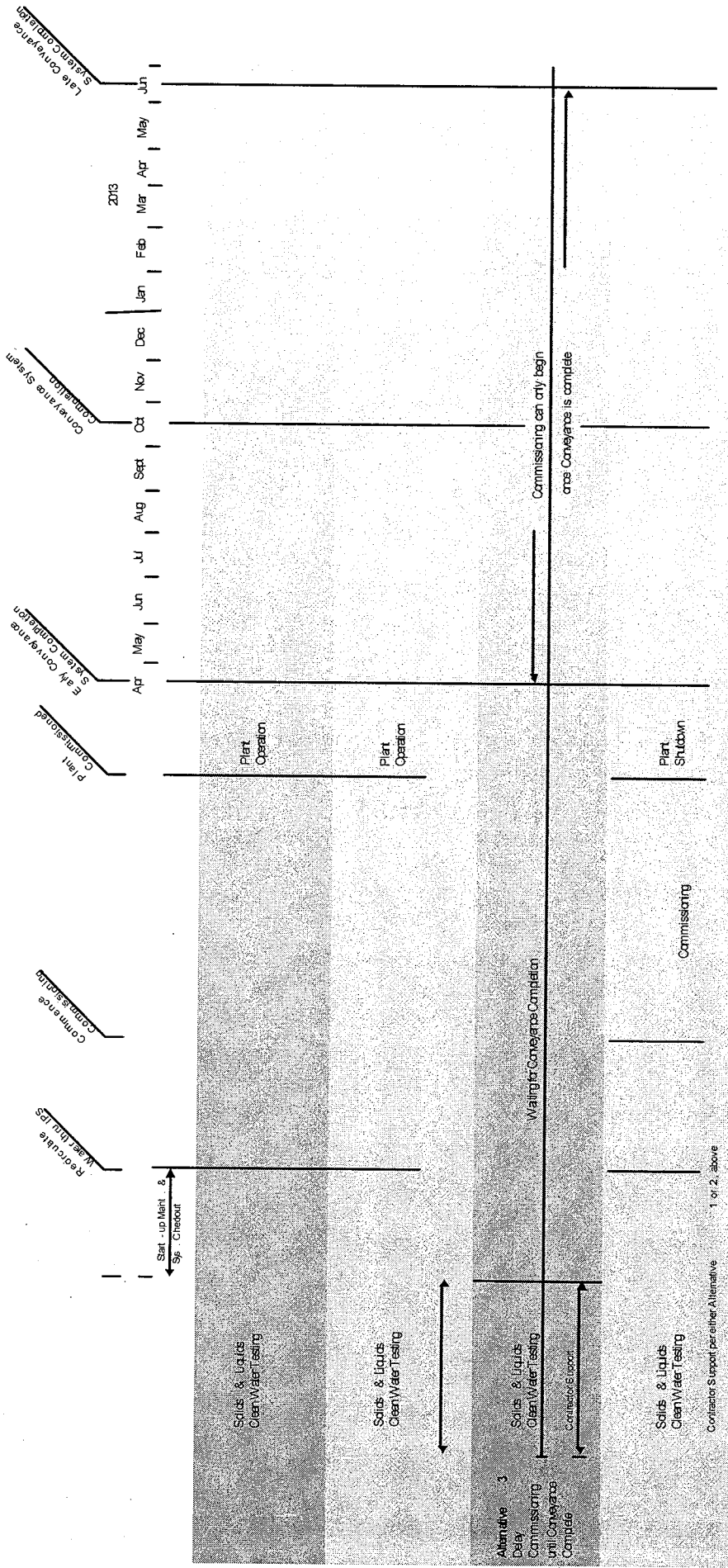
Alternative 1, Extend Liquids and Solids Contracts – King County and Contractors Perform Commissioning. Negotiate time extensions to retain the Liquids and Solids contractors through January 2012, or when commissioning is complete. Recirculate clean water between the IPS and the Plant beginning May 2011. Beginning August 2011, begin pumping wastewater from the IPS to the Plant and commission Liquids and Solids facilities. Continue to discharge treated effluent into the wastewater system until the Conveyance System is operable.

Alternative 2, Do Not Extend Liquids and Solids Contract - King County Performs Commissioning without Contractor Assistance. Begin sewage commissioning in August 2011 without assistance from the contractor. Negotiate deductive change order to eliminate commissioning from the two contracts then issue final acceptance once the contractor finishes contractual requirements. Commission the Plant with county staff beginning August 2011. Discharge treated water into the county Conveyance System until the full Conveyance System is operable.

Alternative 3, Do Not Extend Liquids and Solids Contract - Delay Commissioning until Conveyance is Complete. Remove commissioning scope from Liquids and Solids contracts. Eliminate commissioning scope from both contracts and release the contractors once punch list items are completed. Commission the Plant using King County staff without contractor assistance once conveyance is complete.

Alternative 4, Place Plant on Standby once Commissioning is Complete. Following a six month period of performance under either Alternative 1 or 2 above, place the Plant on standby until the Conveyance System is complete. The Plant would be placed on standby beginning February 2012. King County staff restarts the Plant once the Conveyance System is completed.

Figure 3
Commissioning Alternatives



4.0 Discussion of Potential Risks

Risks have been identified in **Appendix B** associated with potential commissioning and contracting options. Identification and assessment of risk is an important factor in developing operating cost estimates since these risks have a direct bearing on the project schedule and the timing of when the Plant can be placed in operation. The county has already taken steps to manage risk and potential schedule delays to the project including:

- Installing a recirculation line within the Plant to provide for internal recirculation of clean water independent of the IPS. This allows plant testing with clean water to advance without pumping from the IPS.
- A change order has been issued to the IPS contract to modify construction sequencing and provide for removal of the tunnel boring machine. This change order includes temporary piping within the IPS to allow plant commissioning to proceed in advance of the completion of the Central Tunnels.
- Analyzing the possibility of shortening the 90-day schedule duration in the IPS schedule preceding pumping raw sewage to determine if opportunities exist to shorten this duration.
- Reviewing commissioning plans to determine what critical work needs to be performed by the contractors vs. what work can be performed with county forces. By minimizing the contractors' involvement in commissioning to the items necessary to protect the county's interests, it will allow the contractors to demobilize the majority of their workers, while retaining only necessary staff to complete commissioning activities. This will reduce the cost of a time extension.

The discussion below identifies and summarizes other issues impacting the decisions.

- In the event a contract extension cannot be negotiated with the Liquids or Solids contractor, the county has several options. The county may negotiate an extension with the Liquids contractor for assistance with commissioning the Solids facilities, retain consultant staff to assist with commissioning, or undertake the task with only county staff. This will be evaluated once discussions progress with the contractors.
- It should also be understood that, although the Plant is currently on schedule for substantial completion by mid-February 2011, there is potential for delay in construction at the Plant that could further reduce the schedule duration between the IPS and Plant completion. This would reduce the duration of negotiated time extensions with the Liquids and Solids contractors.
- Likewise, potential delays at the IPS could lengthen or impact the start of Plant commissioning.
- Alternatively, further delay in repairing tunnel boring machines or constructing one or both of the tunnels could widen the time gap between plant substantial completion and plant operation with Brightwater influent.

- Another issue relates to the benefits of maintaining plant operation under limited flow until the Conveyance System is completed, compared to the option of completing the commissioning requirement and then shutting the Plant down, and restarting once the Conveyance System is completed. One of the primary reasons to continue plant operations is that the Plant's biological systems will be operational and the key to future plant performance is building "inventory" (biological mass) in the biological treatment systems. These systems include the aeration basins, membrane bioreactors, digesters, and a number of odor control bioscrubbers. Inventory can take weeks to months to build and maintain and, if shutdown, would need to be redeveloped. Shutdown will also require tanks to be cleaned and will likely require continued operation of the odor control facilities even after the shutdown. Tank cleaning does not remove residual odors which may remain for many months after cleaning. Operations and maintenance (O&M) staff will be busy testing and tuning systems to optimize performance during this period, which can be productively used to achieve more reliable plant performance in preparation for full system operation. Therefore, shutdown should only be considered for an extended period and is not recommended for a shorter duration of several months.
- Brightwater operations staff will be transferred from other facilities. Delaying startup will not result in labor savings across WTD. If the Plant is placed on standby, a portion of the staff will be assigned to work temporarily at the West Point and South Treatment Plants, returning to Brightwater when sewage is processed. While the Plant is shut down, it will still require an O&M presence to maintain the facility, rotate pumps and machinery, and maintain staff training and readiness.

Finally, a decrease in chemical and energy use at Brightwater during a period of standby would be at least partially offset by increases in treatment requirements at other treatment facilities. A certain amount of chemicals and energy would still be required to treat these flows at either South Treatment Plant or West Point Treatment Plant. The operating costs developed for this report included a calculation of the costs for the additional flows treated at West Point and South Treatment Plants during the standby period, as well as avoided costs when Brightwater is providing treatment prior to Central Tunnel completion.

5.0 Costs

Section 5 presents the estimated capital and operating costs and the methodology for development of operating costs for each alternative. The estimated operating, capital, and total costs for early, scheduled, and late system completion are presented. Section 5 includes the options evaluated to mitigate operating cost increases, and includes discussion of why the operating costs are deemed reasonable.

5.1 Capital Costs

Delays to commissioning the Plant with sewage require time extension for staff working on the project; management and contract administration; construction management support; engineering support; and other potential costs, such as extended equipment warranties or required maintenance to plant equipment, such as the membrane bioreactors. These types of costs are

considered capital costs. For each potential outcome, estimates were prepared which provide the capital cost for staffing and support services associated with the delay. Capital costs are included in **Table 3** and **Table 4**.

5.2 Operating Cost Projections

To predict operating costs for various flow scenarios and operating conditions, and to determine the best way to optimize plant flows to achieve commissioning and operational objectives while minimizing operational costs, an operating cost model was developed to predict the cost of labor, energy, chemical, and utilities to operate the Plant and the IPS. The model was configured to allow various model inputs to be adjusted, such as seasonal flow volumes, to predict the operating cost on a monthly basis. Each month during a given calendar year was modeled for a given operational scenario and summed to generate annual operating costs. To provide a common basis for comparison of alternatives, operating costs were developed and totaled for the years 2011, 2012, and 2013.

The operating cost estimates are based on the actual units of equipment in service to treat a given volume of flow and rely on empirical cost data for energy, chemicals, utilities and labor based on our extensive experience operating other large regional treatment and conveyance facilities.

Operating costs were evaluated for the Plant and the IPS for various scenarios including the following:

- 2011 operating costs during clean water testing and sewage commissioning
- 2012 and 2013 assuming continued treatment once commissioning is completed
- 2012 and 2013 assuming standby status until Conveyance System completion
- Annual operating costs following system completion

The above costs include avoided costs, or the reduced costs at the West Point and South Treatment Plants, when Brightwater is treating sewage.

The following key assumptions were made in estimating the operating costs:

- The Operations and Maintenance staff assigned to the Brightwater project are from the West Point and South Treatment Plants, not new FTEs. For alternatives involving placing the Plant on standby, approximately half of the Brightwater staff would be temporarily reassigned to other operating plants to perform work but will continue to be budgeted through Brightwater. Consequently, operating labor costs will not change across the division, and reduction in operating costs was not assumed in the cost projections. As discussed in the previous section, there may be future opportunities for labor cost avoidance during periods of extended standby. These will be evaluated as part of future decisions regarding placing the Plant on standby, if there are extended delays in tunnel completion.



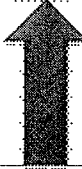

- Options involving placing the Plant on standby will require full staffing for two months to complete plant shutdown. Once the Plant is on standby, roughly half of the staff will be retained to provide ongoing maintenance of equipment.
- Odor control trains will continue running after shutdown. Although the structures and equipment at the IPS and the Plant will be cleaned, the equipment will be operated to ensure there is no potential for odor after shutdown. The operating cost model includes the cost of operating this equipment.

The total annual operating costs when the Plant is in full operation and the Brightwater system is complete are estimated at \$8.8 million.

Table 3, on page 21, summarizes the estimated annual operating cost and capital cost for a projected October 2012 system completion. Appendix B includes a more detailed comparative assessment of risk for each outcome, and an estimate of the capital cost exposure for risk associated with each outcome.

Table 4, on page 22, summarizes the estimated annual operating cost and capital cost for each outcome for system completion in April 2012, October 2012, and June 2013.

**Table 3.
Summary of Estimated Annual Operating Cost
and Capital Cost for each Alternative**

Outcomes	System Completion October 2012			Risk Exposure		
	Operating Cost (Million\$)	Capital Cost (Million\$)	Total Cost (Million\$)	Amount (Million\$)	Level	
Alternative 1, Extend Liquids and Solids Contracts – King County and Contractors Perform Commissioning	\$23.7	\$8.4	\$32.0	\$2.8	Low	
Alternative 2, Do Not Extend Liquids and Solids Contract – King County Performs Commissioning without Contractor Assistance	\$23.7	\$8.6	\$32.2	\$6.0	Medium-High	
Alternative 3, Do Not Extend Liquids and Solids Contract - Delay Commissioning until Conveyance is Complete – King County Performs Commissioning	\$18.4	\$10.7	\$29.1	\$8.1	High	
Alternative 4, Extend Liquids and Solids Contracts, Place Plant on Standby once Commissioning is Complete. King County Restarts Plant	\$21.7	\$8.3	\$30.0	\$3.6	Medium	

Note:

1. Operating costs are combined for years 2011, 2012, and 2013 to provide a comparable time period for comparison of alternatives.
2. Operating costs include operational labor, energy, chemicals, utilities for the Brightwater Treatment Plant and Influent Pump Station.
3. Cost Summaries do not account for potential exposure to risk associated with contractor claims, correcting defective work.
4. Alternatives 3 and 4 transfer 13 operations and maintenance personnel to South Treatment and West Point Treatment Plants for maintenance activities for the interval that Brightwater is not fully operational.
5. Risk exposure is quantified in Appendix B. Quantified risks include exposure to cost impacts associated with correcting defective work, project delays, and extended warranty protection. Risk exposure levels are relative based on the potential capital cost impact associated with each alternative.

**Table 4.
Brightwater Treatment Plant Commissioning Outcomes
Summary of Three-Year Capital and Operating Costs (2011 - 2013)**

Outcomes	Early System Completion April 2012			System Completion October 2012			Late System Completion June 2013			Risk Exposure	
	Operating Cost (Million\$)	Capital Cost (Million\$)	Total Cost (Million\$)	Operating Cost (Million\$)	Capital Cost (Million\$)	Total Cost (Million\$)	Operating Cost (Million\$)	Capital Cost (Million\$)	Total Cost (Million\$)	Amount (Million\$)	Level
Alternative 1, Extend Liquids and Solids Contracts – King County and Contractors Perform Commissioning	\$23.6	\$7.8	\$31.4	\$23.7	\$8.4	\$32.0	\$23.9	\$8.7	\$32.5	\$2.8	Low
Alternative 2, Do Not Extend Liquids and Solids Contract – King County Performs Commissioning without Contractor Assistance	\$23.6	\$8.1	\$31.6	\$23.7	\$8.6	\$32.2	\$23.9	\$8.8	\$32.7	\$6.0	Medium-High
Alternative 3, Do Not Extend Liquids and Solids Contract - Delay Commissioning until Conveyance is Complete – King County Performs Commissioning	\$20.6	\$10.1	\$30.7	\$18.4	\$10.7	\$29.1	\$15.3	\$12.0	\$27.3	\$8.1	High
Alternative 4, Extend Liquids and Solids Contracts, Place Plant on Standby once Commissioning is Complete. King County Restarts Plant	\$23.6	\$7.8	\$31.3	\$21.7	\$8.3	\$30.0	\$17.8	\$8.7	\$26.4	\$3.6	Medium

Note:

1. Operating costs are combined for years 2011, 2012, and 2013 to provide a comparable time period for comparison of alternatives.
2. Operating costs include operational labor, energy, chemicals, utilities for the Brightwater Treatment Plant and Influent Pump Station.
3. Cost Summaries do not account for potential exposure to risk associated with contractor claims, correcting defective work.
4. Alternatives 3 and 4 transfer 13 operations and maintenance personnel to South Treatment and West Point Treatment Plants for maintenance activities for the interval that Brightwater is not fully operational.
5. Risk exposure is quantified in Appendix B. Quantified risks include exposure to cost impacts associated with correcting defective work, project delays, and extended warranty protection. Risk exposure levels are relative based on the potential capital cost impact associated with each alternative.

Table 5, on page 24, translates the cost data of the previous table into sewer rate equivalents to provide another perspective on the cost differentials among outcomes. More specifically, these rate equivalents are based on the differences in costs among the various scenarios and alternatives relative to the most likely outcome of Alternative 1 with a completion date of October 2012¹. They are not intended to anticipate a specific change in the adopted or proposed monthly sewer rate if a particular outcome is determined. Rather the numbers show the differences in total cost among the scenarios accounting for the differential impacts of operating and capital costs on the monthly sewer rate.

Additionally, based on the risk analysis, the potential risk exposure is identified for each option to help distinguish relative risk among the alternatives. This assessment of risk exposure is an estimate of the cost of containing risk events, such as defective work, in the event the risks materialize. For comparison with the cost-based rate equivalents, the risk differentials are translated into rate equivalents based on the assumption that risks will be realized largely as changes in capital costs and will continue through the life of the financing.

The resulting rate equivalents represent an illustrative change in the monthly sewer rate for each of the three years from 2011 to 2013. The analysis assumes the operating costs are evenly distributed across the three-year period and that all scenarios generate the same costs, zero difference, in subsequent years. Although the table presents costs for 2011 to 2013, the contribution of capital cost differences would be expected to continue for the 30-year duration of the financing used for the capital expenditure. However, it should be noted that the capital component of the rate equivalent for all capital cost comparisons is small compared with the overall rate and the operating component of the rate equivalent.

On a technical note, in addition to the monthly sewer rate, WTD charges new connecting customers a “capacity charge.” The charge is levied for 15 years and is currently \$49.07 per month for a single-family residence. This charge is designed to recoup the capital costs of new capacity from the customers who ultimately use it. Changes in the project’s capital costs will eventually be reflected in the capacity charge calculation. Because the underlying components of the capacity charge are calculated on a three-year cycle, the effects of the various outcomes in this report would not be incorporated in the capacity charge until 2013 or 2014 at the earliest. In this analysis, the differences among the capital costs of the scenarios are comparatively small relative to the overall cost of the project. As a result, the maximum effect on the capacity charge (given the results contained herein) would be approximately 5 cents per month, or less than 0.2 percent of the current level.

¹ Most Likely Outcome is based on WTD’s assessment as of January 2010, before considering any potential transfer of tunneling work referenced in the County Executive’s February 18, 2010, Emergency Declaration.

Table 5.
Brightwater Treatment Plant Commissioning Outcomes
Summary of Annual Rate Equivalents* Associated with Capital and Operating Cost (2011 - 2013)

Difference from Alternative 1, System Completion October 2012

Outcomes	Early System Completion April 2012	System Completion October 2012	Late System Completion June 2013	Risk Exposure**		
	Monthly Sewer Rate	Monthly Sewer Rate	Monthly Sewer Rate	Amount (Million\$)	Rate \$/RCE/Month	Level
Alternative 1, Extend Liquids and Solids Contracts – King County and Contractors Perform Commissioning	(\$0.01)	\$0.00	\$0.01	\$2.8	\$0.00	Low
Alternative 2, Do Not Extend Liquids and Solids Contract – King County Performs Commissioning without Contractor Assistance	(\$0.01)	\$0.00	\$0.01	\$6.0	\$0.03	Medium-High
Alternative 3, Do Not Extend Liquids and Solids Contract - Delay Commissioning until Conveyance is Complete – King County Performs Commissioning	(\$0.11)	(\$0.19)	(\$0.30)	\$8.1	\$0.04	High
Alternative 4, Extend Liquids and Solids Contracts, Place Plant on Standby once Commissioning is Complete. King County Restarts Plant	(\$0.01)	(\$0.08)	(\$0.23)	\$3.6	\$0.01	Medium

*Annual Residential Customer Equivalent rate is the effect of the indicated scenario and alternative on the monthly sewer rate for 2011-13 relative to the baseline.

** Risk contingency reflects differences in risk relative to Alternative 1.

Note:

1. Operating costs are combined for years 2011, 2012, and 2013 to provide a comparable time period for comparison of alternatives.
2. Operating costs include operational labor, energy, chemicals, and utilities for the Brightwater Treatment Plant and Influent Pump Station.
3. Potential exposure to risk from contractor claims and correcting defective work is addressed in the risk exposure and not included in the rate equivalent figures.
4. Alternatives 3 and 4 transfer 13 operations and maintenance personnel to South Treatment and West Point Treatment Plants for maintenance activities for the interval that Brightwater is not fully operational.
5. Risk exposure is quantified in Appendix B. Quantified risks include exposure to cost impacts associated with correcting defective work, project delays, and extended warranty protection. Risk exposure levels are relative based on the potential capital cost impact associated with each alternative.

5.3 *Flows During Commissioning and Operations – Optimization of Flows and Reduction of Operational Costs*

During the period when sewage is treated at the Plant prior to system completion, the Plant is expected to treat an average dry weather flow of 14 mgd, and an average wet weather flow of 17 mgd, which is the flow available at the NCPS facility to pump to the Plant. To evaluate opportunities to minimize operating costs during Plant commissioning, the following options were evaluated:

- Staff reviewed the option of reducing flow to the Plant, once commissioning objectives were met, as an opportunity to reduce operating costs. The minimum flow necessary for pumping to the Plant is estimated at 10 mgd. Below 10 mgd, the IPS pumps would begin operating in a “fill and draw” mode of operation, which the Plant and the IPS are not designed for. Consequently, additional control strategies would need to be prepared and the amount of wear on pumps and equipment will increase with the start/stop cycles. The design is based on continuous flow and it is not practical to divert less than 10 mgd to the Plant for treatment on an ongoing basis.
- There is limited capability to modulate and regulate flow at the North Creek diversion structure. More precise metering of flow would require additional control devices at additional cost. This limits the ability to precisely modulate flow diversions to the Plant.
- Generally, the same number of process trains are required at the Plant to handle 10 mgd of flow compared to 15 mgd. Decreasing flow to 10 mgd would not decrease the number of equipment units and process trains in service and consequently, would not result in a significant decrease in energy and chemical consumption. Labor costs would remain constant. Therefore, costs would not be expected to be significantly lower.

Based on the above factors, reduction of flow to the Plant during the interim period prior to system completion is not considered practical or a significant opportunity to reduce operating costs.

5.4 *Evaluation of Opportunities for Operational Labor Cost Reduction During Periods of Plant Standby*

To determine if opportunities exist to reduce the cost of operating the Plant during periods of standby, we analyzed the personnel requirements for operations and maintenance staff to maintain the Plant during extended periods of standby. For alternatives where the Plant is placed on standby, approximately half of the operations and maintenance staff of 26 can be temporarily reassigned to the West Point and South Treatment Plants. Of the total annual operating costs of \$8.7 million under normal operation, staffing labor is estimated at \$2.6 million per year, or \$216,850 per month.

When the Plant is on standby, a significant amount of work will need to be performed. All systems will need to be monitored and maintained. The systems which will be operating include the boiler and heat loop systems, the heating and ventilation system, the instrument air system, the sump pumps, and the storm water system. The electrical distribution system including standby generators will be functional. The control system will be live, and any alarms will have

to be answered. All rotating equipment will need to be exercised and preventative maintenance work orders will need to be completed. Water will remain in some of the tanks in order to exercise equipment and this water will need to be disinfected. Valves will need to be exercised in order to maintain a state of operational readiness. Additionally, there is much work to be completed with the new plant coming online. Staff will be working to complete asset data collection and asset tagging. They will be developing maintenance and operational procedures, in addition to developing the training program for returning employees. Additional refinements of the Plant's instrumentation and control system may be needed to optimize Plant operation.

Placing the Plant on standby may result in the availability of approximately 13 full-time employees (FTEs) for work at the South and West Point Treatment Plants. However, labor costs are not adjusted in this report as they would continue to be a cost that the county incurs. The difference is that standby operation allows a higher level of maintenance activities to be completed at other treatment plants. For any future decisions involving plant standby, a work program for reassigned staff would need to be developed.

5.5 Determination of the Reasonableness of Operating Costs

Proviso 2, Section 105 of Ordinance 16717 requires analysis and verification that the operating costs for Brightwater are reasonable. The determination that the operating costs are reasonable is based on undertaking the actions listed below, which in collaboration with the Brightwater Oversight Management consultant, was deemed a logical methodology to assess the reasonableness of the operating costs for the Brightwater system. The following actions were taken:

- Developed a predictive cost model for chemical and energy consumption based on the specific treatment equipment and systems that will operate at the Plant and IPS for a given flow volume. This is a more accurate estimating methodology compared to previous estimates. It is important to take into consideration the flow volumes to be treated since not all of the Plant systems will need to be operated to treat flow that is available before the Conveyance System is complete.
- Performed model runs on a monthly basis for the years 2011, 2012, and 2013 to account for monthly and seasonal flow and load variations. Performing the model runs based on projected monthly flows improves the accuracy of the estimates compared to developing estimates based on annual average flows.
- Costs are derived from our large wastewater treatment and conveyance system operating experience to date. Where possible, we used existing contractual unit costs for chemicals and energy. For instance, the unit costs for chemicals were taken from existing vendor supply contracts in place at South Plant that will be used to supply chemicals to Brightwater.
- Labor costs are derived from actual labor expenses, including benefits, for operations and maintenance staff assigned to the project.

Based on the above, the operating costs are deemed reasonable because they are based on the specific equipment and systems that will be operated to treat the flow at the Plant under differing monthly flow conditions expected for each alternative. These are predictable expenditures that

have yet to be verified by actual operating experience but will be confirmed once the Plant is up and running. The timing of the operating expenditures will be determined when commissioning and operations actually begin, which are based on progress in completing construction.

6.0 Discussion of Potential Outcomes

Figure 4, on the following page, displays the total costs for each alternative, and the relative risk exposure. Risk exposure for each alternative is quantified in Appendix B, and is shown in Figure 4 as a “band” or potential range of cost exposure to risk. For instance, Alternative 3 has a lower cost but a higher exposure to risk relative to Alternative 2. Quantified risks include exposure to cost impacts associated with correcting defective work, project delays, and extended warranty protection.

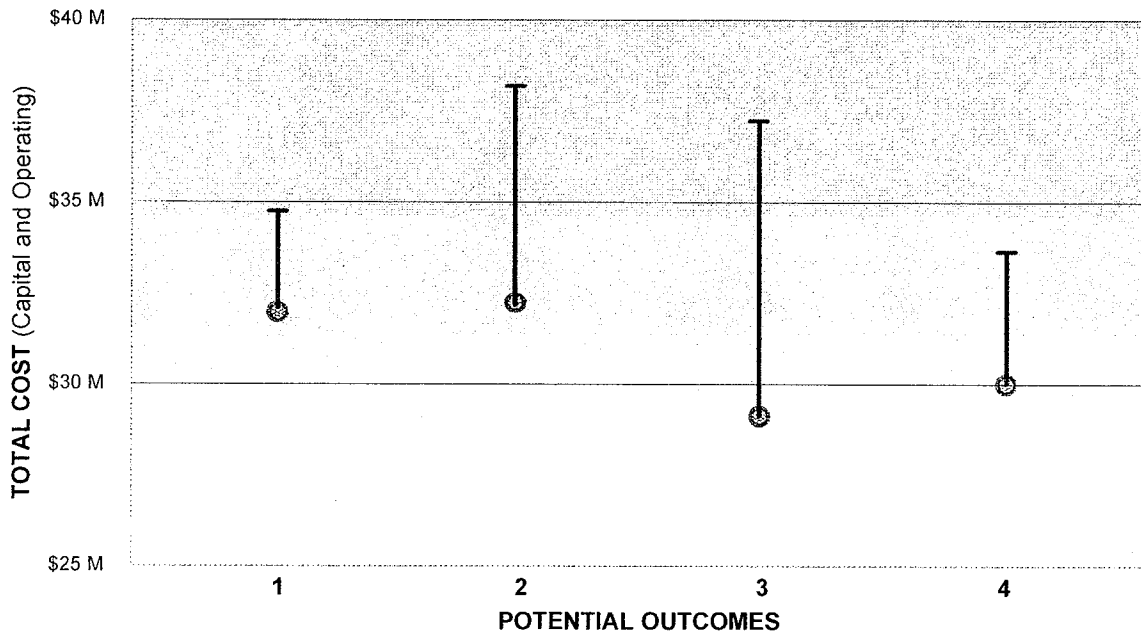
Alternatives 1 and 4 are similar in that they both involve negotiating a time extension to both the Liquids and Solids contractors and completing the commissioning of the Plant early in 2012. These options have higher 2011 through 2013 operating costs compared to Alternative 3, but minimize risk to the project. It is advantageous to maintain the continuity of contractor, consultant, and county staff as seamlessly as possible from the completion of water testing (substantial completion) through commissioning. It also provides an excellent opportunity for the county to optimize Plant processes during a period of lower flow and to remedy any defects before increasing flows. Although the total cost of Alternative 4 is lower than Alternative 1, the disadvantage of Alternative 4 is performing the task of de-commissioning the facilities with limited means of discharging flow and effectively cleaning structures and equipment in anticipation of an extended period of downtime. Operating costs would be reduced but the odor control facilities would need to continue operating to remove residual odors. Also, as discussed above, the secondary and solids biomass would also need to be reestablished upon restarting the Plant. In deciding between Alternatives 1 and 4, the county will monitor the conveyance construction progress and evaluate the length of time that the Plant would be on standby status. A decision would be made by October 2010 on proceeding with the contract extensions.

Alternatives 2 and 3 minimize the cost of contractor extensions but increase risk and cost to the county for correction of defective work, loss of contractor continuity and contractor expertise, interruption of staffing, and warranty extensions. This would be more likely under Alternative 3 where the duration between substantial completion and commissioning is significantly extended and the contracting entities are farther removed from the project. It becomes an inconvenience to the contracting company operations and maintaining a presence will be given less and less attention as the duration increases. Although this scenario is difficult to assign a firm value to, we assume commissioning will be more difficult with commensurate cost implications.

Alternative 3 will result in a substantial time period between the completion of construction and commissioning. This presents a real challenge and risk to the project, as many staff and consultants familiar with the project will be reassigned to other projects, resulting in a loss of institutional knowledge. The Plant is a very complex facility, and the continuity of professional staff involved in the administration, engineering, and construction management have facilitated problem resolution, prevention of delays, and minimization of change orders. It is clearly a benefit to the county to maintain this staff integrity through the completion of the commissioning challenges. Further, proceeding with Alternative 3 could result in unforeseen delays to

completion of the Brightwater system, if problems or defects are uncovered during commissioning which would delay the commissioning and wastewater treatment at the Plant. This would place the Plant on the critical path for Brightwater system completion, and delay needed capacity improvements for the wastewater system. Further delay of the Brightwater system increases the risk of sewage overflows and could have regulatory implications, resulting in enforcement actions or levy of penalties by the Washington State Department of Ecology.

Figure 4
 POTENTIAL OUTCOMES – ESTIMATED TOTAL COSTS & RISK
 SYSTEM COMPLETION OCTOBER 2012



	COST (\$M)	RISK (\$M)
Alternative 1	32.0	2.8
Alternative 2	32.2	6.0
Alternative 3	29.1	8.1
Alternative 4	30.0	3.6

7.0 Recommendations

No specific recommendation is made at this time. Instead, a series of decision points exist that will result in clear contracting direction by the fall of 2010. This report has presented the costs and risks of future alternatives to address potential outcomes under a wide range of Central Tunnel delay scenarios. As 2010 and 2011 unfolds, a clearer picture will emerge of the schedule for completion of the Central Tunnels, the Plant, and the IPS contracts. The Plant continues to be dependent on other project elements, including the IPS and Central Tunnel, and needs to retain flexibility to address the various schedule developments that will be evaluated as the project progresses towards completion.

The scheduled progress of BT-2 is a critical element in the sequence of activities necessary to begin pumping of sewage to the Plant in advance of system completion. If BT-2 is delayed, it will complicate construction sequencing and the installation of piping at the IPS to provide for pumping of sewage to the Plant. This is an important critical milestone necessary to maintain the startup of wastewater treatment at the Plant in August 2011. Staff will continue to monitor progress closely.

If WTD chooses to move forward with negotiating extensions to the Liquids and Solids contracts to facilitate commissioning with sewage in 2011, negotiations with each contractor should be initiated in October 2010 to allow for contract extensions to be in place prior to Plant substantial completion in February 2011. At that time, the team will assess any complications associated with the schedule for completion of BT-2 and BT-3, and the progress of the Liquids and Solids contracts towards substantial completion. There aren't any plant contracting actions that need to be made in advance of this timeframe. If negotiations do not result in an executed contract extension by substantial completion, WTD retains the option of performing the commissioning on its own (Alternative 2) and has sufficient time in the schedule to amend contracts as necessary for consultant support prior to the August 15, 2011 date for commissioning sewage.

Alternatives 2 and 3 are riskier because under these alternatives, the county could be exposed to additional cost increases as a result of correcting defective work. In both of these alternatives, test responsibilities are effectively completed and the contractors are demobilized before commissioning begins and any opportunity for assistance from them to correct any defective work diminishes. As a result, the county may have to pay a separate contractor to repair any defective work. The current Plant construction contractors also contribute to the personnel continuity that has contributed to the success of the project thus far. Interrupting this continuity will increase the county's risk. Alternative 3 carries a substantial amount of risk and has the highest potential to delay completion of the Brightwater system with potential regulatory implications. For that reason, Alternative 3 is not recommended.

If there are extended delays to Central Tunnel completion, resulting in a substantial interval between Plant and Conveyance System completion, Alternative 4 would be considered given the potential to mitigate operating cost increases. The option to place the Plant on standby pending tunnel completion is retained as a future decision, if there are prolonged delays to the Central Tunnel completion. Likely factors that will influence this decision include the extent that commissioning objectives have been achieved during the commissioning period, opportunities for cost avoidance by temporarily reassigning staff to perform work at other plants, the need to

maintain biological systems at the Plant, and compliance with National Pollutant Discharge Elimination System permits.

Appendix A. Contracting Alternatives Discussion

Alternative	Discussion of Alternative	Advantages	Disadvantages
<p><i>Alternative 1, Extend Liquids and Solids Contracts - King County and Contractors Perform Commissioning.</i> Recirculate clean water between the IPS and Plant beginning May 2011. Beginning August 2011, pump wastewater from the IPS to the Plant and commission Liquids and Solids facilities. Continue to discharge treated effluent into the wastewater system until the Conveyance System is operable. Negotiate time extensions to retain the Liquids and Solids contractors through January 2012.</p>	<p>Assumes substantial completion will be achieved by the end of February 2011. Alternative 1 retains both contractors to assist with final commissioning through December 2011 (see <i>Alternative 1 Schedule</i>). This will require negotiation of contract time extensions with both contractors.</p> <p>Under this alternative, time extensions would be negotiated for the Liquids and Solids contracts to retain the contractor's services through January 2012. Staff and consultant support anticipated to be required for this period includes King County and consultant staff. Consultant staff includes construction management, engineering support, and technical and standby subcontractor trade staff from each contract to address mechanical, electrical, and instrumentation and controls modifications that may arise.</p>	<ul style="list-style-type: none"> • Maximizes continuity with contractors' project staff. Typically, key contractor staff is retained through the commissioning process to assist WTD operations staff, and to transfer detailed knowledge gained through construction to WTD staff during the startup of the facilities. • Allows the contractors to fulfill their contractual requirements to complete commissioning of the Plant. This ensures proper operation while the contractors are mobilized (on-site) prior to turning over to WTD staff for operations. Defective work can be readily identified and corrected. • Warranties are in force after the equipment has been installed, tested and accepted. Delaying startup and commissioning may require extending certain warranty periods at additional cost. • Minimizes risk associated with correcting defective work and schedule delays resulting from not having the contractor who built the facility available to assist with problem identification and resolution. • Continued operation of the Plant at low flow until the Central Tunnel is complete will provide opportunity for Operations and Maintenance staff to become increasingly familiar with the Plant facilities; and, final implementation of mechanical and control strategy modifications can be made before increasing flow. • Provides opportunity to improve and optimize plant performance and systems in 2011/2012 while the Plant is operating with sewage. 	<ul style="list-style-type: none"> • Cost of contract extensions. Maintaining a contractor staff presence, including key contractor staff familiar with the construction, will require negotiation of a time extension with both contractors. Depending on the extent of the delay, it is anticipated that, with the exception of a limited core staff, both contractors will demobilize the majority of their forces until wastewater is available, and then remobilize staff to assist in commissioning. • Costs for King County staff consultant construction management and engineering services support will increase due to extended services for contract administration. • Once the Plant is commissioned, it will continue to operate. Relative to Alternatives 3 and 4 (Plant on standby), operating costs will be higher.
<p><i>Alternative 2, Do Not Extend Liquids and Solids Contract - King County Performs Commissioning w/ Contractor Assistance.</i> Begin sewage commissioning in August 2011 without assistance from the contractor. Negotiate deductive change order to eliminate commissioning from the two contracts; issue final acceptance once the contractor finishes contractual requirements. Commission the Plant using King County staff beginning August 2011. Continue to discharge treated water into the King County system until the full Conveyance System is operable.</p>	<p>Maintains the same startup and commissioning schedule as Alternative 1; however, Alternative 2 would involve close out of the Liquids and Solids contracts upon completion of final acceptance. (see <i>Alternative 2 Schedule</i>). The contractor would not be required to perform commissioning. King County, with support from its engineering and construction management consultants, would perform the commissioning.</p>	<ul style="list-style-type: none"> • Contractor costs would be minimized since no time extension would be required. Additional costs will still be incurred for extended warranties and additional consultant support or other costs King County would incur by completing certain contractor activities. Early close out of these contracts will also reduce contract administration by King County consultants. • Increase in capital cost associated with consultant startup support. • King County assumes a significantly larger role in commissioning activities including scheduling and coordination of the many project vendors and equipment suppliers. The burden for negotiation of corrections to defective equipment will be placed on King County staff. • Increases risk for correction of defective work at King County expense. 	<ul style="list-style-type: none"> • King County loses the assistance and expertise of the project contractors during a critical phase of the project. Commissioning with wastewater can trigger facility and equipment difficulties that may not have occurred during water testing and may also be the result of contractor deficiencies, not just vendor related issues. This would result in King County having to facilitate corrective measures without benefit of the contractors' trade staff.

Alternative	Discussion of Alternative	Advantages	Disadvantages
<p>Alternative 3, Do Not Extend Liquids and Solids Contract - Delay Commissioning until Conveyance is Complete, King County Performs Commissioning.</p> <p>Negotiate deductive change order from Liquids and Solids contracts. Require achievement of Final Acceptance by both contracts with the exception of the contract requirements regarding commissioning and release the contractors.</p>	<p>Closes out both construction contracts after Final Acceptance and eliminates commissioning responsibilities from each contract. Minimizes King County's costs relative to interim operations and maintenance of the Plant. Requires King County to assume full responsibility for commissioning after Conveyance System is complete.</p> <p>Significantly delays the whole project completion because commissioning occurs after tunnels and then is on the critical path. Risk of sanitary sewer overflows and penalties is much higher.</p> <p>Requires an interim maintenance management program for the Plant. Plant equipment will require limited operation and maintenance during the interim period that will require staffing and management. Basic utilities and facility management will also be required during this period.</p>	<ul style="list-style-type: none"> Minimizes costs to King County for O&M, contractors and consultants in 2011/2012. Increases cost in 2013. Lowest operational cost in 2011/2012 since no sewage is treated. 	<ul style="list-style-type: none"> Highest risk alternative since commissioning will be delayed for a significant time following construction completion, increasing King County's exposure for correction of defective work. Contractors, vendors and suppliers will use this period to disengage from their responsibility to correct defective work once commissioning begins. King County will face increased costs to bring them in at a later date. Highest risk of discovery of defective work at a later date when equipment is not under warranty and a substantial period of time has lapsed increasing the difficulty and expense of correcting the problems at contractor expense. Discovery of defective work or problems at a later date could introduce delays that could delay the overall completion of the Brightwater system. Further delay of the Brightwater system could introduce regulatory actions, such as penalties. Loss of institutional knowledge presents a significant risk to the correct operation of the facility. There has been a significant investment in staff, consultant, and contractor knowledge of the facility design, construction, and operation, and a high level of team continuity that has contributed to the success of the project thus far. Interrupting this continuity will certainly result in difficulties and delays resolving problems that may arise. Increased capital cost associated with extended consultant support and remobilization of consultant team. When the Plant is commissioned, there will be a need for consultant staff and on call contractor support at additional cost. King County will not receive the benefit of the equipment warranties. Selected equipment may necessitate extensions of the warranties at significant cost. King County will assume responsibility for commissioning. This will require King County to manage the vendors and equipment suppliers during commissioning and performance testing. This extended duration of inactivity will make it substantially more difficult to engage vendors and equipment manufacturers when difficulties arise with the equipment. Shutdown of the Plant will interrupt operations, requiring retaining of plant personnel. Lack of continuity for technical and administrative staff, including consultants, will result in lack of familiarity with technical requirements.
<p>Alternative 4, Place Plant on Standby once Commissioning is Complete.</p> <p>Following a six-month period of performance under either Alternative 1 or 2 above, place the Plant on standby until the Conveyance System is complete. The Plant would be placed on standby beginning February 2012.</p>	<p>This alternative would provide for commissioning of the Plant through the full duration of King County's agreement with Zenon for membrane commissioning and would also provide sufficient time to gain confidence in the other plant facilities before plant shutdown. Under this alternative, once commissioning is complete, the Plant would remain in standby mode until the Conveyance System is complete, allowing full effluent discharge to Puget Sound.</p> <p>Requires an interim maintenance management program for the Plant. Plant equipment will require limited operation and maintenance during the interim period that will require staffing and management. Basic utilities and facility management will also be required during this period.</p>	<ul style="list-style-type: none"> Advantages discussed in Alternative 1. Contractors are retained to complete commissioning requirements. Provides for substantial demonstration of plant facilities to gain confidence in mechanical, electrical and instrumentation and controls systems before shutdown. Staff, consultant and contractor staff continuity are maintained. Operating costs are lower compared to continued operation. 	<ul style="list-style-type: none"> Plant will require extensive draining and cleaning of facilities after shutdown with limited availability of sewer for discharge of waste. Will require pumping and trucking of residual water and solids generated during wash down. Some equipment may require partial disassembly for proper cleaning. Odor control facilities will need to remain operational after shutdown to capture odors generated from cleaning and residual waste materials embedded in tank walls and equipment. Commissioning will develop a biomass within the secondary and solids systems that will be lost upon shutdown and will need to be redeveloped when re-commissioning commences. Shutdown of the Plant will not facilitate plant systems to be optimized, which would be the case if treatment with sewage is continued.

Appendix B. Risk Analysis of Commissioning Outcomes

Potential Risk	Consequences	Probable Maximum Loss	Loss Value	Probability of Impact
Alternative 1 - Extend Liquids and Solids Contracts - King County and Contractors Perform Commissioning				
Defective work discovered during commissioning needs to be remedied; facility does not meet performance specifications.	Defective work discovered during commissioning needs to be remedied; facility does not meet performance specifications.	No expected loss. Contractor on-site to remedy defects without delay.	\$0.0M	Medium
Contractor price proposal for extension of services is not reasonable or consistent with the services to be performed.	King County and the contractor cannot agree on the cost to delay plant commissioning. In this case, the default option would be to perform the commissioning with King County staff, or to have the Liquids contractor provide the staff for commissioning the Solids facilities. Additional consultant support will be required to support the commissioning process.	If agreement for extension cannot be reached, secure additional services from consultants. Cost estimated at \$1.0 - \$2.0 million.	\$2.0M	High
Schedule for BT-2 is turn over TBM removal chamber to Central Tunnel contractor by August 2010 for lining operation, and for the Central Tunnel contractor to turn over TBM removal chamber to the IPS contractor for completion of mechanical work by November 2010. If the contractor(s) are behind on these dates, a change order will be necessary to address complications to the piping and staging work required for sewage commissioning.	(1) Additional change order for Kievit for schedule impact at the IPS for piping modifications at Influent Structure. (2) Extend period for extended services at the treatment plant for Liquids and Solids. Extension for contractor, construction management, and engineering consultants. (3) If period is extended, county has option to release contractors and perform commissioning.	Monthly cost at \$400K.	\$0.8M	Medium
Loss of warranty protection.	Delays to project require extended warranties for selected pieces of equipment.	<\$600K included in capital costs.	\$0.0M	High
Total			\$2.8M	
Alternative 2 - Do Not Extend Liquids and Solids Contracts - King County Performs Commissioning w/o Contractor Assistance				
Potential Risk	Consequences	Probable Maximum Loss	Loss Value	Probability of Impact
Defective work discovered during commissioning needs to be remedied; facility does not meet performance specifications.	(1) <i>Potential extra cost.</i> The contractor might seek reimbursement for any remobilizing/staffing costs it incurred that would not have otherwise existed had the contractor been retained through commissioning as originally contemplated. (2) <i>King County hires another contractor to perform work.</i> If a process does not meet performance specifications, and it is not clear if the cause is a contractor or design defect, King County may proceed with the repair and later determine the responsibility for the cost of the repair. If the contractor is not retained during commissioning, King County will have to conduct a new procurement. To avoid delays, and because the type of problems that may arise are currently unknown, this would likely have to be a work order contract so that the new contractor can be on standby. (3) Delays to completion of commissioning would extend staffing, construction management, and engineering services support at additional cost.	Difficult to quantify potential exposure. If difficult to determine cause, could delay project and extend staffing and consultant cost and result in extended legal costs. Outside services would be required. Up to a maximum of \$3.0 million.	\$3.0M	Medium to High
Lack of contractor staff experienced with the design and construction of the facility make problem identification more difficult during the commissioning phase.	(1) Diagnosis and troubleshooting of problems encountered during commissioning can best be solved with the team who constructed the project including contractor staff, subcontractors, and vendors. King County will have warranties with equipment vendors, but will not have access to contractor staff knowledgeable about facility construction to participate in problem resolution. (2) Additional change order for Kievit for schedule impact at the IPS for piping modifications at the IS. (3) If period is extended, county has option to release contractors and perform commissioning.	Results in additional time to correct problems extending administration and requiring outside expertise. Assume 3 months at \$400K/mo. Monthly cost - 3 months at \$400K.	\$1.2M	High
Schedule for BT-2 is turn over TBM removal chamber to Central Tunnel contractor by August 2010 for lining operation, and for the Central Tunnel contractor to turn over TBM removal chamber to the IPS contractor for completion of mechanical work by November 2010. If the contractor(s) are behind on these dates, a change order will be necessary to address complications to the piping and staging work required for sewage commissioning.	(1) Additional change order for Kievit for schedule impact at the IPS for piping modifications at the IS. (2) Extend period for services at plant for Liquids and Solids. Extension for contractor and construction management and engineering consultants. (3) If period is extended, county has option to release contractors and perform commissioning.	Monthly cost - 3 months at \$400K.	\$1.2M	Medium
Loss of warranty protection.	Delays to project require extended warranties for selected pieces of equipment.	6 Equipment items @ \$100K each - included in capital cost.	\$0.6M	High
Total			\$6.0M	

Alternative 3 - Do Not Extend Liquids and Solids Contracts - Delay Commissioning Unfl Conveyance System is Complete

Potential Risk	Consequences	Probable Maximum Loss	Loss Value	Probability of Impact
Defective work discovered during commissioning needs to be remedied; facility does not meet performance specifications.	<p>(1) <i>Potential extra costs.</i> The contractor might seek reimbursement for any remobilizing/staffing costs it incurred that would not have otherwise existed had the contractor been retained through commissioning as originally contemplated.</p> <p>(2) <i>King County hires another contractor to perform work.</i> If a process does not meet performance specifications, and it is not clear if the cause is a contractor or design defect, King County may proceed with the repair and later determine the responsibility for the cost of the repair. If the contractor is not retained during commissioning, King County will have to conduct a new procurement. To avoid delays, and because the type of problems that may arise are currently unknown, this would likely have to be a work order contract so that the new contractor can be on standby. In addition to the time involved in conducting a separate procurement, the contractor may claim that any repair work performed by the new contractor voids the contractor's warranty if it later turns out that the problem was a contractor defect.</p> <p>(3) <i>Delays to completion of commissioning would extend staffing, construction management, and engineering services support at additional cost.</i></p>	Difficult to quantify potential exposure. If difficult to determine cause, could delay project and extend staffing and consultant cost. Outside services would be required. Extended legal costs could result. Exposure increases relative to Alternative 2 since lapse of time results in increased difficulty in determining source of defective work. Total exposure of up to a maximum of \$5.0 million.	\$5.0M	High
Extended period from the completion of construction to startup results in lack of continuity for staff assigned to the project.	<p>(1) <i>Once the Plant is placed on standby, a portion of the operations and maintenance staff will be retained at the Plant to perform routine maintenance.</i> A reduction in force of King County and consultant staff assigned to the project will result in loss of continuity and intrinsic knowledge of the construction and processes. Upon remobilization, the loss of knowledge will be difficult to replace as the Plant proceeds into the commissioning phase.</p> <p>(2) <i>Retaining staff for operations and maintenance.</i></p> <p>(3) <i>Cost for additional outside services.</i></p> <p>(4) <i>Work order contract.</i></p> <p>(5) <i>Extension of contracts with CDM and CH2M HILL Extension of King County administrative staff.</i></p>	Results in several months additional cost to remobilize staff and consultants. Assume 2 months a \$400K/month.	\$0.8M	High
Lack of contractor staff experienced with the design and construction of the facility make trouble-shooting and identification of problems more difficult during the commissioning phase.	<p>(1) <i>Diagnosis and troubleshooting of problems encountered during commissioning can best be solved with the team who constructed the project including contractor staff, subcontractors, and vendors.</i> King County will have warranties with equipment vendors, but will not have access to contractor staff knowledgeable about facility construction to participate in problem resolution.</p>	Results in additional time to correct problems extending administration and requiring outside expertise. Assume 3 months at \$400K/month.	\$1.2M	High
Extended period on standby results in lack of familiarity with processes.	Retain and remobilize operations and maintenance staff		\$0.1M	Medium
Loss of warranty protection.	Delays to project require extended warranties for selected pieces of equipment. Risk is additional cost of what was allocated in cost summary.	Include \$1.0 million as capital cost, retained \$1.0 million in risk.	\$1.0M	High
Total				\$8.1M

Alternative 4 - Place Plant on Standby Once Commissioning is Complete

Potential Risk	Consequences	Probable Maximum Loss	Loss Value	Probability of Impact
Defective work discovered during commissioning needs to be remedied; facility does not meet performance specifications.	<p>If the contractor is on-site during the commissioning period, defective work can be identified and potentially corrected more quickly and at a lower cost than if the contractor is not present. If defective work is uncovered, may need to extend plant operations to troubleshoot problem and correct.</p>	No expected loss. Contractor on-site to remedy defects without delay.	\$0.0M	High
Contractor price proposal for extension of services is not reasonable or consistent with the services to be performed.	King County and the contractor cannot agree on the cost to delay plant commissioning. In this case, the default option would be to perform the commissioning with King County staff. Additional consultant support will be required to support the commissioning process.	If agreement for extension cannot be reached, secure additional services from consultants. Cost estimated at \$1.0 - \$2.0 million.	\$2.0M	High
Extended standby period results in lack of operator familiarity with processes.	Retain and remobilize operations and maintenance staff		\$0.1M	Medium
Schedule for BT-2 hole-out and completion of work in the IPS the IS could require an additional change order with the IPS contractor for piping for raw sewage commissioning. If completion of BT-2 is extended beyond November 2010, this change order will be required if King County elects to proceed with commissioning raw sewage.	<p>1) Additional change order for Kiewit at the IPS for piping modifications at the IS.</p> <p>2) Extend period for extended services at plant for Liquids and Solids. Extension for contractor.</p> <p>3) If period is extended, county has option to release contractors and perform commissioning.</p>	Monthly cost - 3 months at \$400K.	\$1.2M	Medium
Loss of warranty protection.	Delays to project require extended warranties for selected pieces of equipment.			
King County staff to clean plant facilities after initial commissioning.	Cost impact of cleaning and trucking waste.		\$0.0M	High
Decommissioning may impact long term maintenance of equipment.	Operation and then extended shutdown of equipment could damage wearable parts requiring replacement.		\$0.2M	High
Total				\$3.6M