Lake Oswego · Tigard Water Partnership
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Brown AND Caldwell

Technical Memorandum

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Subject: Treatment Technology Selection
Business Case Evaluation: Workshop 2

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Workshop Summary

This document provides an overview of the discussions and decisions from Workshop 2 of a three-workshop business case evaluation (BCE) process that will determine the water quality objectives and select the treatment technologies for the upgrade and expansion of the Lake Oswego Water Treatment Plant. The attendance list is presented in Appendix A.

Workshop Preparation

The following describes steps taken in preparation for Workshop 2. Workshop 1 resulted in four main alternatives and a total of 15 alternative variants, which are summarized in Table 1.

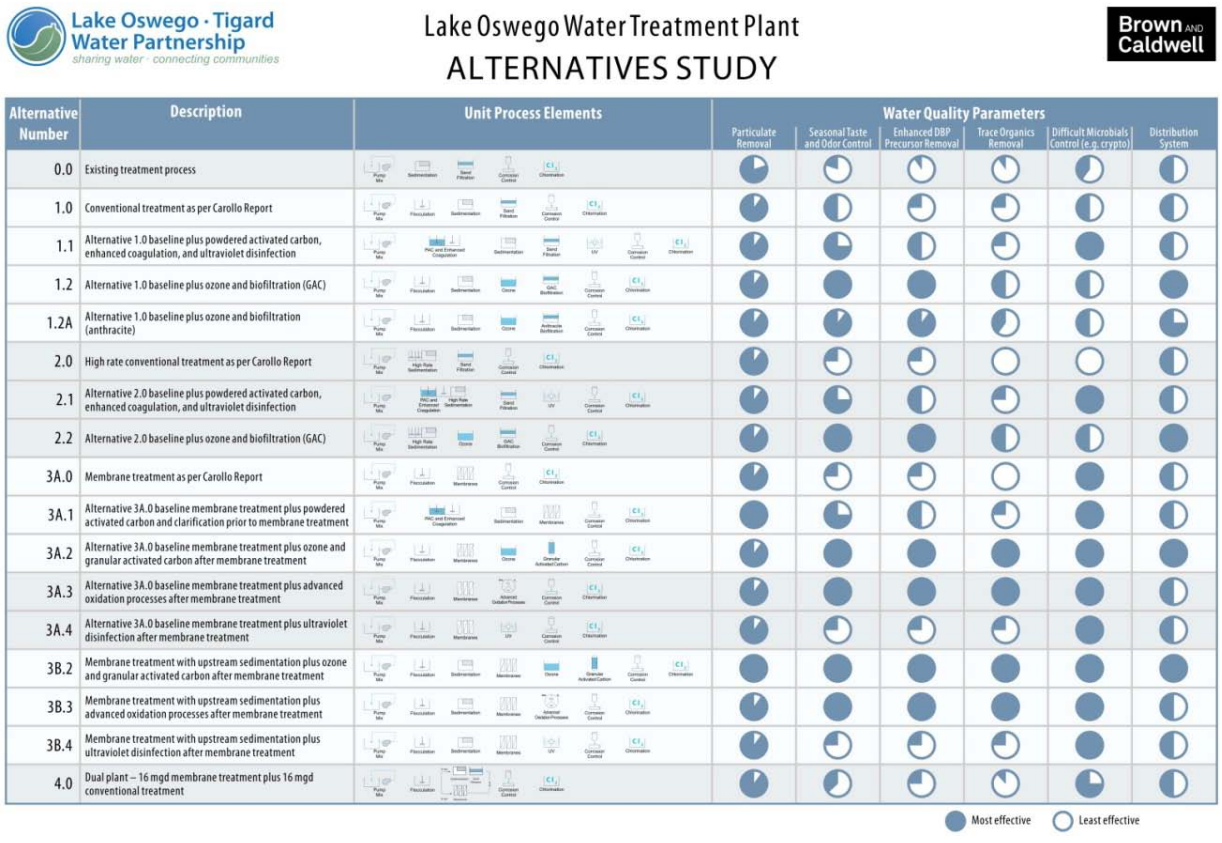
Table 1. Summary of Alternatives

Alternative	Description
1.0	Conventional treatment as per Carollo report
1.1	Add powdered activated carbon, enhanced coagulation, and ultraviolet disinfection to Alternative 1.0 baseline to address treatment parameters except trace organics.
1.2	Add ozone and biofiltration to the conventional treatment to Alternative 1.0 baseline to address the five additional treatment parameters.
2.0	High-rate conventional treatment as per Carollo report
2.1	Add powdered activated carbon, enhanced coagulation, and ultraviolet disinfection to Alternative 2.0 baseline to address treatment parameters except trace organics.
2.2	Add ozone and biofiltration to the high-rate conventional treatment alternatives to Alternative 2.0 baseline to address the five additional treatment parameters.
3A.0	Membrane treatment as per Carollo report
3A.1	Include powdered activated carbon and clarification before Alternative 3A.0 membrane treatment baseline for seasonal taste and odor treatment.
3A.2	Follow Alternative 3A.0 with ozone and granular activated carbon to address the five additional treatment parameters.
3A.3	Include advanced oxidation processes after Alternative 3A.0 membrane treatment to address the five additional treatment parameters.
3A.4	Include ultraviolet disinfection after Alternative 3A.0 membrane treatment to address microbial constituents.
3B.2	Utilize membrane treatment plus upstream sedimentation and install sedimentation basins to off-load membrane solids loading to extend membrane life and increase operating flux. Follow membranes with ozone and granular activated carbon to address the five additional treatment parameters.
3B.3	Utilize membrane treatment plus upstream sedimentation and install sedimentation basins to off-load membrane solids loading to extend membrane life and increase operating flux. Include advanced oxidation processes after membrane treatment to address the five additional treatment parameters.
3B.4	Utilize membrane treatment plus upstream sedimentation and install sedimentation basins to off-load membrane solids loading to extend membrane life and increase operating flux. Include ultraviolet disinfection after membrane treatment to address microbial constituents.
4.0	Dual plant-membrane treatment plus conventional treatment: include additional sedimentation such that 16 million gallons per day (mgd) is treated with conventional rapid sand filtration media and 16 mgd is treated with membrane technology

For each of the above alternatives the following information was developed:

- capital costs
- operations and maintenance costs that included refurbishment and replacement
- net present value (NPV) based on 6 percent discount rate and 3 percent escalation
- unit cost of treated water per million gallons
- power consumption
- site requirements (percentage of original site utilized)
- total chemical use
- waste sludge produced
- site layouts
- process schematics.

This information was pulled into summary sheets. Graphical depictions of the unit process trains were rendered and a consumer reports-style comparison was developed to convey the relative effectiveness of each alternative in treating the five water quality parameters discussed in Workshop 1. The parameters are particulate removal, seasonal taste and odor treatment, enhanced disinfection byproduct (DBP) removal, trace organics removal, and difficult microbials (e.g., cryptosporidium) removal. Figure 1 shows the final version, reflecting input from the Expert Panel, of the water quality comparison presented at Workshop 2.



Alternative Number	Description	Unit Process Elements	Water Quality Parameters: Particulate Removal	Seasonal Taste and Odor Control	Enhanced DBP Precursor Removal	Trace Organics Removal	Difficult Microbials Control (e.g. crypto)	Distribution System
0.0	Existing treatment process							
1.0	Conventional treatment as per Carollo Report							
1.1	Alternative 1.0 baseline plus powdered activated carbon, enhanced coagulation, and ultraviolet disinfection							
1.2	Alternative 1.0 baseline plus ozone and biofiltration (GAC)							
1.2A	Alternative 1.0 baseline plus ozone and biofiltration (anthracite)							
2.0	High rate conventional treatment as per Carollo Report							
2.1	Alternative 2.0 baseline plus powdered activated carbon, enhanced coagulation, and ultraviolet disinfection							
2.2	Alternative 2.0 baseline plus ozone and biofiltration (GAC)							
3A.0	Membrane treatment as per Carollo Report							
3A.1	Alternative 3A.0 baseline membrane treatment plus powdered activated carbon and clarification prior to membrane treatment							
3A.2	Alternative 3A.0 baseline membrane treatment plus ozone and granular activated carbon after membrane treatment							
3A.3	Alternative 3A.0 baseline membrane treatment plus advanced oxidation processes after membrane treatment							
3A.4	Alternative 3A.0 baseline membrane treatment plus ultraviolet disinfection after membrane treatment							
3B.2	Membrane treatment with upstream sedimentation plus ozone and granular activated carbon after membrane treatment							
3B.3	Membrane treatment with upstream sedimentation plus advanced oxidation processes after membrane treatment							
3B.4	Membrane treatment with upstream sedimentation plus ultraviolet disinfection after membrane treatment							
4.0	Dual plant – 16 mgd membrane treatment plus 16 mgd conventional treatment							

Figure 1. Alternatives Study Comparison

In addition, memoranda were developed discussing the water quality targets for the project and the aquifer storage and recovery (ASR) issue at Tigard.

Risk and triple bottom line considerations were drafted, and the information was posted to the SharePoint site as it became available.

Workshop Overview

The main objective of Workshop 2 was to review the 15 alternative variations and screen the alternatives down to 3 to 5 alternatives to move forward for a full BCE cost comparison to be presented and reviewed in Workshop 3.

General Discussion

The workshop started with a review of the information developed. During this review, the Expert Panel asked that another variation to Alternative 1.2 be considered in which granular activated carbon (GAC) is replaced with anthracite. Alternative 1.2.A was consequently added to the list, making 16 alternatives for review; a planning-level cost estimate was quickly developed at the workshop for Alternative 1.2.A relative to costs developed for the other alternatives.

The ASR topic was discussed and the results of an investigation by GSI Water Solutions were presented. The study found that the injection of ozonated water would not be an issue for the Tigard ASR wells, and Tigard staff agreed that potential ASR impacts can be taken off the list of potential risks for ozone treatment.

A discussion was held on the relative risk for each process technology and a general cost discussion was held. Process risk is discussed below. The initial costs were generally accepted with the exception of two items. It was thought that the cost of the ozone system might be too high, and that the cost for Alternative 4.0, the dual plant, was too low.

Triple bottom line considerations were discussed and initial parameters for qualitative screening were selected. The alternatives were then screened based first on their ability to meet water quality parameters, second by their ability to meet other triple bottom line parameters, and finally using a combination of meeting both water quality and triple bottom line parameters. This workshop utilized a qualitative approach to screen the 16 alternatives down to 6 alternatives that will be subjected to a quantitative BCE cost evaluation for final alternative selection in Workshop 3.

Process Risk Discussion

The Expert Panel discussed each of the main process technologies and gave a general evaluation of the risks of each. The following summarizes this process risk discussion.

- *Conventional process*
  - meets water quality requirements; however, there is risk of filter breakthrough
  - turbidity events will require operator reaction to ensure no negative impacts to finished water quality, but it should be a manageable issue
  - takes higher operator skill and attentiveness to respond to variable raw water quality.

- *High-rate conventional*
  - same risks as conventional process
  - higher risk of mechanical failure.
- *Powdered activated carbon*
  - seasonal use for taste and odor control
  - question of whether enough can be added to be effective
  - harder to control as it is a reactive method for control of taste and odor
  - not necessarily a bad approach; it is a "pain" to handle, but not any worse than other alternative
  - creates a larger amount of waste to be removed.
- *Granular activated carbon*
  - no local regeneration facilities for GAC
  - potential limits to GAC availability.
- *Ozone*
  - potential limits to liquid oxygen availability
  - having the oxygen tank on site is a safety hazard
  - operational issue: operations and maintenance intensive
  - includes pressure release valves on liquid oxygen tanks, which can be noisy.
- *Biofiltration*
  - can cause underdrain fouling, which would involve emergency disinfection procedures.
- *Advanced oxidation processes*
  - requires additional chemicals
  - requires pilot testing
  - limited performance history at water treatment plants (used at remediation sites, but not as much for water treatment) so reliability is a concern
  - reactive
  - community risk with the storage of hydrogen peroxide.
- *Ultraviolet*
  - slight risk of mercury release due to accidental bulb breakage
  - only really addresses microbial water quality parameters.

- *Membranes*
  - turbidity event may be difficult to treat
  - need same level of pretreatment as for a granular media filter
  - demands on operations and maintenance can increase as the membranes age with increased refurbishment cycles
  - proprietary technology that is not highly standardized causes a risk of obsolescence
  - risk of cost escalation.

Alternative Screening

After review of the information and the addition of Alternative 1.2.A, the initial assumptions made by Brown and Caldwell on the alternatives' abilities to meet the five water quality parameters of particulate removal, seasonal taste and odor treatment, enhanced DBP removal, trace organics removal, and additional microbial removal were tested with the Expert Panel and changes were made to the initial scores. At the suggestion of the Expert Panel, an additional category of distribution system impacts and water stability was added at Workshop 2. Each parameter was given a weight between 1 and 5, and each alternative was scored on how it met each parameter on a scale from 0–1.0. Table 2 summarizes the parameter weighting criteria.

Table 2. Water Quality Benefit Screening Criteria and Weight

Parameter	Weighting
Particulate removal	5
Seasonal taste and odor treatment	5
Enhanced DBP precursor removal	3
Additional cryptosporidium removal	2
Trace organics removal	1
Distribution quality	4

The scores for each parameter were summed to represent a weighted water quality benefit. A cost/benefit ratio was applied by dividing the NPV by the weighed water quality benefit. The top five alternatives based on the initial assessment of water quality cost/benefit are listed in Table 3.

Table 3. Top Five Alternatives Based on Water Quality Benefit Screening Criteria

Alternative	Description	Score
1.2.A	Add ozone and biofiltration to the conventional treatment Alternative 1.0 baseline to address the five treatment parameters using anthracite as the filter media.	5.44
1.2	Add ozone and biofiltration to the conventional treatment to Alternative 1.0 baseline to address the five treatment parameters.	6.83
1.1	Add powdered activated carbon, enhanced coagulation, and ultraviolet disinfection to Alternative 1.0 baseline to address treatment parameters except trace organics.	6.94
1.0	Conventional treatment as per Carollo report	7.67
2.2	Add ozone and biofiltration to the high-rate conventional treatment alternatives to Alternative 2.0 baseline to address the five additional treatment parameters.	7.67

Weighting was also developed for other triple bottom line parameters including economic, environmental, and community. The criteria and weighs used for these parameters are listed in Table 4.

Table 4. Triple Bottom Line Screening Criteria and Weight

Parameter	Weighting
State approval	1
Operability	5
Maintainability	5
Constructibility	2
Reliability and resiliency	5
Proactive process	3
Site utilization	2
Energy	5
Chemical deliveries	1
Safety/chemical risk	5
Residuals	2
Other waste products	1
Host community impacts	5
LO/T community impacts	5
Proprietary technology/obsolescence	2

The scores for each parameter were summed to represent a weighted triple bottom line score. A cost/benefit ratio was applied by dividing the NPV by the weighed triple bottom line score.

The top five alternatives based on triple bottom line parameters are listed in Table 5.

Table 5. Top Five Alternatives Based on Triple Bottom Line Screening Criteria

Alternative	Description	Score
1.0	Conventional treatment as per Carollo report	5.13
1.2.A	Add ozone and biofiltration to the conventional treatment Alternative 1.0 baseline to address the five treatment parameters using anthracite as the filter media.	6.41
2.0	High-rate conventional treatment as per Carollo report	6.97
1.2	Add ozone and biofiltration to the conventional treatment to Alternative 1.0 baseline to address the five treatment parameters.	7.16
4.0	Dual plant-membrane treatment plus conventional treatment: include additional sedimentation such that 16 mgd is treated with conventional rapid sand filtration media and 16 mgd is treated with membrane technology	7.32

The weighted scores for both the water quality and triple bottom line parameters were combined and a cost/benefit ratio was developed using the NPV. The top alternatives based on the total score are listed in Table 6.

Table 6. Combined Screening Assessment Results		
Alternative	**Description**	**Score**
1.2.A	Add ozone and biofiltration to the conventional treatment to Alternative 1.0 baseline to address the five additional treatment parameters using anthracite as the filter media.	2.94
1.0	Conventional treatment as per Carollo report	3.07
1.1	Add powdered activated carbon, enhanced coagulation, and ultraviolet disinfection to Alternative 1.0 baseline to address all additional treatment parameters except trace organics.	3.52
1.2	Add ozone and biofiltration to the conventional treatment to Alternative 1.0 baseline to address the five additional treatment parameters.	3.91
4.0	Dual plant-membrane treatment plus conventional treatment: include additional sedimentation such that 16 mgd is treated with conventional rapid sand filtration media and 16 mgd is treated with membrane technology	3.93
2.1	Add powdered activated carbon, enhanced coagulation, and ultraviolet disinfection to Alternative 2.0 baseline to address all additional treatment parameters except trace organics.	4.28
2.2	Add ozone and biofiltration to the high-rate conventional treatment alternatives to Alternative 2.0 baseline to address the five additional treatment parameters.	4.32

Discussion was conducted on the screening process. Based on Expert Panel and staff input, Alternative 4.0 was removed, as the operability and maintainability with managing two separate plants was deemed a fatal flaw for this option. This screening moved Alternative 2.1 into a top five position. In addition to adding Alternative 2.1 to the top list to move forward, it was suggested that Alternative 2.2 be retained. Its score was very close to that of Alternative 2.1, and based on the qualitative nature of the screening in Workshop 2 the Expert Panel wanted to see how it would compare in the more quantitative analysis in Workshop 3.

Six alternatives were retained for further evaluation going into Workshop 3; these alternatives are shown in Table 7.

Table 7. Alternatives Retained for Additional Evaluation	
Alternative	Description
1.2.A	Add ozone and biofiltration to the conventional treatment to Alternative 1.0 baseline to address the five treatment parameters using anthracite as the filter media.
1.0	Conventional treatment as per Carollo report
1.1	Add powdered activated carbon, enhanced coagulation, and ultraviolet disinfection to Alternative 1.0 baseline to address treatment parameters except trace organics.
1.2	Add ozone and biofiltration to the conventional treatment to Alternative 1.0 baseline to address the five treatment parameters.
2.1	Add powdered activated carbon, enhanced coagulation, and ultraviolet disinfection to Alternative 2.0 baseline to address treatment parameters except trace organics.
2.2	Add ozone and biofiltration to the high-rate conventional treatment alternatives to Alternative 2.0 baseline to address the five treatment parameters.

Next Steps

In preparation for Workshop 3, the costs from Workshop 2 will be further refined along with site layouts. A hydraulic profile will be developed. Cost and benefits for triple bottom line parameters such as operability, reliability, impacts during construction, energy use, and chemical use will be quantified and the carbon footprint will be calculated for each alternative. In addition, risk factors that impact scope, schedule, and performance will be developed for consideration for each alternative.

Workshop 3 is scheduled for Thursday, June 10, 2010.

APPENDIX A

WORKSHOP #2 ATTENDANCE LIST

The following people were in attendance at Workshop #2:

- **City of Lake Oswego**
  - Joel Komarek
  - Kari Duncan
  - Jane Heisler
  - Bob Burgeson
  - Bob Blezinski
- **City of Tigard**
  - Dennis Koellermeier
  - John Goodrich
- **Brown and Caldwell**
  - Corianne Hart
  - Bill Persich
  - Steffran Neff
  - Jon Holland
  - Doug Wise
  - Jack Warburton
- **Barney & Worth**
  - Clark Worth
- **Citizen Sounding Board**
  - Gretchen Buehner
  - Gary Strealy
- **Expert Panel**
  - Jeff Neemann – Black & Veatch
  - Matthew Marshall – Carollo
  - Lee Odell – CH2M Hill
  - Pete Kreft – MWH
  - Eva Nieminski – Utah Department of Environmental Quality