Hillsboro Water Supply Options—TM#6 - Water Quality and Treatment Review

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Introduction

This memorandum identifies the treatment processes needed for each of the four additional water supply sources being considered by the City of Hillsboro. The recommended treatment processes would produce treated water similar to the quality of water currently supplied by the Joint Water Commission (JWC) system. The recommended processes are based on a review of existing water quality data.

The four additional water supply sources being considered are:

1. Tualatin Basin Water Supply Project (TBWSP) Option: This option would draw raw, untreated water from an expanded Hagg Lake through the JWC System.
2. Willamette-Newberg Option (East and West Sub-Options) and the Willamette-Wilsonville Option: These three options would draw raw, untreated water from the Willamette River from the Newberg pool, which extends from the City of Newberg, River Mile 51, downstream to Willamette Falls at Oregon City, River Mile 26.5; The water would be treated to provide treated water similar in quality to that provided by the existing JWC system.
3. Portland Supply Option: This option would purchase disinfected water from the Portland Water Bureau (PWB). The PWB draws from two raw water sources with distinctly different water qualities, Bull Run and the Columbia River Well Field. The Columbia River Well Field Supply is used when turbidity levels in the Bull Run Supply are high. Water from the City of Portland would be treated to provide treated water similar in quality to that provided by the existing JWC system
4. Northern Groundwater Supply Option (NGSO): This option would pump raw, untreated groundwater from the area between the City of Scappoose and Multnomah Channel. The raw water would be treated to provide treated water similar in quality to the existing JWC system.

A fifth source, the Tualatin River near Durham, was identified but does not have sufficient capacity to meet Hillsboro's demands and cannot obtain a water right. Therefore, it was removed from consideration in the preliminary screening prior to water quality review.

Described below are the pertinent regulatory requirements and the water quality data sources. These are followed by an evaluation of the water quality data, review of water quality risks, determination of treatment requirements to effectively mitigate that risk, and conclusions about the water quality issues associated with each of the candidate water supply sources, including a recommendation for additional water quality sampling as part of advancing the design work on the next stage of alternative selection.

Regulatory Background

Public water systems in Oregon are regulated by the U.S. Environmental Protection Agency (EPA), primarily through the 1996 Amendments to the Safe Drinking Water Act, and by the Oregon Department of Human Services—Drinking Water Program. To maintain primacy for the enforcement of the Safe Drinking Water Act (SDWA), Oregon must adopt water quality regulations that are at least as stringent as EPA's standards. Oregon has adopted water quality standards equal to EPA's standards and has not adopted more stringent water quality standards.

EPA has established enforceable Maximum Contaminant Levels (MCLs) for approximately 100 contaminants and treatment technique requirements for other contaminants. MCLs are set to protect the public against consumption of drinking water contaminants that present a risk to human health.

In addition, EPA has established secondary regulations that set non-mandatory water quality standards for 15 contaminants. EPA does not enforce these Secondary Maximum Contaminant Levels (SMCLs). They are established only as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color, and odor. These contaminants are not considered to present a risk to human health at the SMCL.

EPA is in a continuous process of reviewing occurrence and health effects data for additional contaminants that are not currently regulated to determine if new MCLs are warranted.

The SDWA includes a process that EPA follows to identify and list unregulated contaminants which may require a national drinking water regulation in the future. EPA periodically publishes this list of contaminants (called the Contaminant Candidate List or CCL) and decides whether to regulate additional contaminants. The list of unregulated contaminants is also used to prioritize research and data collection efforts to help EPA determine whether a specific contaminant should be regulated. The first CCL (CCL 1) of 60 contaminants was published in March 1998, the second CCL 2 of 51 contaminants was published in February 2005, and the final CCL 3 of 104 chemicals or chemical groups and 12 microbiological contaminants was published October 2009. The list includes chemicals used in commerce, pesticides, biological toxins, disinfection byproducts, and waterborne pathogens. The contaminants on the list are not regulated by existing national primary drinking water regulations, are known or anticipated to occur in public water systems, and

may require regulation. EPA evaluated approximately 7,500 chemicals and microbes and selected 116 candidates for the Final CCL 3.

EPA is considering developing regulations for contaminant groups as well as developing new regulations for individual contaminants. The strategy of regulating groups of contaminants was also highlighted in the October 2010 Regulatory Update prepared by J. Alan Roberson, the American Water Works Association Director of Security and Regulatory Affairs. Roberson summarized EPA's new drinking water strategy as consisting of the following four components:

1. Address groups of contaminants (emerging contaminants).
2. Promote use of new technologies for both monitoring and treatment.
3. Leverage use of existing statutes such as the Toxic Substances Control Act for protecting source waters.
4. Promote easy access to utility monitoring data.

Since regulatory requirements for endocrine disrupting chemicals (EDCs) and pharmaceuticals and personal care products (PPCPs) are still being developed, there is some risk in developing a new source for Hillsboro before regulatory requirements are known. Among the contaminant groups being considered by EPA are the following EDCs and PPCPs: estrogenic compounds, androgenic (steroid hormone) compounds, pharmaceuticals, and antibiotics. Depending on source water quality, treatment performance and changing regulatory requirements, there is a risk that Hillsboro's new treatment plant may need to be upgraded to meet possible future but unknown regulations at a higher incremental cost as compared to installation at the time of original plant construction. However, good treatment plant design to proactively mitigate the major contaminants being considered by the EPA should conservatively situate Hillsboro in a minimal risk position. Therefore, this memo has selected effective mitigating treatment processes for each source option for all of the contaminants that identified in the specific source option.

Another emerging contaminant for which regulations are being developed is algal toxins. Algae blooms have affected reservoirs upstream of surface water supplies for Salem, Medford, and other Oregon cities. One group of algal toxins, microcystins, has been detected in algal blooms in several lakes and reservoirs in Oregon. EPA has placed algal toxins on the Contaminant Candidate List for consideration for future regulation.

Water Quality Data Sources

Water quality data were obtained from the following reports collected by GSI (GSI) Water Solutions, Inc. from various sources and provided for this study:

- *Water Quality Monitoring Activities* dated August 2007.
- *Willamette River Water Treatment Pilot Study Executive Summary* dated August 2004.
- *Willamette River Raw Water Monitoring Program 1994-1996*.
- *Willamette River Raw Water Monitoring Program 1998-1999*.

- *Willamette River Raw Water Monitoring Program 1999-2000.*
- *Willamette River Raw Water Monitoring Program 2001-2002.*
- *Willamette River Raw Water Monitoring Program 2003 and 2004.*
- Finished water quality comparison for JWC, City of Portland, and Wilsonville sources in 2003 and 2004.
- Finished water quality comparison for JWC, City of Portland, and Wilsonville sources in 2005 and 2006.
- Report prepared by Alexin Analytical Laboratories for a sample of JWC water collected in August 2009.

Data for the occurrence of personal care products and other anthropogenic compounds associated with wastewater discharges were obtained from the 2002 USGS report *Water-Quality Data for Pharmaceuticals, Hormones, and Other Organic Wastewater Contaminants in U.S. Streams, 1999-2000*. Additional data describing the quality of the Portland Supply were obtained from the City of Portland.

Evaluation of Source (Raw) Water Quality Data

This section evaluated the quality of the supply option source water to identify appropriate treatment processes or state the water quality of a source option is a fatal flaw for that option. The water quality data evaluated for this memorandum are summarized in Table 1, which is included at the end of this memorandum. Water quality data were summarized for the following six categories:

1. Customer acceptance parameters (e.g. water quality parameters of aesthetic concern to customers after treatment.)
2. Inorganic chemical parameters of the source water.
3. Microbiological quality of the source water.
4. Disinfection byproducts expected after treatment of the source water.
5. Organic chemical parameters of the source water.
6. Radionuclides in the source water.

No fatal flaws were identified which would eliminate any of the options based on raw water quality. Based on available source water quality data, all options will require further treatment using available treatment technologies to produce finished water that meets drinking water standards.

Table 1 summarizes regulatory requirements for treated water, quality of treated water currently delivered by JWC, quality of the sources available to Hillsboro, and the treatment processes needed to produce treated water similar to that currently delivered by JWC. Raw water quality data is provided for two of the sources, the Willamette-Newberg Pool and NGSO, since the treatment processes would need to treat raw water to produce treated water similar to that currently delivered by JEC. Water quality data for the PWB source is after disinfection, since Hillsboro would purchase disinfected water from the PWB and treat it further to produce water similar in quality to that currently delivered by the JWC system.

The data provided by GSI did not include occurrence data for EDCs and PPCPs for the source options. These are currently not regulated as drinking water contaminants. Therefore, water systems do not regularly monitor for these contaminants. State and federal agencies have performed limited monitoring for these contaminants but only in recent years as advances have been made in analytical techniques to allow measurements at nanogram per liter levels. A majority of EDC's and PPCP's are effectively addressed by ozonation and granular activated carbon filtration coupled with conventional water treatment processes.

Very limited data is available for the TBWSP Option since the dam raise has not been constructed and therefore available water quality data is limited to the existing non-expanded dam environment. Additionally, no data was available for the other three sources for two water quality concerns, blue-green algae and the toxins they may produce, and taste and odor compounds. Both of these elements however can be treated using ozonation and granular activated carbon filtration coupled with conventional water treatment processes.

Water Quality Considerations – TBWSP After Treatment by JWC

The JWC system provides treated water meeting customer requirements and regulatory requirements for drinking water. The City of Hillsboro has determined that water from other sources would need to be similar in quality to that provided by the JWC system. The following discussion reviews the water quality provided by JWC in each of six categories. Since water from the TBWSP would be stored in Hagg Lake and treated and delivered by JWC, water quality from this option is assumed to be similar to that provided by the existing JWC system.

Customer acceptance criteria

Treated water delivered by JWC has low concentrations of dissolved solids and hardness and moderately low concentrations organic carbon. Low concentrations of dissolved solids and hardness are desirable, especially for industrial uses. Low concentrations of organic carbon are desirable for industrial uses and also limit the formation of disinfection byproducts. Neither iron nor manganese were detected in the treated water. If present, iron and manganese may cause undesirable staining of fixtures and laundry. No data was available for silica concentrations in the finished water. If present, silica affects the use of water for some industrial operations.

Inorganic Parameters

Of the inorganic chemicals for which data was available, only nitrate was detected in JWC finished water. High concentrations of nitrate would be a concern for some infants. The concentration of nitrate was less than 10 percent of the regulatory limit.

Microbiological quality

Treated water delivered by the JWC system is of high microbiological quality, consistently meeting regulatory requirements.

Disinfection byproducts

Treated water delivered by the JWC system meets regulatory requirements for disinfection byproducts, with maximum concentrations of less than 50 percent of the regulatory limit.

Organic Chemical Parameters

JWC analyzes its water for all regulated organic chemicals and 41 additional unregulated organics. None of the organic chemicals for which laboratory data was available were detected. No data were available for EDCs and PPCPs.

Radionuclides

No radionuclides have been detected in treated water delivered by the JWC system.

Water Quality Considerations - Willamette Newberg Option (West and East Sub Options) and the Willamette Wilsonville Option

The Willamette Newberg (West and East Sub Options) and the Willamette Wilsonville Option Raw will draw raw water from the Newberg Pool of the Willamette River. Water from the Newberg Pool is currently being treated at the Willamette River Water Treatment Plant (WRWTP) at Wilsonville. For contaminants regulated following treatment, it is assumed that data available from treated water produced by the WRWTP predicts the performance of a new water treatment plant that would supply Hillsboro provided that new treatment plant uses similar treatment processes as currently being used in the WRWTP.

Customer acceptance criteria

Raw water from the Newberg Pool has low concentrations of dissolved solids and hardness and moderately low concentrations organic carbon similar to water supplied by JWC. Iron was not detected in the treated water. Manganese was detected in the raw water at a concentration that requires treatment. Silica was detected in the raw water. Since no silica data was available for the JWC source, it is not known if raw water from the Willamette has a higher or lower silica concentration than the JWC source. Silica affects the use of water for some industrial operations. Raw water from the Willamette has an earthy odor associated with algae and treatment would be needed to produce water similar in quality to that provided by JWC. Total organic carbon (TOC) values for the Willamette River generally ranged from 1.0 to 2.0 mg/L. One very high value was reported (18 mg/L) but it is unclear if this was an actual value or in error. There is no MCL for TOC but TOC levels drive treatment techniques for surface water supplies because TOC may contribute to the formation of disinfection by-products. Regulations require enhanced coagulation processes for TOC levels in excess of 2.0 mg/L. In addition to contributing to disinfection by-products, TOC also may adversely affect some industrial uses such as semiconductor manufacturing.

Inorganic Parameters

Of the inorganic chemicals for which data was available, a very low concentration of arsenic was detected in one sample of raw water, a very low concentration of nickel was detected in one sample of raw water, and nitrate was detected at levels similar to that found in water supplied by JWC. No arsenic has been detected in treated water at the WRWTP. Nickel is not currently regulated as a drinking water constituent and was present at a concentration lower than that proposed for regulation. The concentration of nitrate was less than 10 percent of the regulatory limit.

Microbiological quality

Giardia has been detected in a small number of raw water samples from the Newberg Pool. No giardia has been detected in treated water produced by the WRWTP. Bacteria are

assumed to be present in the raw water, but are removed by water treatment processes. Bacteria have not been detected in treated water produced by the WRWTP.

Disinfection byproducts

Disinfection byproducts are produced by chlorination of raw water containing naturally occurring organic carbon. Treated water produced at the WRWTP meets regulatory requirements for disinfection byproducts, with maximum concentrations of less than 50 percent of the regulatory limit.

Organic Chemical Parameters

Raw water from the Newberg Pool has been analyzed for the presence of 191 different organic chemicals. A very low concentration of metalachlor was detected in one raw water sample. Very low concentrations of atrazine, simizine, and DEHP have been detected sporadically in a handful of samples and a consistent trend is not apparent from sampling for organic chemicals in raw water from the Newberg Pool. No data for EDCs and PPCPs are available for the Newberg Pool. Existing data do not provide sufficient information to assess the presence of EDCs and PPCPs in the Willamette Newberg Option (East and West Sub Options) and the Willamette Wilsonville Option or the risk presented by EDCs and PPCPs if they are present. Additional data would help verify if EDCs and PPCPs are present and that ozonation and adsorption with granular activated carbon will remove the EDCs and PPCPs that are found.

Radionuclides

No radionuclides have been detected in raw water from the Newberg Pool.

Water Quality Considerations - Portland Supply Option

The Portland Supply Option will draw source water from the PWB water system. This PWB system draws from both from unfiltered surface and ground water sources. Surface water from impoundments in the Bull Run watershed is supplied when turbidities are low. When turbidities are higher than the regulatory limit of 5 NTU in the Bull Run watershed, the Portland water system supplies ground water from its Columbia Wellfield. Treatment for both sources is limited to disinfection using chloramines and pH adjustment to limit corrosion of customer service pipes.

Customer acceptance criteria

Water from the PWB system varies greatly in dissolved solids and hardness concentrations. Water from the Bull Run watershed has low concentrations of dissolved solids and hardness. Manganese is detected at higher concentrations than in water delivered by JWC in water from the Bull Run watershed and the Columbia Wellfield. Iron is detected in water from the Columbia Wellfield, but not the Bull Run watershed. Water from the Columbia Wellfield has concentrations of dissolved solids up to four times higher than in water delivered by JWC and hardness from twice to seven times higher than in water delivered by JWC. Silica has been detected in water from the Bull Run watershed. Since no data is available for silica in water from the JWC system, it is not possible to compare the silica concentration in the two supplies.

Inorganic Parameters

Of the inorganic chemicals for which data was available, very low concentrations of cyanide (less than 25 percent of the regulatory limit) have been detected in water from the Bull Run watershed. The concentration of nitrate was highest in water from the Columbia Wellfield, but was less than 6 percent of the regulatory limit.

Microbiological quality

The PWB system provides effective treatment for bacteria, but not giardia nor cryptosporidum. Giardia has been detected in one sample from the Bull Run Watershed, but is generally not detected. Some of the Portland reservoirs are not covered, creating the possibility of contamination. If Portland's system continues to remain unfiltered, water supplied to Hillsboro from the Portland system would require filtration to be compatible with Hillsboro's other water supplies. Without treatment, the higher turbidity levels from the Portland system may be problematic for some customers, particularly electronic manufacturers. It is likely that a direct filtration process would provide acceptable treatment.

Disinfection byproducts

Disinfection byproducts are produced by chlorination of raw water containing naturally occurring organic carbon. Treated water produced at the Wilsonville Water Treatment Plant meets regulatory requirements for disinfection byproducts, with maximum concentrations of less than 40 percent of the regulatory limit.

Organic Chemical Parameters

Regulated organic chemicals have been not been detected in the Portland Water system. Low concentrations of several PPCPs, including acetamenophin, sulfamethoxazole, estradiol, and ethinyl estradiol, have been detected in the Portland sources. Since no data is available for EDCs and PPCPs in other sources, it is not possible to assess the occurrence of these chemicals relative to other sources.

Radionuclides

A very low concentration (less than 7 percent of the screening level) of one regulated radionuclide, beta particles, has been detected in water from the Bull Run watershed. One unregulated radionuclide, radon, has been detected in water from the Bull Run watershed.

Water Quality Considerations – Northern Groundwater Supply Option

The NGSO will draw water from wells in the Columbia Alluvium between the City of Scappoose and Multnomah Channel. Limited water quality data was available from existing wells in the area. The groundwater is assumed to be similar in quality to that produced from the City of Portland Columbia Wellfield. If the Northern Groundwater source alternative is selected for implementation, additional water quality data will need to be collected from test wells. The data would be used to assess the presence of regulated water quality parameters, agricultural chemical contaminants, EDCs, PPCPs, and other constituents of interest. In addition the possible impact of contaminated sites near the confluence of the Willamette River and Multnomah Channel should be evaluated in more detail. It would be desirable to have sampling data available from at least one test well. It would be desirable to collect samples quarterly for a year (four well pumping tests). The concentrations of arsenic, iron,

and manganese are of particular interest. Groundwater from the Northern Groundwater Supply Option may be classified as groundwater under the influence of surface water, which will affect choice of treatment processes. Additional groundwater modeling would be needed to assess the impact of water from Multnomah Channel, the Columbia River, and local ponds that might be drawn in by pumping.

Customer acceptance criteria

Raw groundwater from the NGSO is expected to have concentrations of dissolved solids three to four times higher than those in water currently delivered by JWC. Raw ground water is expected to have hardness concentrations six to ten times higher than those in water currently delivered by JWC. Iron and manganese are expected to be present at high enough concentrations to exceed customer acceptance. Only one iron value was reported for the proposed wellfield between the City of Scappoose and Multnomah Channel, and it was slightly below the iron SMCL. The mean and average values for dissolved iron in samples from wells on Sauvie Island exceeded the SMCL of 0.3 mg/L. All mean and average values for dissolved manganese in the three Northern Groundwater zones exceeded the SMCL of 0.05 mg/L. No data was available for silica concentrations in the groundwater. If present, silica affects the use of water for some industrial operations. Organic carbon is expected to be present at concentrations acceptable to customers.

Inorganic Parameters

Several arsenic exceedances were associated with shallow sand layers that are expected to be above the zones that will be pumped. A number of samples from Sauvie Island south of the proposed wellfield exceeded the arsenic MCL of 0.010 mg/L. The concentration of nitrate is assumed to be less than 10 percent of the regulatory limit. The concentration of other regulated inorganic chemicals is assumed to be well below regulatory limits.

Microbiological quality

Raw groundwater from the NGSO is assumed to be groundwater under the influence of surface water.

Disinfection byproducts

Disinfection byproducts produced during treatment are assumed to be below regulatory limits.

Organic Chemical Parameters

No organic chemical data were reported for the Northern Groundwater sources. A groundwater withdrawal may affect recharge patterns and influence the potential for contamination of the Northern Groundwater source from the Columbia River. One result may be shortened travel times from Multnomah Channel and the Columbia River to the Northern Groundwater aquifer, which could increase concentrations of organic chemicals, EDCs, and PPCPs concentrations in the groundwater supply if these contaminants are present in the river.

Radionuclides

No data is available for radionuclides in water produced by NGSO.

Treatment Requirements

All four of the water sources available to the City of Hillsboro can be treated to provide finished water meeting requirements of the Safe Drinking Water Act. Treatment requirements for each source have been evaluated based on a review of existing water quality data. The treatment required for each source is presented below:

- **TBWSP Option**: Due to the likely changes in the source water quality when the Scoggins Dam is raised, water drawn from Hagg Lake and treated at an expanded Joint Water Commission Water Treatment Plant using existing treatment processes with the addition of ozone would continue to meet the requirements of the City of Hillsboro. Raw water for the TBWSP Option should be treated using ozone, coagulation and flocculation, sedimentation, filtration with dual media, and disinfection with chlorine.
- **Willamette Newberg (West and East Sub Option) and the Wilsonville Option**: The Willamette River presents a low risk option if the water is appropriately treated. Water from the Willamette River can be successfully treated using the treatment processes currently in place at the Willamette River Water Treatment Plant at Wilsonville. The treatment experience at the existing WRWTP at Wilsonville provides good guidance for determining treatment requirements for this source. These processes include pretreatment by coagulation and flocculation, ballasted sedimentation, ozonation (for primary disinfection, organics removal, and taste and odor control), deep bed media filtration using granular activated carbon (GAC) over sand media, and post-disinfection using chlorine. As additional water quality data become available, the treatment processes should be re-evaluated for continued applicability. The impact of mixing treated water drawn from the Willamette River with existing supplies should also be evaluated. The combination of ozonation plus GAC adsorption is likely to be effective in removing a broad range of organic chemicals, including EDC and PCP compounds. Ozonation is also effective for removing algal toxins and taste- and odor-causing compounds. The addition of EDC and PPCP compounds to existing sampling programs would provide additional data that could be used to further evaluate treatment processes.
- **Portland Supply Option**: The Portland Supply Option presents a low risk option if the water is treated. Treatment would be needed to remove chloramines, filter to provide an additional barrier removing microbiological contaminants and reduce elevated turbidity levels, and rechlorinate to provide water similar to that currently provided by JWC. Split stream reverse osmosis might be required to reduce dissolved solids and hardness as the system switches between the Bull Run Supply and the Columbia River Wellfield supply. The City of Hillsboro uses free chlorine to disinfect and maintain a residual. The City of Portland uses a combination of chlorine and ammonia (chloramines) to disinfect its sources. The chloramines would need to be removed from City of Portland water to be compatible with the Hillsboro system. As additional water quality data become available, they should be evaluated. The impact of mixing water from the Portland Supply Option system with existing supplies should be evaluated.

- **Northern Groundwater Supply Option:** Raw water from the Northern Groundwater Supply Option should be treated using chlorine oxidation to precipitate iron and manganese, coagulation and flocculation, filtration with dual media, split stream reverse osmosis to remove dissolved solids and hardness, and disinfection with chlorine. The impact of mixing treated water drawn from the Northern Groundwater Supply Option with existing supplies should also be evaluated**.**

TABLE 1
Summary of Source Water Quality and Treatment Requirements by Source

Criteria	Regulatory Requirement or Guidance (EPA unless otherwise listed) P=Primary regulation S=Secondary regulation)	Willamette Newberg (East and West Sub Options) and the Willamette Wilsonville option	Portland Supply Option		Northern Groundwater Supply Option	TBWSP Option (After treatment by JWC)
			Bull Run	Columbia Wellfield		
Description	Source water assessment	Surface water from; upstream urban development, agricultural activity, and forests	Treated surface water from protected watershed; treated by chloramination	Treated groundwater from Blue Lake, Troutdale Sand, and Sand and Gravel aquifers treated by chloramination	Groundwater assumed under the influence of surface water; Columbia River alluvium	Surface water from forested watershed with limited rural development and small number of roads
Recommended treatment processes to match treated water currently delivered by JWC	Not a regulated parameter	Coagulation and flocculation, ballasted sand sedimentation, ozonation, sedimentation, deep bed granular media filtration with GAC over sand, disinfection with chlorine	For Hillsboro portion (36 MGD) to meet customer requirements: Oxidation to remove chloramines, coagulation, flocculation, ozonation, sedimentation, granular media filtration, disinfec-tion with chlorine For others: No additional treatment	For Hillsboro portion (36 MGD) to meet customer requirements: Oxidation to remove chloramines, coagulation, flocculation, ozonation, sedimentation, granular media filtration, disinfection with chlorine For others: No additional treatment	Iron and manganese removal, coagulation and flocculation, granular media filtration, split stream reverse osmosis, disinfection using chlorine	Coagulation, flocculation, ozonation, sedimentation, granular media filtration, disinfection with chlorine
Customer Acceptance Parameters (Water quality parameters of concern to Customers)						
Total dissolved solids	<500 mg/L (S)	53 to 76.8 mg/L	18 to 35 mg/L	17 to 270 mg/L	175-220 mg/L	60 to 74 mg/L
pH (after pH adjustment)	6.5 to 8.5 (S)	7.67 to 8.11	7.8 to 8.2	7.1 to 8.5	6.3 to 8.3	7.33 to 7.6
Hardness	<250 mg/L (Oregon S)	22.4 to 28.2 mg/L	5.9 to 8.1 mg/L as $CaCO_3$	52 to 220 mg/L as $CaCO_3$	25 to 200 mg/L as $CaCO_3$	26 to 32 mg/L as $CaCO_3$
Silica	None	13 to 17 mg/L (USGS)	3.8 to 4.9 mg/L	No data	No data	No data
Iron	<0.3 mg/L (S)	ND	ND	0.012 to 0.11 mg/L	0.05 to 0.65 mg/L	>0.3 mg/l
Manganese	<0.05 mg/L (S)	0.004 mg/L (treated water)	0.002 to 0.012 mg/L	0.0010 to 0.46 mg/L	0.001 to 0.40 mg/L	>0.05 mg/l
Total organic carbon	2 mg/L trigger in raw water for enhanced coagulation	1 to 2 mg/l in raw water, with one report of 18 mg/l <0.8 mg/L in treated water	0.95 to 1.5 mg/L in treated water	ND to 1.5 mg/L in treated water	No data	0.83 to 0.88 mg/L

TABLE 1
Summary of Source Water Quality and Treatment Requirements by Source

Criteria	Regulatory Requirement or Guidance (EPA unless otherwise listed) P=Primary regulation S=Secondary regulation)	Willamette Newberg (East and West Sub Options) and the Willamette Wilsonville option	Portland Supply Option		Northern Groundwater Supply Option	TBWSP Option (After treatment by JWC)
			Bull Run	Columbia Wellfield		
Others: Color, odor	Varies	Earthy odor associated with algae (raw water)	Acceptable	Acceptable	No data	No color, no odor data
Inorganic Chemical Parameters						
Arsenic	<0.010 mg/L	One sample at 0.0006 mg/L in raw water, ND in treated water	ND	ND	0.001 to 0.023 mg/L in shallow sand alluvium at Sauvie Island	ND in production zone, Detected at 0.01 mg/l or more in shallow sands
Lead and copper	Lead<0.15 mg/L; copper <1.3 mg/L	Traces of lead in treated water	Treated water is mildly corrosive to lead plumbing materials		No data	Not corrosive
Nitrate	<10 mg/L as N	0.3 to 0.8 mg/L	0.01-0.04 (Raw water)	ND to 0.64 mg/L	No data	0.6 to 1.0 mg/L
Fluoride	EPA < 4mg/L	ND	ND	No data	No data	ND
Other regulated: Antimony, barium, beryllium, cadmium, chromium, cyanide, mercury, selenium, sulfate, thallium	Varies	ND or well below regulatory limit	Cyanide at 0.046 mg/L; Below standard of 0.2 mg/L	Below standard or ND	0.005 mg/L in shallow sands on Sauvie Island, Below regulatory limit of 0.002 mg/L	ND or well below regulatory limit
Other secondary or nonregulated: Aluminum, silver, zinc, nickel	Varies	ND except one sample with low concentration of nickel	Below standard or ND	No data	No data	ND
Microbiological Quality						
Turbidity	Varies, <0.3 NTU for treated water, <5 for untreated water	0.037 to 0.039 NTU	0.2 to 1.6 NTU	0.7 mg/L	No data	<0.04 NTU
Bacteria	Goal of zero; required treatment technique	ND (treated water)	Uncovered reservoirs present risk of contamination from waterfowl and storm events, Chloramination only treatment.		No data; Assumed under influence of surface water	Raw water is assumed to be under influence of surface water, ND (treated water)

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			Bull Run	Columbia Wellfield		
Giardia	Goal of zero	<16% of raw water samples, ND in treated water	Detection in one Bull Run sample		No data	ND (treated water)
Cryptosporidium	Goal of zero	ND (treated water)	ND		No data	ND (treated water)
Chlorine	<4 mg/L	Complies; Chlorinated for disinfection	Treated water - 2 mg/L chloramines		No data	Will be chlorinated for disinfection
Algae and algal toxins	Proposed for regulation	No data	No data		No data	No data
Disinfection Byproducts						
THMs (after treatment)	<0.08 mg/L (P)	0.00562 to 0.00591 mg/L	0.021 mg/L		No data	0.028 to 0.0388 mg/L
Haloacetic acids (after treatment)	<0.06 mg/L	ND to 0.00195 mg/L	0.042 mg/L		No data	0.030 mg/L
Organic Chemical Parameters						
Regulated organic chemicals (50 chemicals)	Varies	ND except DBPs and sporadic atrazine, simizine, and DEHP at very low concentration	ND		No data	ND except DBPs
Personal care products and pharmaceuticals	No regulations or guidance	No data for Newberg Pool;	Sporadic, very low concentrations of caffeine, acetaminophen, ibuprofen,	Sporadic, very low concentrations of acetaminophen, caffeine, sulfamethoxazole, estradiol, ethinyl estradiol, possible sampling or lab contamination	No data	No data
Unregulated organics or organics proposed for regulation (41 chemicals)	No regulations or guidance	ND except for one instance of metachlor at <0.000001 mg/L; Analyzed for additional 160	No data	No data	No data	ND for 41 analyzed

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			Bull Run	Columbia Wellfield		
		chemicals, all ND				
Radionuclides						
Regulated radionuclides: Alpha particles, Beta particles and photon emitters, radium 226 and 228, uranium (P)	Varies	1 sample in 2002 - Gross alpha, radium, and uranium detected well below regulatory standards	Beta particles at 3.4 picocuries/L, below screening level of 50 picocuries/L		No data	ND
Radon (unregulated)	No regulation	1 sample in 2002 - ND	145 picocuries/L		No data	ND

ND = Not detected