GSI Water Solutions, Inc.

TECHNICAL MEMORANDUM

Water Supply Analysis for Buildable Lands Assessment in the 310 Zone

To: Dave Anderson, Public Works Director – City of The Dalles

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Introduction

The City of The Dalles (City) will be updating its Water System Master Plan to anticipate water supply, distribution, and storage infrastructure needs over the next 20 years. Among the considerations for the City's water supply development needs are recent changes in the City's buildable land inventory. In 2013, the City completed a Growth Management Report to evaluate the capacity of the City's urban growth boundary (UGB) to accommodate 20-year forecasted housing and employment needs. The Growth Management Report notes that:

> *"Prior to Northwest Aluminum's decision [to close its facility and put most of their land on the market], The Dalles had no suitable employment sites over 50 acres in size, and would have needed to expand the UGB to include two 50+ acre employment sites. However, Northwest Aluminum's decision…means that all of the City's large-site industrial needs can be met within the existing (2013) UGB."*

Based on this increase in the availability of land for large industrial water users within the City's UGB, and more specifically within Service Zone 310 (310 Zone), an assessment of the potential buildout water supply demands and associated water supply infrastructure needs in the 310 Zone is being conducted to inform the upcoming Water System Master Planning effort.

This technical memorandum presents an analysis of the City's current water source capacity and water supply augmentation options for increasing the City's water supply capacity to meet the potential buildout water supply demands of the 310 Zone.

Analysis

The City's water supply system was analyzed to determine current water source capacity available to meet existing demands and to identify water supply augmentation options for increasing the City's water supply capacity to meet estimated buildout demands in the 310 Zone. This analysis included an assessment of the City's existing water source infrastructure[1], estimated buildout demands in the 310 Zone, and constraints on

[1] For the purpose of this memorandum, "water source infrastructure" includes the capacity of the City's groundwater supply wells and the Wicks water treatment plant. The supply capacity and any limitations of the City's distribution system relating to the transmission and delivery of water to meet system demands, such as transmission capacity of mainlines and use of in-system storage (storage tanks), are not considered in this memorandum.

the City's water sources, including source availability (streamflow limitations and sustainable annual yield of the aquifer) and water right authorizations.

City Water Supply Sources and Water Right Authorizations

The City holds a number of water rights authorizing the use of several different sources of surface water and groundwater, which are summarized in **Table 1**. The City currently uses a combination of groundwater from multiple City wells and surface water from Dog River, South Fork Mill Creek, and Crow Creek Reservoir for supply. The following sections summarize both the City's water supply sources and associated water rights, and its current water supply capacity from these sources.

Groundwater

The City holds 19.63 cubic feet per second (cfs) (12.7 million gallons per day [mgd]) of water rights for the use groundwater from the basalt aquifer underlying the City known as "The Dalles Ground Water Reservoir" or "The Dalles Pool Aquifer" (Table 1). Of this total, the City currently uses 11.70 cfs (7.6 mgd) from its Jordan, Marks, and Lone Pine wells. This leaves 7.93 cfs (5.1 mgd) of authorized rate remaining under the City's groundwater rights to meet its future demands. The City also holds a limited license for implementation of Aquifer Storage and Recovery (ASR) in The Dalles Pool Aquifer (ASR LL 025). The limited license allows the City to use up to four proposed ASR wells to store up to 1,200 million gallons (MG) of treated surface water in The Dalles Pool Aquifer for subsequent recovery and use. The water stored by ASR is a separate volume of water available for the City's exclusive use apart from the native groundwater of The Dalles Pool Aquifer accessible under the City's groundwater rights. The City has not yet initiated its ASR program and would need to develop at least one of the ASR wells to begin implementing ASR.

The groundwater aquifer used by the City has important resource limitations. The Dalles Pool Aquifer is regulated by Oregon Water Resources Department (OWRD) as part of The Dalles Critical Groundwater Area (CGWA), which includes monitoring of groundwater use by existing users and prohibition of new groundwater rights for applications filed after the CGWA designation in 1959. Although The Dalles Pool Aquifer is an extremely productive aquifer, it is susceptible to over-pumping. Based on data and observations collected from The Dalles Pool Aquifer in support of the CGWA designation and in the years since its establishment, the sustainable annual yield[2] (SAY) of The Dalles Pool Aquifer is estimated to be approximately 5,500 acre-feet (1792 MG) (Golder, 1999). Historically, the annual volume of groundwater pumping from The Dalles Pool Aquifer has exceeded the SAY, resulting in declines in the aquifer water level. In the past decade (since 2010), however, the annual volume of groundwater pumped from The Dalles Pool Aquifer (including the City's groundwater use) has been approximately 1,800 acre-feet (586 MG)[3] based on water use data collected by OWRD for the users of groundwater within the CGWA . This leaves approximately 3,700 acre-feet (1206 MG) of annual groundwater use available within the SAY of The Dalles Pool Aquifer[4].

Surface Water

The City's surface water is obtained from the watersheds of Dog River and South Fork Mill Creek. The City's surface water rights include a right to all of the water (no specified rate) at the City's Dog River intake, a right to use up to 2 cfs (1.3 mgd) from South Fork Mill Creek, and rights that allow the storage of up to 3,055 acre-feet of water (955 MG) in Crow Creek Reservoir and the subsequent use of that stored water (Table 1).

[2] The annual volume of groundwater than can be withdrawn from the aquifer without causing aquifer level declines.
[3] Of the 1,800 acre-feet of annual groundwater use from The Dalles Pool Aquifer, approximately 1,300 acre-feet is associated with groundwater users other than the City.
[4] Based on our review and understanding of the existing water users of The Dalles Pool Aquifer, we do not expect this annual volume to appreciably change over time, apart from the City's use of groundwater and any future use of the NWA water rights.

Table 1. Summary of City Water Rights for Supply

Source	Water Right				Priority Date	Type of Use	Authorized Rate		Authorized Volume
	Application	Permit	Claim or Decree	Certificate			cfs	gpm	
Groundwater									
Lone Pine Well Jordan Street Well Marks Well ASR 1			GR 4258		10/11/1923	Municipal, Domestic, Irrigation, Manufacturing, and Industrial	5.124	2,300	N/A
Marks Well	U-135	U-127		15543	11/1/1940	Municipal	2.68	1,203	N/A
Marks Well	U-181	U-189		86380	10/4/1945	Municipal	0.69	310	N/A
Jordan Street Well	G-23	G-7806		48991	10/16/1953	Municipal	5.5	2,469	N/A
Lone Pine Well	G-1415	G-7807		60026	3/13/1959	Municipal	4.46	2,002	N/A
Mill Creek Well	U-181	U-189		85886	10/4/1945	Municipal	0.81	364	N/A
Stadelman Well			GR 4257		1910	Domestic / manufacturing	0.368	165	N/A
Aquifer Storage and Recovery									
Dog River, South Fork Mill Creek, and Crow Creek Reservoir	LL-025	--	--	--	N/A	Storage and Recovery of water for Municipal Use	Recharge 16.7 cfs (7,496 gpm) for recharge; 1,875 gpm per well Recovery 2,500 gpm per well		1,200 MG

Table 1. Summary of City Water Rights for Supply (Continued)

Source	Water Right				Priority Date	Type of Use	Authorized Rate		Authorized Volume
	Application	Permit	Claim or Decree	Certificate			cfs	gpm	
Surface Water									
South Fork Mill Creek			Mill Creek Decree	5691	1862	Municipal	2.0	898	N/A
Dog River			Hood River Decree	14954	8/1/1870	Municipal	"All the water in stream at point of diversion"		N/A
Crow Creek Reservoir	S-43668	S-32479		60410	5/29/1967	Municipal	N/A	N/A	955 AF
Crow Creek Reservoir	S-84050	S-53930		N/A	1/21/1999	Municipal	N/A	N/A	2,100 AF
Columbia River	S-55346	S-49653		N/A	1/13/1986	Municipal	40	17,953	N/A
Surface Water Storage									
South Fork Mill Creek and Dog River	R-43667	R-4988		44917	5/29/1967	Storage for Municipal Use	N/A	N/A	955 AF
South Fork Mill Creek and Dog River	R-84049	R-13105		N/A	1/21/1999	Storage for Municipal Use	N/A	N/A	2,100 AF

The quantity of water available from Dog River and South Fork Mill Creek varies seasonally based on the amount and timing of precipitation, and the type of precipitation (i.e., accumulation as snow pack versus precipitation in the form of rain). The latter is of particular significance as snowpack provides natural storage of water during the winter that is subsequently released during the spring as the snowpack melts. The supply of water available from the City's surface water sources is higher during the winter and spring than during the summer and fall. According to the City's 2014 Water Management and Conservation Plan (GSI, 2014), the firm surface water supply capacity based on the reliability of the City's surface water sources during the summer is 5.4 cfs (3.5 mgd).

The City holds certificated water rights for storage and use of 955 acre-feet (311 MG) of water in Crow Creek Reservoir and for subsequent use of the stored water for municipal uses by the City (Table 1). The City also has water rights authorizing the storage and use of an additional 2,100 acre-feet (684 MG) in the Crow Creek Reservoir. To date, these additional water rights to store and use stored water have not been developed; these water rights were obtained for a potential expansion option of the reservoir that has not been completed. The expansion of the reservoir would require permitting with various state and federal agencies, including a Special Use Permit because a portion of the reservoir is located on U.S. Forest Service lands.

The City also holds a water right for the use of up to 40 cfs (25.8 mgd) from the Columbia River; however, the City does not currently use this source. The City would need to obtain authorization from the U.S. Army Corps of Engineers and construct an intake, and the City would need to construct potable water treatment facilities to develop this source of supply.

Current Capacity of Water Source Infrastructure

As discussed in the preceding sections, the water supply available from the City's existing water supply sources is dependent not only on the water source availability and associated water rights, but also on the capacity of the City's water supply infrastructure. **Table 2** shows the maximum capacity of the City's existing water supply facilities, which are used as the basis for the analyses in this memorandum.

Table 2. Capacity of the City's Existing Water Source Infrastructure

Source	Maximum Capacity	
	Instantaneous (cfs)	Daily (mgd)
Jordan Well	3.90	2.52
Marks Well	3.34	2.16
Lone Pine Well	4.67	3.02
Subtotal Groundwater	**11.91**	**7.70**
Wicks WTP	7.42	4.80*
Total	**19.33**	**12.50**

Notes
* The firm supply capacity available from the Wicks WTP based on the reliability of the City's surface water sources during the summer is 3.5 mgd.

Water from Dog River and South Fork Mill Creek, as well as stored water in Crow Creek Reservoir, are all withdrawn from a single intake on South Fork Mill Creek at the Wicks water treatment plant (WTP). The Wicks WTP has a current maximum finished water production capacity of 7.42 cfs (4.8 mgd) with a maximum flow through capacity of 8.66 cfs (5.6 mgd). According to City operations staff, the output of the Wicks WTP is limited to the maximum finished water production capacity of 7.42 cfs (4.8 mgd). Further, as discussed in the preceding section, the firm supply capacity available from the Wicks WTP based on the reliability of the City's surface water sources during the summer is 3.5 mgd.

Projected Demands

RH2 Engineering, Inc. estimated maximum day demands of 6.8 mgd based on the buildable commercial and industrial area available in the 310 Zone and unit demands per acre (RH2, 2020). This buildout demand for the 310 Zone would be in addition to the City's current maximum day demand of 9.0 mgd, resulting in a total estimated maximum day demand of 15.8 mgd (RH2, 2020).

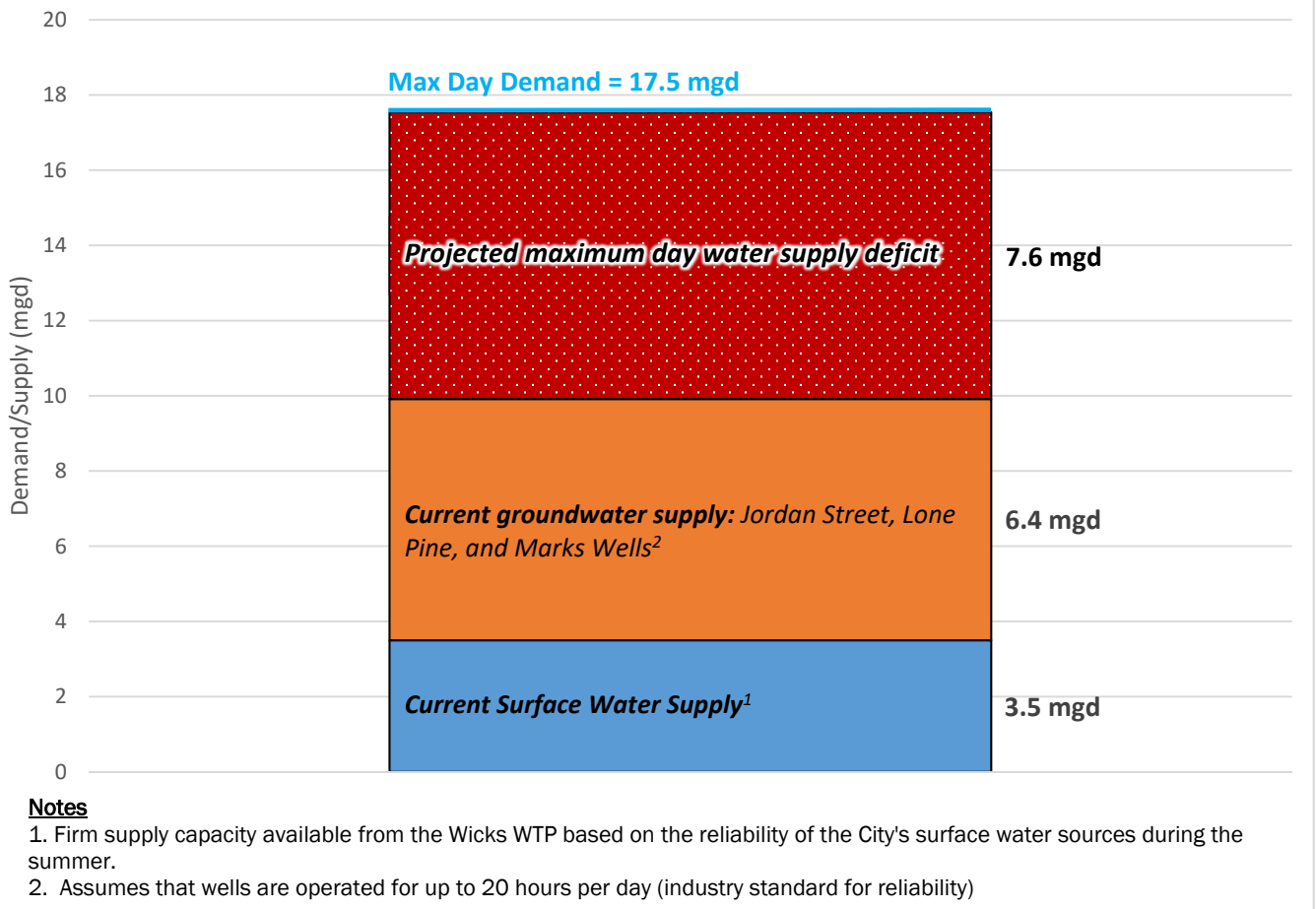
Figure 1 shows the water supply capacity available from the City's current water source infrastructure during a ***maximum day demand scenario*** at buildout of the 310 Zone based on the following assumptions:

- The total maximum day demand includes the estimated maximum day demand at buildout of the 310 Zone (15.8 mgd) plus a demand allowance for 20 years of growth in other City service zones (1.7 MG)[5] for a total of 17.5 mgd.
- The maximum day demand occurs during the City's peak demand season (June through September).
- The firm supply capacity available from the Wicks WTP during the peak demand period is 3.5 mgd.
- The City's groundwater supply wells are operated at full pumping rate capacity for 20 hours[6].
- Contributions of in-system storage (storage tanks) to meet demand are not considered

As shown in Figure 1, the City is able to meet an estimated 9.9 mgd of the 17.5 during the maximum day demand scenario, leaving a projected deficit of 7.6 mgd.

[5] Based on annual growth of 1.1% from 2019; assumed to be principally residential growth
[6] This duration of pumping is within industry standards for reliability.

Figure 1: Current water supply capacity during a maximum day demand scenario.



Notes
1. Firm supply capacity available from the Wicks WTP based on the reliability of the City's surface water sources during the summer.
2. Assumes that wells are operated for up to 20 hours per day (industry standard for reliability)

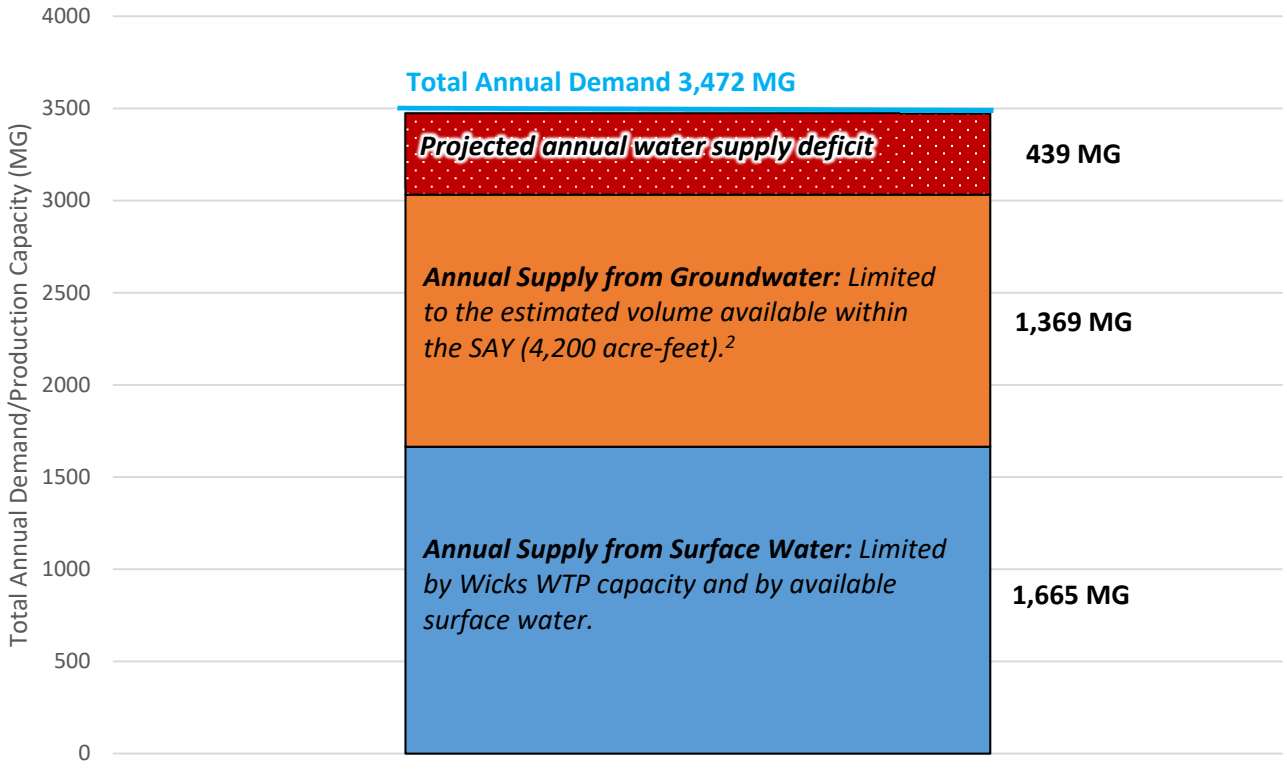
Figure 2 shows the water supply available from the City's current water source infrastructure during an ***annual demand scenario*** at buildout of the 310 Zone based on the following assumptions:

- The total annual demand is based on a function of the estimated annual demand of the City with buildout of the 310 Zone, including 20 years of growth in other City service zones.
- Surface water supply from Wicks WTP is used as the primary source of supply to meet demands.
- The water available from Wicks WTP is limited by the capacity of the plant, the capacity of the City's existing surface water rights, and actual surface water source availability in an average year[7]:
- The City's groundwater supply wells are operated to supplement surface water to meet demand and are limited to a maximum annual pumping volume of 4200 acre-feet[8] to not exceed the SAY of The Dalles Pool Aquifer

As shown in Figure 2, the City is able to meet an estimated 3,034 MG of the 3,472 MG demand during the annual demand scenario, leaving a projected deficit of 439 MG.

[7] Source water availability is equal to the average of actual measured natural flow of the Dog River and South Fork Mill Creek, and stored water from Crow Creek Reservoir during the 2013 through 2015 calendar years, representing snow pack conditions that range from an exceptionally poor water year (2015) to a good water year (2014).
[8] This assumes that the annual volume of groundwater use by other users remains consistent with the past decade of use, being 1,300 acre-feet, leaving 4,200 acre-feet for the City's use.

Figure 2: Current water supply capacity during an annual demand scenario.



Notes:

1. Surface water supply conditions based on average of 2013 through 2015.
2. For the purposes of this figure, which is intended to show the annual water balance, groundwater was assumed to be limited only by the SAY and is not limited by well capacity on a daily or instantaneous rate basis.
3. Maximum surface water diversion is the lesser of Wicks WTP capacity (as shown in Table 2) or surface water available for diversion from the Dog River, South Fork Mill Creek, and Crow Creek storage within City's water rights.

Water Source Supply Augmentation Options

Options for increasing the City's water supply capacity to meet projected demands may include additional development of both groundwater and surface water. A number of the water supply augmentation options presented below are standalone options for increasing the City's water supply capacity. For several of the options, however, the increase in water supply capacity is contingent on the implementation of other improvement options.

- **Additional Groundwater Supply Wells**. The combined capacity of the City's current groundwater supply wells is 11.91 cfs (7.7 mgd), which leaves 7.72 cfs (5.0 mgd) of available water right rate under the City's existing groundwater rights for use of The Dalles Pool aquifer. This additional authorized rate of use could be realized at new wells. Assuming that a new well would have a production capacity similar to the City's existing wells (2.6 mgd per well), the currently unused water right rate available under the City's existing groundwater rights could be utilized by two new wells (one at 2.6 mgd and second at 2.4 mgd).

  NWA was previously one of the largest users of groundwater from The Dalles Pool Aquifer. With the closure of NWA, GSI has identified up to 6.01 cfs (3.9 mgd) of former NWA water rights that may be available for acquisition by the City. These NWA water rights appear to be in good standing (valid for continued use) but

are not being fully utilized for groundwater production at this time[9]. The City could explore the feasibility of acquiring these additional groundwater rights to meet its projected demands. These former NWA water rights would be sufficient to cover a third new well at 2.6 mgd, plus an additional 1.3 mgd that could be allocated to a fourth well.

The City could also explore development of groundwater from a new aquifer source. The restrictions of the CGWA apply only to The Dalles Pool Aquifer and the Threemile Ground Water Reservoir (the latter is located to the southeast of the City of The Dalles). The Dalles Pool Aquifer is associated with one geologic unit (the Frenchman Springs) of the Columbia River Basalt Group (CRBG); however, there are several additional units of the CRBG that underlie the Frenchman Springs, which are known to be productive aquifers. The Grande Ronde Basalt formation (located at an estimated depth of 500 to 800 feet below the City[10]) has been recently developed in Mosier as an alternative groundwater source to the Frenchman Springs (and other shallower basalts units). Utilization of an alternative aquifer source such as the Grande Ronde, would require exploration drilling and acquisition of new water rights for the use of groundwater from this new aquifer source.

- **ASR Wells.** The City's ASR limited license allows the City to store treated surface water from the Wicks WTP in The Dalles Pool Aquifer. Generally, the City would store water in the aquifer when there is surplus flow available from Dog River and South Fork Mill Creek (during winter and early spring) and then recover that stored water when supply from these surface water sources are diminished (during the summer). In addition to being a water management tool for excess surface water, the water stored by ASR is a separate volume of water (source) available for the City's exclusive use apart from the native groundwater of The Dalles Pool Aquifer accessible under the City's groundwater rights. Further, ASR would provide the City with a tool to manage native groundwater withdrawals during the summer months so as to not exceed the SAY. In addition, a 'bank' of ASR storage can be developed during wet years (high availability of surface water) and carried over for recovery during dry years (reduced availability of surface water).

  As the City's demand increases with buildout of the 310 Zone, the capacity of the Wicks WTP may not be sufficient to provide water to meet the demands of the municipal system and also provide water for ASR recharge during the winter and spring. Therefore, expansion of the Wicks WTP will likely be necessary for expansion of the ASR program beyond the first ASR well. The utility of ASR as a water supply augmentation option would be maximized by the planned expansion of the Wicks WTP

- **Artificial Groundwater Recharge.** The City may also be able to obtain a water right for the use of South Fork Mill Creek for artificial groundwater recharge (AR). AR would be conceptually similar to ASR, involving the City storing treated surface water from the Wicks WTP in The Dalles Pool Aquifer during winter months when surplus surface water is available. However, unlike ASR, the water added to the aquifer by AR does not create a separate volume of water (source); rather, the water recharged to the aquifer by AR would be used to offset native groundwater withdrawals by the City that would otherwise exceed the SAY. The same wells used for ASR can be used for AR. The potential source of water for AR would be South Fork Mill Creek. Currently, the City is limited to a diversion of 2.0 cfs from South Fork Mill Creek.[11] While additional water from South Fork Mill Creek is not available for a new water right for direct diversion, water **is** available for AR[12]. GSI anticipates that the City could obtain a new limited use license to test AR for up to

[9] There has been continued use of the water rights since the closure of NWA; however, that use has been minor and so for planning purposes it is assumed that the use of these water rights is not included in the current annual volume of groundwater use occurring within the CGWA (i.e., 1,300 acre-feet).
[10] No water supply wells within The Dalles area reach the Grande Ronde Basalt, but a deep well (WASC 50312) located south of the City appears to penetrate the top of the Grande Ronde Basalt.
[11] The 2.0 cfs limit applies only to South Fork Mill Creek natural flow.
[12] OWRD evaluates the availability of water for artificial groundwater recharge at the 50% exceedance level (same as for storage projects).

4.67 cfs for the months of January through April; additional steps would need to be taken to obtain a water use permit for AR.[13].

The expansion of the Wicks WTP would be likely necessary to implement AR while also supplying water for winter-time demands and ASR implementation.

- **Surface Water.** There are two potentially viable options for expansion of the City's surface water supplies: expansion of the Wicks WTP to provide additional supply from the surface water sources currently utilized by the City, and development of a diversion and potable water supply treatment plant to facilitate use of the Columbia River as a new source of supply for the City. GSI understands that the City has the ability to expand the treatment capacity of the Wicks WTP without making significant structural changes to the WTP, and that this expansion is a planned capital improvement project identified by the City's 2006 Water System Master Plan. The planned expansion of Wicks WTP capacity[14] would increase the City's ability to meet winter and spring demands with surface water while also providing an increased supply of treated surface water available for ASR and AR.

  The City holds a surface water permit for the use of up to 40 cfs from the Columbia River. Since the City currently has no infrastructure on the Columbia River, the City would need to obtain approvals to construct an intake, potable supply water treatment plant, and transmission line. The construction of the intake and the associated in-water work will likely require extensive permitting through multiple state and federal agencies and will likely require bucket-for-bucket mitigation (i.e., matching the rate of diversion) to address impacts to federally listed fish.

  For the purposes of this memorandum the expansion of the Crow Creek Reservoir is not considered as a water supply augmentation option due to the uncertainty associated with permitting, the anticipated high cost of reservoir expansion, and because reservoir expansion could be considered redundant to storing water in the aquifer using ASR.

Water Source Infrastructure Improvement Scenario

This section presents and discusses a potential water source infrastructure improvement scenario that the City could implement to meet projected demands. The water source infrastructure improvements presented are based on an assessment of the water source supply augmentation options presented in the preceding section with consideration of following:

- Time required to implement with respect to resulting supply being available
- Source availability and sustainability of supply
- Permitting associated with development
- Sequential development dependencies of options
- Certainty of water source supply

Table 3 provides a summary of the potential water source infrastructure improvement scenario, including a brief discussion of each water source infrastructure improvement.

[13] A limited license for AR provides authorization for up to 5 years, and can be renewed for additional 5 year periods. There is a permitting pathway for a permanent authorization for AR, an AR permit; however, OWRD's Hood River Basin Program does not explicitly state Aquifer Recharge as a classified use of water, which would be a necessary requirement for approval of an AR permit. A basin plan exception could be requested from OWRD to overcome this requirement; based on preliminary discussions with OWRD, OWRD would consider a basin plan exception for aquifer recharge, but additional assessment is needed of this option if it is to be pursued.

[14] The planned expansion of the Wicks WTP would increase the plant's capacity to 10.4 mgd, which is expected to result in a maximum finished water production capacity of 9.1 mgd.

Table 3. Potential Water Source Infrastructure Improvement Scenario

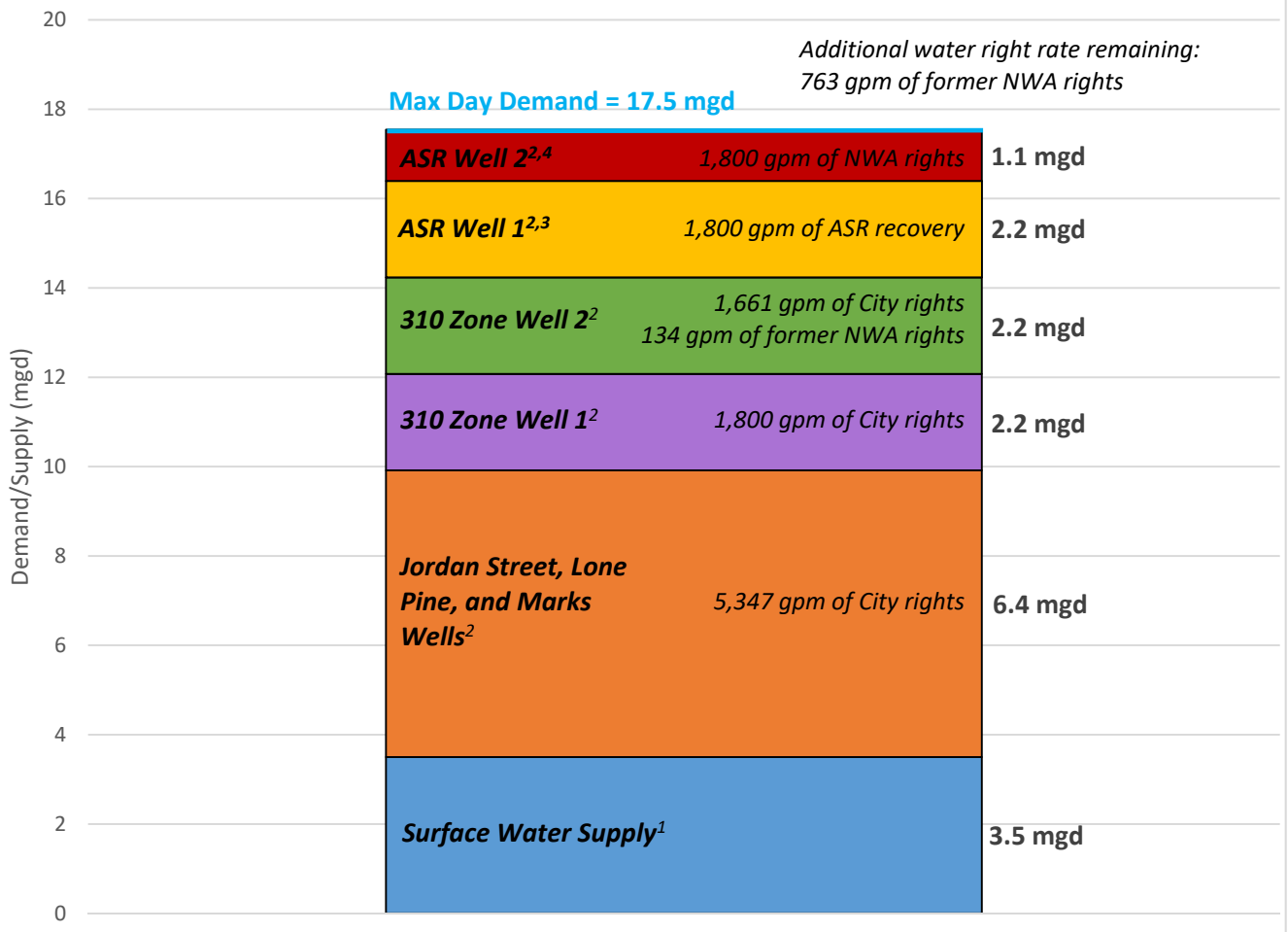
Water Source Infrastructure Improvement	Description	Comments
Near-term Improvements		
Construction of Groundwater Supply Wells in the 310 Zone	• Up to 7.72 cfs (5.0 mgd) of water right rate is available under the City's existing groundwater rights, which is sufficient for two wells with yields similar to the City's existing wells. • These wells will utilize an existing aquifer source with well-known aquifer hydraulic properties. • These wells will provide additional water supply capacity relatively quickly to meet increasing near-term demands and thus providing time for implementation of other water source infrastructure improvements. • Locating the new wells in the 310 Zone will limit the distribution infrastructure improvements required to supply water within the service zone where the projected demands will occur (see RH2, 2020).	• The additional annual volume of groundwater pumped from these wells is not expected to exceed the SAY in the near-term (approximately 4200 acre-feet of annual volume is currently available within the SAY); however, the aquifer from which the additional groundwater will be pumped is actively monitored by OWRD as part of the CGWA designation, and is an existing important source of water for the City. Accordingly, monitoring of the aquifer water level over time as groundwater pumping increases is recommended to facilitate early detection of any aquifer water level changes of concern.
Acquisition of Former NWA Water Rights	• Up to 6.01 cfs (3.9 mgd) of former NWA water rights for The Dalles Pool Aquifer. • Because CGWA designation prohibits the ability to obtain new water rights from The Dalles Pool Aquifer, the acquisition of the NWA water rights provides an opportunity for the City to obtain a significant quantity of additional existing water rights for aquifer. • These water rights would provide the City with additional water right rate to accommodate greater per well pumping rates for the 310 Zone wells if the yield of those wells is found to be in excess of the anticipated yields for the wells (2.6 mgd), and/or would allow the City to utilize the planned ASR wells to pump native groundwater in addition to recovered stored water under the City's ASR limited license.	
Construction of ASR Wells	• The City's existing ASR limited license authorizes the use up to four ASR wells to store up to 1,200 MG of treated surface water in The Dalles Pool Aquifer for subsequent recovery and use by the City. • The construction of an ASR well will allow the City to use its existing surface water infrastructure to begin building a volume of stored water in The Dalles Pool Aquifer. Because the stored ASR water is a separate source from the native groundwater of The Dalles Pool Aquifer, the City can use ASR to manage the City's withdrawal of native groundwater from the aquifer (as demands increase over time) to ensure sustainability of the aquifer resource. • ASR wells can be used for both ASR operations and to pump native groundwater; thus an ASR well can also provide redundancy for the City's groundwater supply wells.	• Upon expansion of the Wicks WTP, the City will have increased capacity to divert and treat additional surface water in excess of winter demands, enabling the construction of additional wells for expansion of the ASR program • In the analysis of the maximum day scenario, it is assumed that all wells will be operated simultaneously at up to 20 hours per day in order to meet the maximum day demand of 17.5 mgd. While this supply analysis does not consider contributions of in-system storage (storage tanks) which would contribute to meeting demand and reduce the required runtime of the wells, it is recommended that consideration be given to construction of at least one additional well to provide system redundancy in the event that operational issues occur at one or more wells.
Expansion of the Wicks WTP	• The expansion of the Wicks WTP will allow the City to increase its diversion and use of surface water to meet demands when additional surface water supplies are available (winter), reduce the duration of time that the City needs to use groundwater to supplement its surface water supply, and to provide treated surface water (in excess of that needed to meet demands) for implementation of ASR and AR.	• The expansion of the Wicks WTP would facilitate increased implementation of both ASR and AR.
Long-term Improvements		
Apply for a Limited License for AR	• A limited license for AR would increase the City's ability to divert winter flows on South Fork Mill Creek beyond the City's existing 2.0 cfs (1.3 mgd) water right for this source. • The water diverted under the limited license would be recharged to the aquifer, providing the City with the ability to directly offset actual or projected native groundwater withdrawals that would otherwise exceed the SAY.	• Although the ability to implement AR would likely not be realized until after expansion of the Wicks WTP, the permitting process with OWRD may take as long as two years so it would be advantageous to begin the permitting process for this option in advance or concurrent with the expansion of the WTP.
Develop Groundwater from Other Aquifers	• The restrictions of the CGWA on The Dalles Pool Aquifer do not apply to other deeper aquifer units. The Dalles Pool Aquifer is associated with one geologic formation unit (the Frenchman Springs) of the Columbia River Basalt Group (CRBG); however, there are several additional units of the CRBG that underlie the Frenchman Springs, which are known to be productive aquifers.	• Utilization of an alternative aquifer source such as the Grande Ronde Basalt formation, would require exploratory drilling to determine potential yield and water quality, as well as acquisition of new water rights for the use of groundwater from this new aquifer source.
Develop a Point of Diversion on the Columbia River	• The Columbia River could offer a significant and reliable source of supply for the City that would be one option available to the City for developing additional supply for continued growth beyond the projected buildout of the 310 Zone.	• Development of the City's Columbia River source is identified as a long-term supply option because of the potential time that would be required to complete the necessary permitting and bucket-for-bucket mitigation and to construct the infrastructure required to develop and utilize this water supply source.

Figure 3 shows the expected water supply capacity available during a ***maximum day demand scenario*** at buildout of the 310 Zone after implementation of the near-term water source infrastructure improvements listed in **Table 3**. Assumptions of the maximum day demand scenario include the following:

- The total maximum day demand includes the estimated maximum day demand at buildout of the 310 Zone (15.8 mgd) plus a demand allowance for 20 years of growth in other City service zones (1.7 MGD) for a total of 17.5 mgd.
- The maximum day demand occurs during the City's peak demand period.
- The firm supply capacity available from the Wicks WTP during the peak demand period is 3.5 mgd. Because surface water supply during summer is limited by water source availability, the supply from Wicks WTP during a dry summer is not expected to change following expansion of the WTP.
- The production capacity of each new well is 2.6 mgd.
- Groundwater supply wells are operated at full pumping rate capacity for up to 20 hours.
- Contributions of in-system storage (storage tanks) to meeting demand are not considered.
- The City has acquired the 6.01 cfs (3.9 mgd) of former NWA water rights, which in combination with the City's existing water rights, provide sufficient water rights for native groundwater from the City's existing three water supply wells, two new 310 Zone wells, ASR Well 1, and one additional new City production well.

As shown in **Figure 3**, the City is able to meet the projected demand of 17.5 MGD during the maximum day demand scenario using a combination surface water (3.5 mgd), native groundwater (11.9 mgd), and recovery of stored ASR water (2.2 mgd).

Figure 3: Projected water supply capacity during a maximum day demand scenario with increased supply developed from implementation of water source infrastructure improvements.



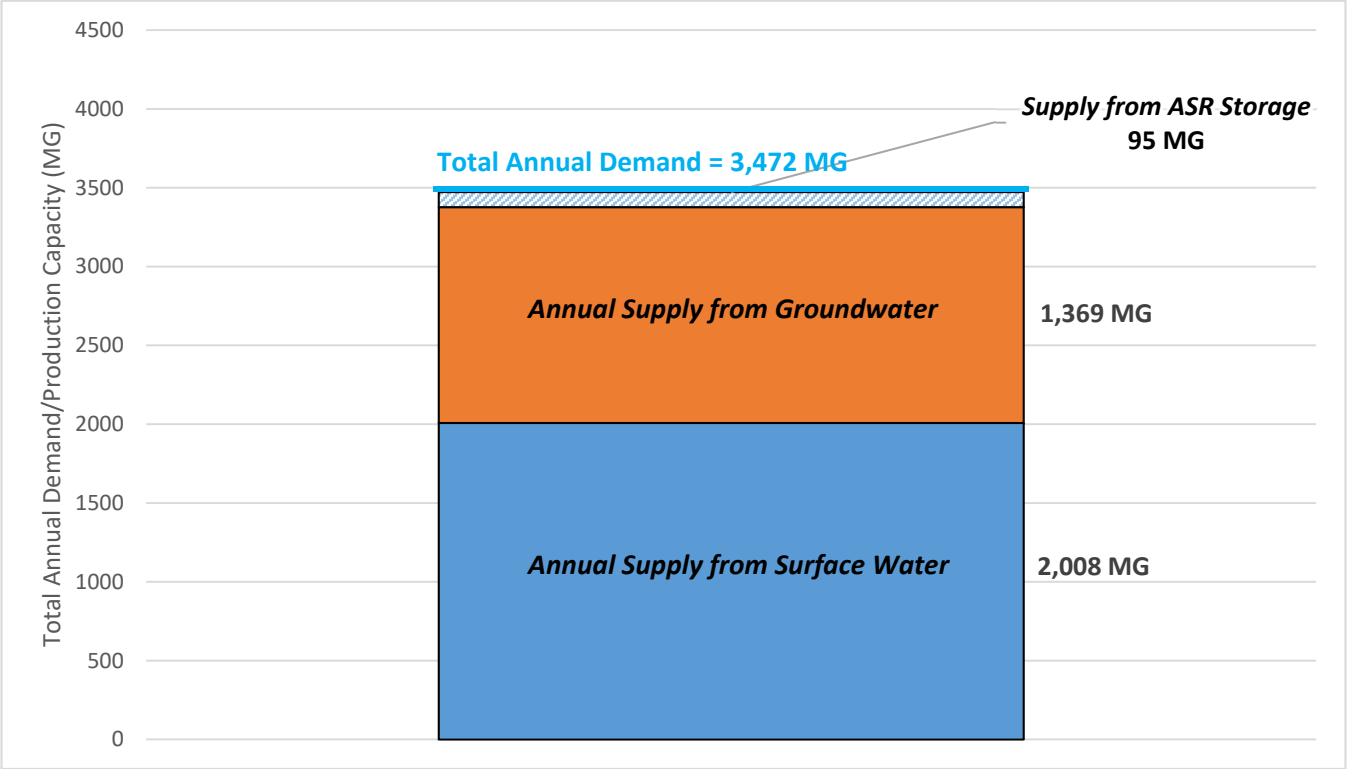
Notes
1. Firm supply capacity available from the Wicks WTP based on the reliability of the City's surface water sources during the summer
2. Assumes that wells are operated for up to 20 hours per day (industry standard for reliability)
3. Up to 1,850 gpm of ASR recovery per well allowed under ASR LL 025. Could also be used as a source for native groundwater
4. This could optionally be constructed as and additional groundwater supply well

Figure 4 shows the expected water supply available during an ***annual demand scenario*** at buildout of the 310 Zone after implementation of the near-term water source infrastructure improvements listed in **Table 3**. Assumptions of the annual demand scenario include the following:

- The total annual demand is based on a function of the estimated annual demand of the City at buildout of the 310 Zone, including 20 years of growth in other City service zones.
- Surface water supply from Wicks WTP is used as the primary source of supply to meet demands.
- The water available from Wicks WTP is limited by the capacity of the plant, the capacity of the City's existing surface water rights, and the surface water source availability in an average year.
- 102 MG of surface water (beyond that needed to meet system demands) is estimated to be available during the winter for ASR storage in an average year.
- Groundwater supply wells are operated to supplement surface water to meet demand and are limited to a maximum annual pumping volume of 4,200 acre-feet (1,369 MG) to not exceed the SAY of The Dalles Pool Aquifer.
- The City has acquired the 6.01 cfs (3.9 mgd) of former NWA water rights, which in combination with the City's existing water rights, provide sufficient water rights for native groundwater from the City's existing three water supply wells, two new 310 Zone wells, ASR Well 1, and one additional new City production well.

As shown in **Figure 4**, the City is able to meet a projected annual demand 3,472 MG during an annual demand scenario using a combination of surface water (2,008 MG), native groundwater (1,369 MG), and recovery of stored ASR water (95 MG). An additional 7 MG of ASR storage would be available for the City to meet annual demands in excess of the 3,472 MG demand considered in the annual demand scenario.

Figure 4: Projected annual water supply capacity during an annual demand supply scenario with increased supply developed from implementation of water source infrastructure improvements



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