Chapter 4

WATER RESOURCE ANALYSIS

4.1 Introduction

The City of Tumwater (City) can obtain its drinking water from twelve regularly active groundwater wells and one emergency well in three wellfields: Palermo, Airport, and Bush. The City requires additional supplies to meet demand growth. This chapter assesses the City's water rights and ability to supply from existing infrastructure. A future water supply strategy is developed, which considers wellhead protection and potential impacts of climate change. The future water supply strategy is developed using the City's Brewery rights, Golf course water right, and proposed Northeast wellfield and additional future source wellfields.

4.2 Water Rights Summary

The City has complex water rights for its existing wells. The City's water rights documentation can be found in Appendix I. This section assesses the ability of the existing water rights to meet future water supply needs on a system-wide basis. Improvements to mitigate water right deficiencies are presented as part of the future water supply strategy.

4.2.1 Existing Water Rights

The City's existing groundwater water rights are summarized by wellfield in Table 4.1. The City tracks instantaneous withdrawals and daily use from its wells. Wellfield water rights allow for withdrawals in excess of individual rights in most cases. Therefore, the City also tracks total withdrawals from each wellfield.

The City has a total allowable instantaneous withdrawal of 12,006 gallons per minute (gpm) and a total allowable annual withdrawal of 7,776 acre-foot per year (ac-ft/yr). Withdrawals from the Lathrop Water System (G2-25876) currently only meet that small system's demand. The Lathrop water system was integrated into the City's water system in May 2019. The Golf Course well (G2-01071) produces non-potable water that is used to irrigate the Tumwater golf course when reclaimed water is not available; it is not used to meet municipal demands.

Table 4.1 Existing Water Rights Summary

Well Name	Water Right	Priority Date	Maximum Instantaneous Flow Rate, (Qi) (gpm)		Annual Volume, (Qa) (ac-ft/yr)	
			Primary	Non-Additive	Primary	Non-Additive
Palermo Wellfield						
1	C-857D (G2-00618)	1/1/1931	220		1	
16	C-858D (G2-00619)	5/1/1939	350		423	
3	C-859D (G2-00620)	10/1/1944	250		135	
4	G2-GWC3547 (G2-05142)	2/25/1959 4/23/1949	55 750		13 250	
17	C-547A (G2-*01108CWRIS)	5/11/1965	500		91	709
1, 3, 4, 6, 8, 16, 17	C-5402A (G2-07608) G2-26816 (permit)	10/14/1985	980	2,125	2,100	913
		Subtotal Rights	**3,105**		**3,013**	
Airport Wells						
9	G2-GWC2924@1 (IRRIGATION)	6/18/1948	25		6.32	
9	G2-GWC2723@1 (IRRIGATION)	6/27/1955	74		20.4	
9	G2-GWC480@1 (IRRIGATION)	11/28/1947	30		1	
11, 15	G2-00271C (Seasonal)	1968	600		60	
9, 10, 11, 14, and 15	7765P (Now P-7278)	8/30/1965	2,500		2,454	
		Subtotal Rights	**3,229**		**2,541.72**	
Bush Wellfield						
12	G2-25607	5/13/1980		450	102	122
12	G2-24504	4/13/1977	100		32	
12	G2-24255	8/15/1976	350		90	
12	G2-28195	3/29/1991		910		1,465
14	G2-26815	10/14/1985	250		16.5	
14	C-7582 (G2-GWC7582)	4/10/1968	500		750	
		Subtotal Rights	**1,200**		**990.5**	

Well Name	Water Right	Priority Date	Maximum Instantaneous Flow Rate, (Qi) (gpm)		Annual Volume, (Qa) (ac-ft/yr)	
			Primary	Non-Additive	Primary	Non-Additive
Brewery Wellfield						
WF	785-D	7/20/1936	68		109	
WF	784-D	7/15/1937	67		108	
WF	34-A	5/22/1946	167		267	
WF	453-A	3/23/1950	233		76	
WF	4587-A	1/22/1960	750			1,723
WF	G2-01073C	1/23/1967	300			1,440
WF	G2-01072C	4/22/1971	300			140
WF	G2-20844C	3/13/1973	287			1,379
Well 39	G2-26058C	1/12/1982	1500(2)		201	
		Subtotal Rights(1)	**2172**		**761**	
Lathrop Water System						
	G2-25876	4/27/1981	300		70	
		Total Potable Water Rights	**10,006**		**7,376.22**	
Tumwater Golf Course(3)						
	G2-01071	9/9/1970	2,000		378	
		Total Water Rights	**12,006**		**7,776.22**	

Notes:
(1) Brewery Wellfield water rights shared with City of Lacey and City of Olympia. Subtotal represents City of Tumwater's one-third share of total rights (Q_i = 6,515 gpm and Q_a = 2,284 ac-ft/yr).
(2) Qi is alternate to shallower supplies.
(3) Supply currently used for irrigation and not part of potable water system.

4.2.2 Pending Water Rights

The City's pending water rights applications are listed in Table 4.2. The City currently anticipates using all pending water rights for potable supply, save for the Bruhn Water Right. The Bruhn Water Right is a "Family Farm Act" water right and cannot be used for municipal purposes; the City intends to place into trust for mitigation. In addition to these pending applications, the City is pursuing other water rights options whose outcome is undetermined at this time.

Table 4.2 Pending Water Rights

Wellfield	Number	Priority Date	Qi (gpm)	Qa (ac-ft)	Notes
			Primary	Primary	
Future Sources					
	G2-30229	2/11/2005	2,226	2,154	New application pending with Ecology(3).
	C-9038(1)	9/23/1970	100	40	Lakeland Manor water rights. Purchase agreement and transfer of rights to City of Tumwater is pending. City will identify new withdrawal location and apply to transfer rights to future source location.
	CG2-25005GWRIS(1)	10/24/2005	70	21	Bruhn Water Right transfer agreement executed for simple ownership of the rights.
	Doelman Water Right(2)		1,000	300	Doelman Water Right – Agreements pending. Qi expected to be less due to need to spread out annually. Current right is an irrigation right. Valuation study under way.
NE Wellfield					
	G2-29888	11/23/1999	2,000	2,200	New application pending with Ecology(3).

Notes:
(1) City acquired this water right after source of supply analysis was completed. Water rights are not included as existing water rights in this analysis. Final use of this water right may be for municipal consumption or mitigation for future water rights. Not included in future supply strategy presented in Section 4.3.3.
(2) City began negotiations for water rights acquisition after source of supply analysis was completed. Water rights are not included as pending water rights in analysis.
(3) Ecology - Washington State Department of Ecology.

4.3 Source of Supply Analysis

4.3.1 Potable Water Right Assessment

The City's existing potable water rights are compared against anticipated future demands to identify if additional water rights are needed. Water rights are compared to the conservative demand projections. Preparing to meet the conservative demand projections positions the City to fulfill its duty to serve new customers in its Retail Water Service Area (RWSA), as it would be unable to quickly obtain new water rights if demands exceed the lower planning demand projection scenario.

From Table 4.1, the City holds potable water rights with a total Qi of 10,006 gpm and Qa of 7,376.22 ac-ft/yr. This total excludes the non-potable Tumwater Golf Course water right (G2-01071). The City's existing instantaneous water rights, Qi, were compared against the maximum day demand (MDD) conservative projections and annual volume water rights, Qa, were compared against the average day demand (ADD) conservative projections. Table 4.3 summarizes the analysis results for existing demand (2016) and the projected 10-year and 20-year demands. The results are also shown graphically in Figure 4.1 and Figure 4.2 for Qi and Qa, respectively. Additional detail can be found in the Washington State Department of Health (DOH) Water Right Self-Assessment Form in Appendix I.

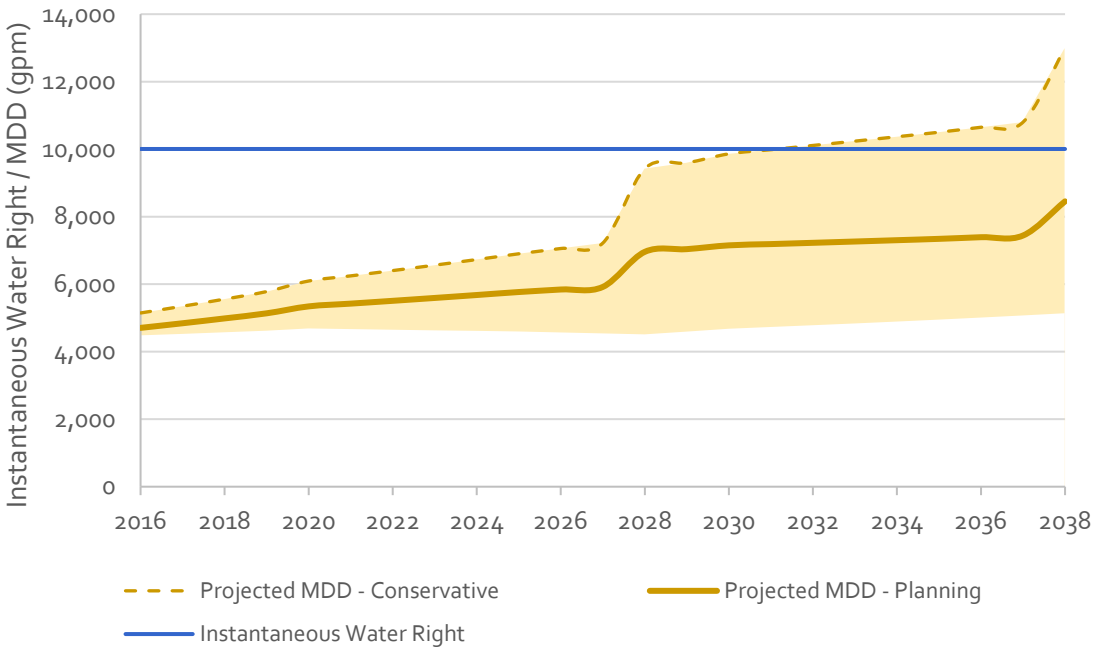

Figure 4.1 Instantaneous Potable Water Right Analysis

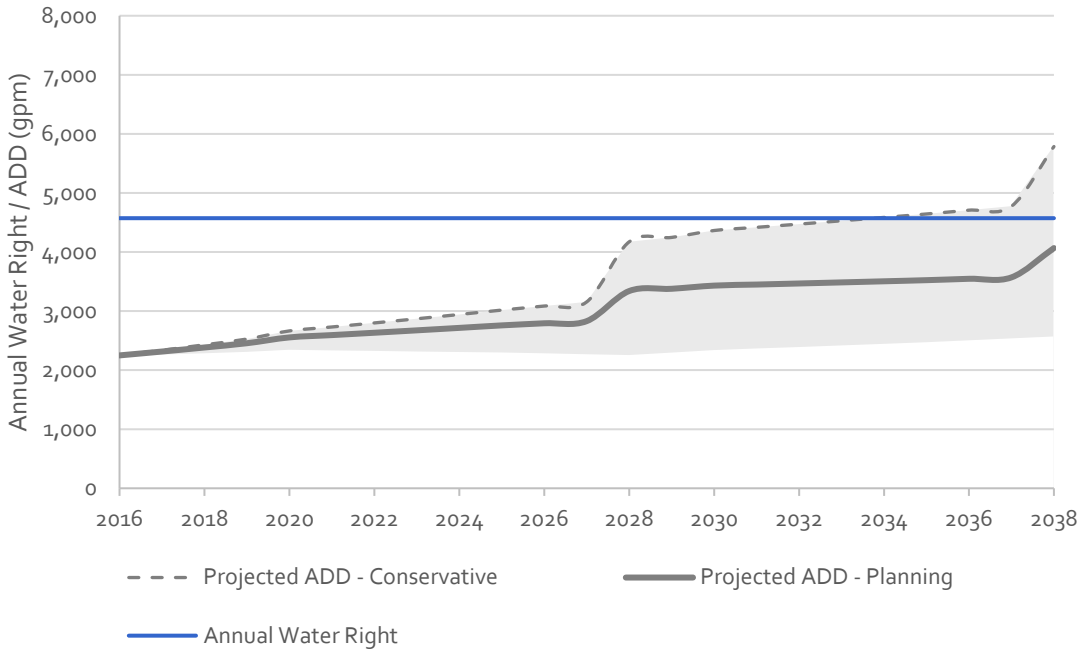

Figure 4.2 Annual Potable Water Right Analysis

The City holds insufficient potable water rights to meet the conservative demand projections through the planning period. Existing instantaneous water rights are exceeded by MDD in 2032 and annual volume water rights are exceeded by ADD in 2034. By 2038, instantaneous water rights deficiency is projected to be 2,988 gpm. Annual volume deficiency in 2038 is projected to be 1,957 ac-ft/year.

The City will need to secure additional water rights within the 20-year planning period. Pending water rights applications shown in Table 4.2, if approved, will provide the City with an additional 4,326 gpm Qi and 4,396 ac-ft/year Qa. In addition, the City intends to convert the Golf Course water right to a potable right, providing 2,000 gpm Qi and 400 ac-ft/year Qa. The total pending water rights applications and conversions will be sufficient to meet projected 20-year deficiencies, as shown in Table 4.3.

Table 4.3 Potable Water Right Analysis Summary

	2016			10-year Planning Period			20-year Planning Period		
	Water Rights[1]	Water Use	Balance	Water Rights[1]	Water Use[1]	Balance	Water Rights[1]	Water Use	Balance
Qi (gpm)	10,006	6,177	3,829	10,006	9,473	533	10,006	13,075	(3,069)
Qa (ac-ft/yr)	7,376	3,619	3,758	7,376	6,766	611	7,376	9,391	(-2,015)
Pending Water Rights Applications and Conversions									
Qi (gpm)	6,326								
Qa (ac-ft/yr)	4,796								

Note:
(1) Total considers only City's current potable water rights. Tumwater Golf Course irrigation right of 2,000 gpm Qi and 400 ac-ft/yr Qa not included in totals.

4.3.2 Ability to Supply

The City's existing wells were evaluated for their ability to supply considering source limitations other than water rights. Ability to supply analyses considered the following components for each well/wellfield:

- Pumping capacity: Physical pumping capacity for each individual well or the total for each wellfield as provided by the City.
- Water rights: Maximum instantaneous water rights and annual volume water rights. Analysis for MDD considered maximum instantaneous right. Analysis for ADD considered annual volume right.
- Operational limitations: Wellfield limitations that limit well output.
- Treatment capacity: Total treatment capacity for the City's water treatment plants (WTPs) that treat the Palermo and Bush wellfields.
- Ability to Supply: The maximum production for a well/wellfield given all pumping, water right, operational, or treatment limitations.

Ability to supply analyses were conducted for ADD and MDD. ADD ability to supply identifies the City's ability to supply its system-wide demand over an entire year. MDD ability to supply considers the ability of the City to meet system-wide peak demands.

4.3.2.1 MDD Ability to Supply

The MDD ability to supply is summarized in Table 4.4. Maximum instantaneous water rights exceed the pumping capacity for all of the City's wellfields due to aquifer limitations. Operational limitations are the limiting factor for MDD supply at the Palermo Wellfield, where wells are rotated to manage water levels. Pumping capacity (well yield) is the limiting factor for MDD supply from the Bush and Airport Wellfields. Total MDD ability to supply is 5,998 gpm.

Table 4.4 MDD Ability to Supply

Well	Pumping Capacity (gpm)	Water Rights (gpm)	Operational Limitation (gpm)	Treatment Capacity (gpm)	Ability to Supply (gpm)
Palermo Wellfield					
3[1]	0				
4	373				
6	364				
8	254	3,105	1,520	2,000	1,520
16	355				
17	284				
Subtotal	**1,630**				
Airport Wells					
9	371				
10	118				
11	240		N/A	N/A	1,540
15	811				
Subtotal	**1,540**	4,429[2]			
Bush Wellfield					
12	665				
14	2,273		N/A	N/A	2,938
Subtotal	**2,938**				
Emergency Well					
24[3]	0		0	N/A	0
Total	**6,108**	**7,534**			**5,998**

Notes:
(1) Well is currently out-of-service. City is evaluating alternatives to rehabilitate the well.
(2) Water rights for Airport Wells and Bush Wellfield combined.
(3) In August of 2019, Well 24 was taken offline and disconnected from the water system.

The City also considers supply redundancy when evaluating the ability to meet MDD with the largest source offline. The City's largest well, Well 14, has a pumping capacity of 2,273 gpm, 38 percent of the total MDD ability to supply. With Well 14 offline MDD ability to supply is reduced to 3,725 gpm, as presented in Table 4.5. The table condenses the MDD ability to supply by wellfield. In August of 2019, Well 24 was taken offline and disconnected from the water system. With redundancy considered, MDD ability to supply is reduced to 3,725 gpm. Maintaining Well 14 operation is crucial to the City's overall supply strategy.

Table 4.5 Redundant MDD Ability to Supply

Well	Pumping Capacity (gpm)	Ability to Supply (gpm)	Redundant Ability to Supply (gpm)
Palermo Wellfield	1,630	1,520	1,520
Airport Wells	1,540	1,540	1,540
Bush Wellfield	2,938		665
12	665	2,938	665
14	2,273		0
Emergency Wells			
24(1)	0	0	0
Total	**6,108**	**5,998**	**3,725**

Note:
(1) In August of 2019, Well 24 was taken offline and disconnected from the water system.

4.3.2.2 ADD Ability to Supply

The ADD ability to supply is summarized in Table 4.6. Annual volume water rights for the Airport and Bush wellfields were combined for this analysis due to the nature of their annual water rights. ADD ability to supply is limited primarily by annual water rights. Total ADD ability to supply is 4,057 gpm.

In addition to the identified annual ability to supply, system reliability was considered when meeting ADD. Wells/wellfields without a backup power source were not considered to be reliable sources and were given no capacity when calculating the City's reliable ability to supply for ADD. ADD ability to supply is limited primarily by annual water rights. The City's reliable ability to supply is limited by the lack of backup power for any of the Airport wells. Total Reliable ADD ability to supply is 3,898 gpm.

Table 4.6 ADD Ability to Supply

Wellfield	Pumping Capacity (gpm)	Water Rights (gpm)	Operational Limitations (gpm)	Treatment Capacity (gpm)	Backup Power	Ability to Supply (gpm)	Reliable Ability to Supply
Palermo	1,630	960	1,520	2,000	Yes	960	960
Airport	1,540	3,098	N/A	N/A	No	3,098	0
Bush	2,938		N/A	3,000	Yes		2,938
Total	**6,108**	**4,057**				**4,057**	**3,898**

4.3.3 Supply Strategy

4.3.3.1 Criteria

The City's Future Supply Strategy was developed to provide sufficient supplies for the following conditions:

- Normal: Meet ADD and MDD with all available supplies.
- Reliability: Meet ADD on back-up power.
- Redundancy: Meet MDD with the largest well out-of-service.

Supplies were compared against conservative demand projections in order to position the City to fulfill its duty to serve new customers in its RWSA.

4.3.3.2 MDD Supply Analysis

The existing ability to supply for the three conditions listed above was compared to the conservative demand projections. Figure 4.1 graphically compares the MDD ability to supply with the demand projections over the planning period. The MDD Ability to Supply, detailed in Table 4.5, is presented for normal and redundant conditions. For comparison, the maximum instantaneous water right is also shown.

Supply redundancy is a concern for the City, with a deficiency for all demand projection scenarios and a 1,658 gpm deficiency compared to the conservative MDD projection. In addition to supply redundancy concerns, the City is projected to have deficient normal MDD supply by 2020 for the conservative demand projection or by 2027 for the planning demand projection. Additional supplies are needed to meet the City's normal and redundancy criteria.

Table 4.7 summarizes the City's redundant supply balance throughout the planning period. The redundant supply deficiency is projected to grow from an existing 1,658 gpm to 9,350 gpm by 2038.

Table 4.7 MDD Supply Analysis Summary

	2017	2028	2038
MDD[(1)] (gpm)	5,383	9,473	13,075
Existing Supply (gpm)	5,998	5,998	5,998
Existing Redundant Supply (gpm)	3,725	3,725	3,725
Redundant Supply Balance (gpm)	(1,658)	(5,748)	(9,350)

Note:
(1) Conservative Demand Scenario.

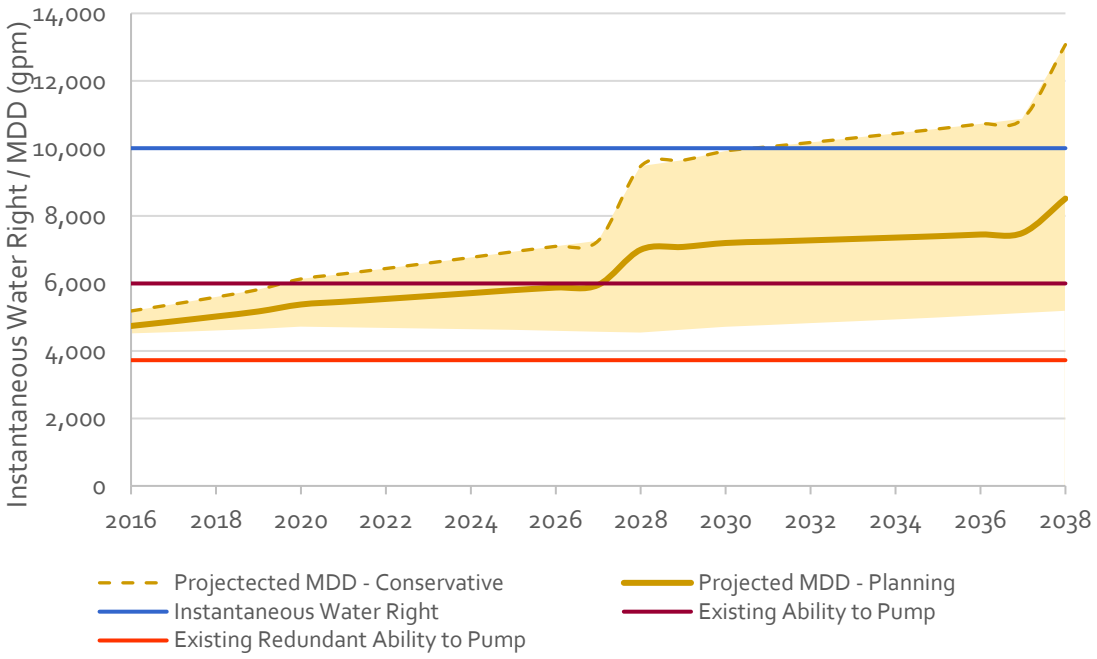

Figure 4.3 MDD Supply Analysis

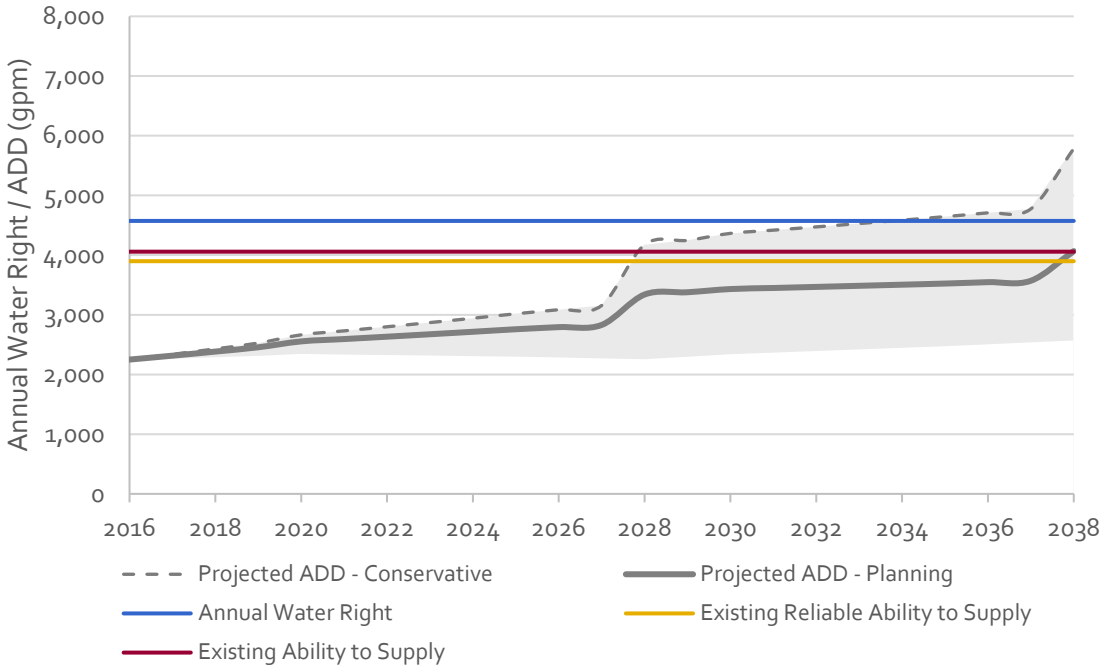

Figure 4.4 ADD Supply Analysis

4.3.3.3 ADD Supply Analysis

The existing ability to supply was compared to the conservative demand projections for the conditions described above. Figure 4.4 graphically compares the ADD ability to supply with the demand projections over the planning period. The ADD Ability to Supply, detailed in Table 4.6, is presented for normal and reliable conditions. For comparison, the annual water right is also shown.

The City's existing infrastructure provides adequate reliable supply through 2027, when a large user is anticipated to come online, considering the conservative demand projection. Additional supply will be needed to meet ADD by 2028. Supply reliability could be enhanced by adding backup power to at least one of the Airport Wells, but additional supplies will still be needed to meet demand growth by 2028.

Table 4.8 summarizes the City's reliable supply balance throughout the planning period. The reliable supply balance is projected to go from an existing surplus of 1,561 gpm to a deficit of 1,888 gpm by 2038.

Table 4.8 ADD Supply Analysis Summary

	2017	2028	2038
ADD(1) (gpm)	2,337	4,173	5,786
Existing Supply (gpm)	4,057	4,057	4,057
Existing Redundant Supply (gpm)	3,898	3,898	3,898
Redundant Supply Balance (gpm)	1,561	(275)	(1,888)

Note:
(1) Conservative Demand Scenario.

4.3.3.4 Supply Strategy

The previous evaluations showed that the City needs to develop additional supplies to meet their normal, redundant, and reliable supply criteria. The future supply strategy needs to increase supply to meet both demand growth and improve supply redundancy.

In order to meet projected MDD and satisfy redundancy criteria, the City needs to develop multiple new supply sources within the next five years and additional large supplies in the 20-year planning horizon. Supply development timing is dictated by MDD supplies. New MDD supplies provide sufficient supply to meet the ADD.

The quantity and timing of the supply improvements were estimated based on the MDD projections and the likely time frame for developing new supplies. The City plans to develop six potential supply sources, which are summarized in Table 4.9. Their impact on ability to supply is shown for MDD in Figure 4.5 and ADD in Figure 4.6. The supply strategy relies on securing new water supply sources and water rights. In the short-term, the City intends to convert the Golf Course water right from irrigation to municipal use and develop their portion of the Brewery Wellfield. The Northeast Wellfield and an additional future source will also need to be developed within the 20-year planning period to meet future supply needs. The Northeast Wellfield and the additional future source will require new water rights.

Table 4.9 Future Supply Source Summary

Implementation Timing	Supply Source	Supply Capacity	Description
2020	Lathrop Well	MDD: 300 gpm ADD: 40 gpm	Connection of the Lathrop well to the system. This requires approximately 1,600 linear feet of 12 inch distribution main.
2020	Tumwater Golf Course Well	MDD: 2,000 gpm ADD: 250 gpm	Conversion of the Golf Course Water Right and Well to potable water supply. Requires conversion of water right from Irrigation to Municipal Use. Well will require disinfection and additional yard piping.
2021	Brewery Wellfield	MDD: 2,170 gpm ADD: 470 gpm	Development of the Brewery Wellfield. The Strategic Plan (RH2 2016) identified the completion of two wells, disinfection, and potentially Manganese treatment. Distribution and transmission are recommended.
2024	Well 15 Auxiliary Generator	ADD Reliable: 150 gpm	Install auxiliary generator at Airport Wellfield to reliably power Well 15.
2026	Future Source	MDD: 2,230 gpm ADD: 1,340 gpm	Obtain water rights and develop the Future Source. The water right application requested four wells be developed.
2036	NE Wellfield	MDD: 2,000 gpm ADD: 1,360 gpm	Obtain water rights and develop the NE Wellfield. The Water Right Application requested four wells be required.

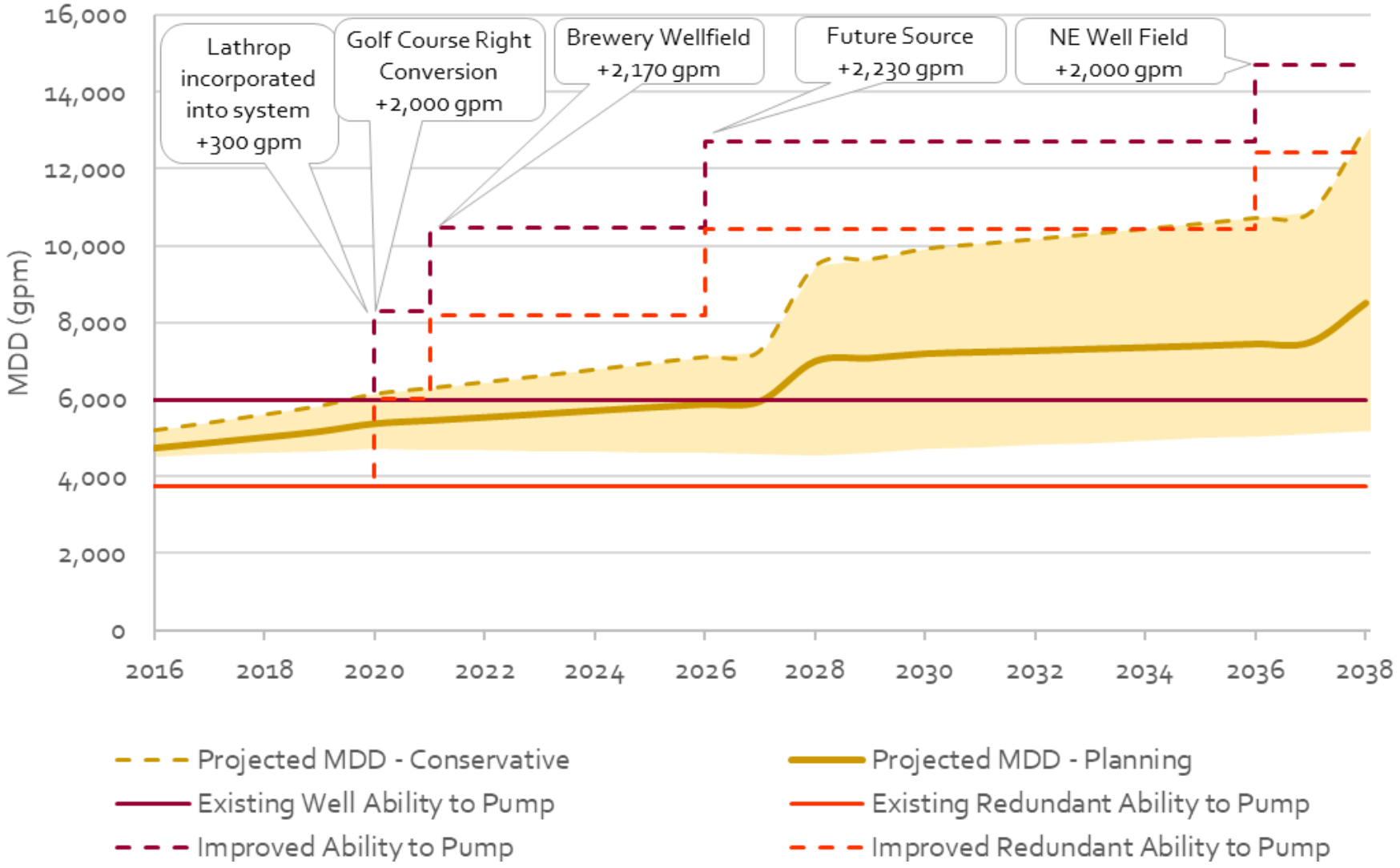

Figure 4.5 MDD Supply Strategy Analysis

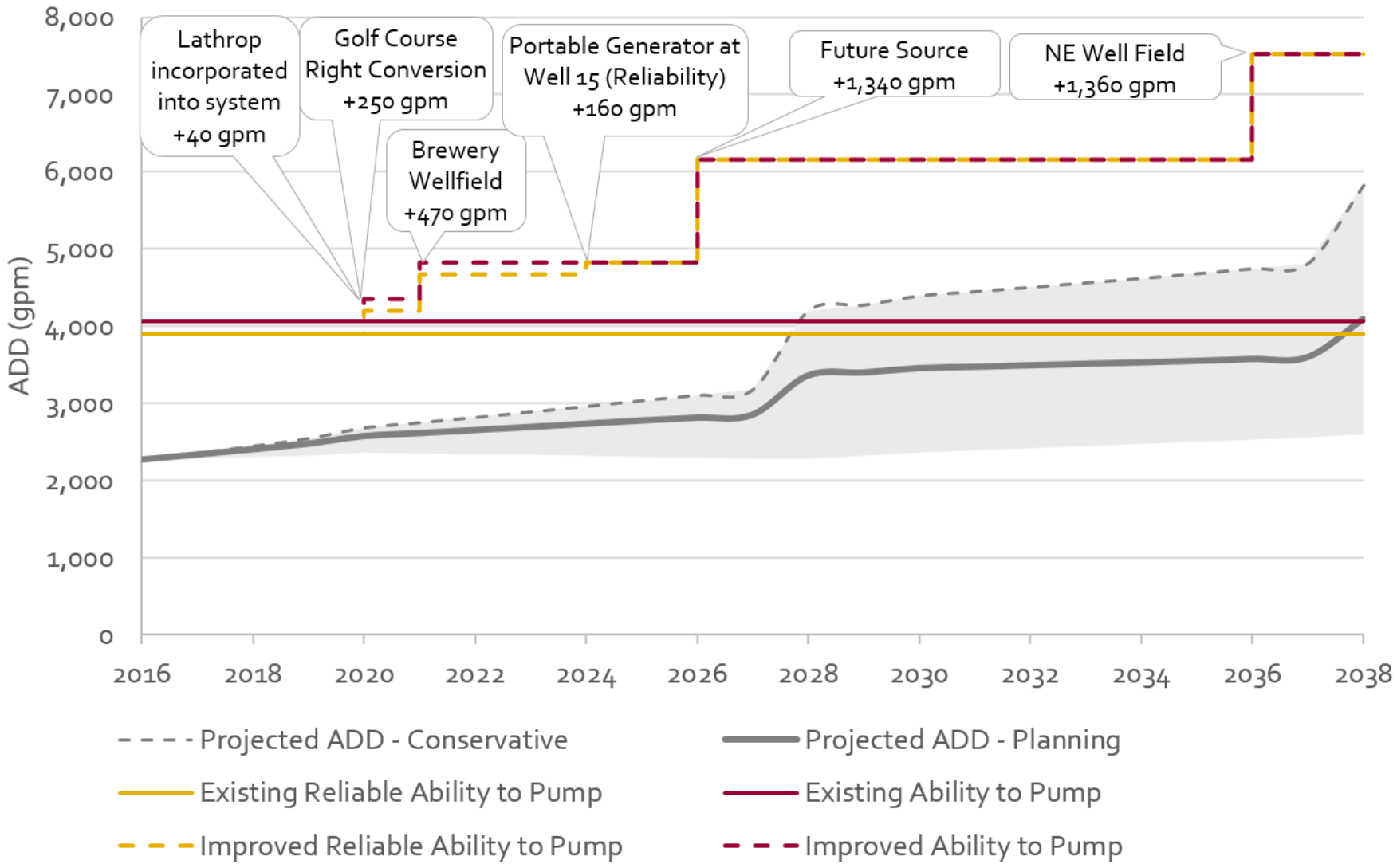

Figure 4.6 ADD Supply Strategy Analysis

In the event of delays in developing the Brewery Wellfield or securing the water rights and developing a future source, the City could install a non-additive well at the Bush Wellfield to increase supply redundancy. This would require expansion of the existing site, which may not be feasible. As an alternative, the non-additive well could be sited at the Northeast Wellfield. This well could then be converted to a primary well in the future when the Northeast Wellfield is developed.

The City can further address system reliability by installing a portable generator or source of back-up power at Well 15 or the Airport Wellfield. It was also assumed that all new supplies brought online would be reliable. Adding a back-up power source to Well 15 would ensure the City fully satisfies reliability criteria.

Well rehabilitation may allow the City to bring pumping capacity closer to the maximum instantaneous water rights. This would provide additional MDD supply capacity, but would not address the redundancy concerns. Well rehab would not address future ADD supply deficiencies, as pumping capacity exceeds annual volume water rights. Rehab was recently done on Well 10, but the City does not have plans to rehab other wells at this time.

Table 4.10 summarizes the City's MDD supply and redundant MDD supply balance with the supply improvements. The proposed supply strategy ensures the City meets normal MDD criteria and redundancy criteria for the conservative demand throughout the 20-year planning period. By 2038, it is projected that there will be a small MDD redundant supply deficit of 100 gpm.

Table 4.10 MDD Supply Analysis with Improvements Summary

	2017	2028	2038
MDD (gpm)	5,383	9,473	13,075
Existing Supply (gpm)	5,998	12,695	14,695
Existing Redundant Supply (gpm)	3,725	10,422	12,422
Redundant Supply Balance (gpm)	(1,658)	949	(653)

Table 4.11 summarizes the City's ADD supply and redundant ADD supply balance with the supply improvements. The proposed supply strategy ensures the City meets normal ADD criteria and reliability criteria throughout the 20-year planning period.

Table 4.11 ADD Supply Analysis with Improvements Summary

	2017	2028	2038
ADD (gpm)	2,337	4,173	5,786
Improved Supply (gpm)	4,057	6,157	7,521
Improved Reliable Supply (gpm)	3,898	6,157	7,521
Reliable Supply Balance (gpm)	1,561	1,984	1,735

4.4 Impacts of Climate Change on Supply

Impacts of climate change on the City's groundwater supplies were evaluated as part of this water system plan update. Climate change models generally predict warmer, wetter winters, and hotter, drier summers in the Pacific Northwest. Although climate change may alter seasonal precipitation patters, it is not expected to significantly change annual precipitation for the Tumwater area in the future. As a result, groundwater sources, like the City's wells, are expected to continue to receive similar recharge volumes. Risks of climate change impacts on supply quantity and availability are likely to be small.

Climate change could pose greater risks to shallow aquifers in river systems. Changes to the flow pattern of the Deschutes River could impact water levels in the shallow valley aquifer tapped by the Palermo Wellfield. Of the existing wells at the Palermo Wellfield, only Well 8 is expected to be at risk from lower summer aquifer recharge. Overall, the risk of negative impacts from climate change on the local aquifers supplying the City's groundwater supplies is expected to be low. See Appendix J for the full climate impacts technical memorandum.

4.5 Water Quality

4.5.1 Wellhead Protection Program

The City's 2016 Wellhead Protection Plan (WHPP) is in place to prevent contamination of the City's groundwater supplies. The City's WHPP was developed in accordance with guidelines published by DOH. Wellhead protection areas were delineated for the Palermo, Airport, and Bush wellfields. The WHPP establishes management strategies and response plans for responding to groundwater emergencies. The WHPP is included in Appendix L.

The City's contaminant source inventory was updated in 2017 and is also included at the end of Appendix L. The updated contaminant source inventory identifies 86 contaminant sources of potential concern within the wellhead protection areas. As part of the update, a process was established for the City to continue to perform contaminant source inventory updates every two years.

4.5.2 Water Quality Plan

Appendix K is the 2019 update to the City's Water Quality Plan. The Water Quality Plan outlines the regulations, water quality program activities, program management, and emerging water quality issues.

4.5.3 Palermo Wellfield

The Palermo Wellfield Superfund Site has two primary contaminants of concern, trichloroethylene (TCE) and tetrachloroethylene (PCE). Several early action and long-term remedies have been taken at the site. Located in a light commercial and residential area, the site is surrounded by single-family dwellings, private businesses, and recreation facilities. Currently, the Environmental Protection Agency is evaluating whether there are additional remedies that should be employed at the site.

In 1993, the City of Tumwater detected TCE in three of the city's drinking water supply wells. The city initially removed the impacted wells from service. The Environmental Protection Agency constructed a treatment system that removes these contaminants from the water at the Palermo Wellfield. The source of the TCE was determined to be from industrial operations from former and current Washington Department of Transportation facilities. In addition, a dry cleaning facility contaminated groundwater with PCE. The EPA installed a subdrain system and conducted source remediation at the drycleaners. The EPA currently re-evaluating the remedy and will determine if additional actions should be taken at this site.