3.0 Water Capacity Requirements

3.1 General

Development of the water capacity requirements are a critical element of the master plan for consideration in the overall water supply planning as well as the spatial distribution of demands, and peaking factors, for accurate distribution system modeling.

A water utility must be able to supply water at rates that fluctuate over a wide range. Yearly, seasonally, monthly, daily, and hourly variations in water use occur, with higher use during a hot and dry year (i.e. "Design Year"). Water usage also follows a diurnal pattern with peaks in the morning and late afternoon. The rates most important to the hydraulic design and operation of a water treatment plant and distribution system are average day demand (AD), seasonal peak demand (SP), maximum day demand (MD), and maximum hour demand (MH).

- Average Day use is the total annual water use divided by the number of days in the year. The average day rate is used primarily as the basis for estimating maximum day and maximum hour demand for a design year. The average day rate is also used to estimate future revenues and operating costs.
- Seasonal Peak is the average daily use of water over the highest three consecutive months of demand during a given year, generally June through August or July through September. Raw water supply must be evaluated against the seasonal peak design demand to ensure that during a 90-day period of high seasonal demands, the supply capacity is sufficient to meet the water requirements.
- Maximum Day use is the maximum quantity of water used on any one day of the year. The maximum day rate is used to size water supply, treatment facilities, and to determine pumping station capacity needs. The water supply and treatment must be adequate to supply water at the maximum day rate during a design year (hot and dry) which could occur any given year. Pumping capacity must be able to transfer sufficient supply to meet maximum day needs for the system overall and for all individual service levels.
- Maximum hour use is the peak rate at which water is required during any one hour of the year. Since minimum distribution systems are usually experienced during maximum hour, the size and location of storage and pumping facilities are evaluated against this condition. Maximum hour demands are partially met through storage equalization which minimizes the required capacity of transmission mains and permits a more uniform and economical operation of the water supply, treatment and pumping facilities.

3.2 Historical Water Production and Usage

Historical water usage trends and supply characteristics were reviewed and updated to include data from Years 2013 through 2018. Several data sources were used during this update and include:

- Lincoln Distribution Monthly Reports, January 2013 through December 2018
- Production Reports, FY13/14-FY19/20 (FY19/20 does not provide a complete data set until the fiscal year is over at the end of August 2020)
- Total Metered Sales by Customer Class, January 2013 through December 2018
- Metered Sales by Account, All Billing Cycles for 2018

Monthly water treatment plant operating reports (Monthly Reports) were provided from October 2013 through February 2020. Each monthly report contained daily pumpage and usage characteristics for the given month of the report. The most important factors coming from these reports (noted by the same column name from the monthly report) are the following:

- Ashland Pumpage – Well field pumpage is the water delivered to the treatment plant by the wells and is measured by four raw water meters at the head of the treatment plant.
- Treatment and Transmission Usage – In previous master plans, this component which has been referred to as "Treatment and Transmission Usage", is actually a measure of how much water is used directly at the plant, either by process or in-house. This component is the difference between raw water entering the plant (Ashland Pumpage) and the water being pumped into the system in conjunction with storage contribution to meet demands (Lincoln Usage). This is not a discrete column in the pumpage reports and is instead a calculated value. This information is important so that the plant uses are included as a factor in water demand projections. Hereafter in this report, this will be referred to as "Plant Usage" and this term is recommended to use in future Master Plans.
- Lincoln Usage – This data provides the daily calculated usage within the distribution system including non-revenue water. The average of the daily usage over a year equates to AD and the maximum daily value during a given year represents the maximum day of that year. This usage includes the non-revenue water component.
- Lincoln Maximum – This data provides the maximum hour demand for each day. In review of these values, it was noted that the reports can overestimate the maximum hour demand by providing an instantaneous demand from a very discrete time-step (such as a 5-minute period) and the time-step in the calculation could be less than one hour. Corrections were made to some of the maximum hour demands based on discussions with City staff in regard to a few of the over-reported values. City staff provided an updated data set queried from the report to help replace some of the overestimated values in the previous data set and these corrected values were used to review the usage trends.

3.2.1 Ashland Pumpage

The daily Ashland Pumpage was used to develop the average monthly demand and to determine the seasonal peak 90-day pumpage. Figure 3-1 provides the monthly average demands for the last 10 years.

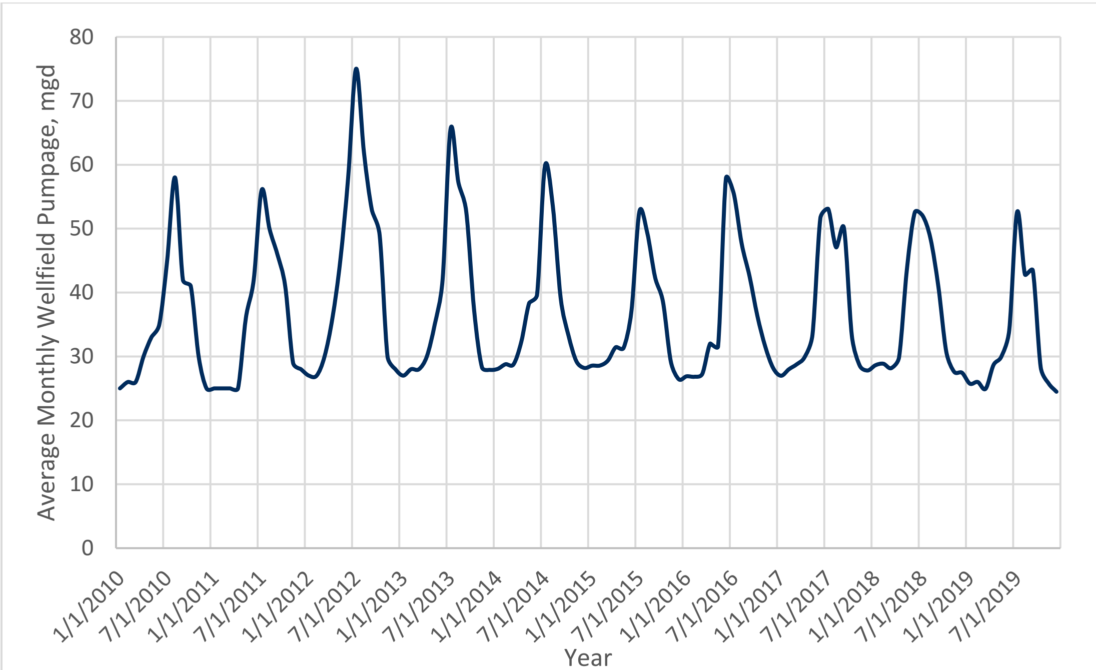

Figure 3-1 Ashland Well Field Pumpage, Monthly Average 2010 - 2019

The SP production is the average daily well field pumpage during the peak three months of water use for each fiscal year. In the recent past, 2012 is considered as a design condition, i.e. hot-and-dry year. The typical SP occurs in June through August or July through September time frame and is used to evaluate future well field production needs. A summary of the Ashland well field pumpage and SP is presented in Table 3-1. The highest seasonal peak/average day (SP:AD) ratio occurred in Year 2012 with a value of 1.56. This value will be used as a design value to obtain the Seasonal Peak 90-day demand based on the average day demand. As noted previously, Year 2019 data is not included in the tables in the following section because the data is incomplete since the fiscal year runs through August 2020.

Table 3-1 Ashland Well Field Pumpage and Seasonal Peak Production

Year	Ashland Well Field Pumpage,		Seasonal Peak Production			
	Total, MG	Average, mgd	Total, MG	Average Day (mgd)	SP Month Time Period	SP/AD
2000	15,041	41.1	5,004	54.4	J, A, S	1.32
2001	14,569	39.9	5,322	57.8	J, A, S	1.45
2002	15,122	41.4	5,884	64	J, J, A	1.55
2003	14,513	39.8	5,491	59.7	J, A, S	1.50
2004	13,885	38.0	4,604	50	J, A, S	1.32
2005	14,775	40.5	5,558	60.4	J, A, S	1.49
2006	14,851	40.7	5,240	57	J, J, A	1.40
2007	13,369	36.6	5,180	56.3	J, A, S	1.54
2008	12,906	35.3	4,371	47.5	J, A, S	1.35
2009	12,512	34.3	4,068	44.2	J, A, S	1.29
2010	12,062	33.0	4,448	48.3	J, A, S	1.46
2011	13,111	35.9	4,675	50.8	J, A, S	1.42
2012	15,747	42.3	6,058	65.8	J, J, A	1.56
2013	14,381	39.4	7,118	58.5	J, A, S	1.48
2014	13,880	38.0	6,205	51	J, J, A	1.34
2015	12,744	34.9	5,852	48.1	J, A, S	1.38
2016	13,491	37.0	6,534	53.7	J, J, A	1.45
2017	13,321	36.4	6,156	50.6	J, J, A	1.39
2018	13,759	37.7	6,205	51	J, J, A	1.35
Planning Criteria						**1.56**
Source: Ashland Well Field, Transmission and Distribution Reports						

3.2.2 Plant Usage

Plant Usage can be calculated by subtracting the Lincoln usage from the Ashland well field pumpage. Table 3-2 shows the Plant Usage for Year 2000 through Year 2018. As noted in the *2014 Master Plan*, additional Plant Usage occurred in Year 2011 through Year 2013 because of increased backwashing due to higher manganese concentrations, but usage has declined since that period. For design values moving forward, it is anticipated to experience Plant Usage similar to those experienced prior to Year 2011 and after Year 2013.

Table 3-2 Plant Usage

Year	Ashland Well Field Pumpage, MG	Total Annual Lincoln Usage, MG	Plant Usage, MG	Total Annual Plant Usage, %
2000	15,041	15,265	-224	-1.5%
2001	14,569	14,603	-34	-0.2%
2002	15,122	14,807	315	2.1%
2003	14,513	13,693	820	6.0%
2004	13,885	12,820	1,065	8.3%
2005	14,775	13,845	930	6.7%
2006	14,851	14,025	826	5.9%
2007	13,369	12,796	573	4.5%
2008[(1)]	13,006	11,984	1,022	8.5%
2009	12,512	11,941	571	4.8%
2010	12,062	11,338	724	6.4%
2011	13,111	11,686	1,425	12.2%
2012	15,474	14,032	1,442	10.3%
2013	14,381	12,912	1,469	11.4%
2014	13,880	12,646	1,234	9.8%
2015	12,744	11,595	1,149	9.9%
2016	13,491	12,723	768	6.0%
2017	13,321	12,498	823	6.6%
2018	13,759	12,678	1,081	8.5%
Historical Average (Excluding 2000/2001)				**7.5%**
Historical Average (Excluding 2000/2001 and 2011 – 2013)				**6.8%**

[(1)]Total Well Field Pumpage does not match with prior table as listed in the 2014 Master Plan. It is unclear why, but the higher value was used in the average of Total Annual Plant Usage and the Peaking Factors developed in the next section.

3.2.3 Distribution System Usage

The data from the monthly reports was used to update the historical usage characteristics for Years 2000 through 2018 and is provided in Table 3-3. The Lincoln usage - or, the total water transmitted to the distribution system - is used to assess high service pumping requirements, as well as finished water transmission and distribution system needs. This table also provides the basis to develop design values for projecting system peaking factors (PF) for maximum day and maximum hour demand.

A review of this table shows that the design value of 2.4 in the *2014 Master Plan* has only been experienced once in the last 19 years and is overly conservative. Therefore, the design peaking factor must be updated. The update uses the projections based on a probability of exceedance once every 12 years, to be consistent with the probability of exceedance used in the *2014 Master Plan*. This projection leads to a design peaking factor for MD:AD of 2.25.

The characteristics for maximum hour peaking, even with the addition of data from Years 2013 through 2018, has not changed since the *2014 Master Plan*. A recommended design value of 4.3 remains consistent, representing a probability of exceedance once every 12 years.

Table 3-3 Historic Water Usage and Peaking Factors (PF)

Year	Total Annual Pumpage, BG	Total Annual Lincoln Usage, BG	Average Day Demand, mgd	Maximum Day Demand, mgd	Maximum Hour Demand, mgd	MD:AD PF	MH:AD PF	MH:MD PF
2000	15.0	15.3	41.8	86.0	127.5	2.1	3.0	1.5
2001	14.6	14.6	40.0	85.5	102.1	2.1	2.6	1.2
2002	15.1	14.8	40.6	90.4	136.9	2.2	3.4	1.5
2003	14.5	13.7	37.5	78.0	125.7	2.1	3.4	1.6
2004	13.9	12.8	35.1	65.8	93.3	1.9	2.7	1.4
2005	14.8	13.8	37.9	87.6	114.1	2.3	3.0	1.3
2006	14.9	14.0	38.4	75.7	117.6	2.0	3.1	1.6
2007	13.4	12.8	35.1	84.9	122.6	2.4	3.5	1.4
2008	13.0	12.0	32.8	69.1	117.7	2.1	3.6	1.7
2009	12.5	11.9	32.7	60.1	136.7	1.8	4.2	2.3
2010	12.1	11.3	31.1	70.1	133.3	2.3	4.3	1.9
2011	13.1	11.7	32.0	69.3	127.5	2.2	4.0	1.8
2012(1)	15.5	14.0	38.4	80.0	150.3	2.1	3.9	1.9
2013	14.4	12.9	35.4	72.5	140.5	2.0	4.0	1.9
2014	13.9	12.6	34.6	68.8	128.0	2.0	3.7	1.9
2015	12.7	11.6	31.8	65.0	117.0	2.0	3.7	1.8
2016	13.5	12.7	34.9	70.6	133.0	2.0	3.8	1.9
2017	13.3	12.5	34.2	63.9	122.0	1.9	3.6	1.9
2018	13.8	12.7	34.7	66.5	132.0	1.9	3.8	2.0
Historical Average	13.9	13.0	35.7	74.2	125.1	2.1	3.5	1.7
92nd Percentile All Years (1 in 12-year exceedance probability)						**2.29**	**4.09**	**1.96**
92nd Percentile Last 12-Years (1 in 12-year exceedance probability)						**2.25**	**4.30**	**2.10**

(1) The maximum hour value has changed from what was reported in the 2014 Master Plan for this year. It was found to be over-estimated (instantaneous value rather than hourly maximum). City staff provided an updated maximum hour and verified the number listed in this report.

3.3 Historical Metered Sales

3.3.1 Historical System Metered Sales

Historical metered sales data was provided for Years 2013 through 2018 for this update. This data was used to assess the mix of residential and non-residential water use and to determine typical per-capita water use rates. In addition, this data was used to update the non-revenue water characteristics. Table 3-4 summarizes the historical metered sales, including the distribution between residential and non-residential usage, as well as the resulting non-revenue water and a 10-year running average. The data shows that the percentage of residential metered sales has consistently been around 65 percent of total sales and this ratio was selected as a design value in the demand projections.

Table 3-4 Historical Metered Sales

Year	Historical Metered Sales					Average Day Lincoln Usage, mgd	Non-Revenue Water, % of AD	Non-Revenue Water 10-Year Running Average %
	Residential, mgd	Residential, %	Non-Residential, mgd	Non-Residential, %	Total			
2000	23.7	65	12.9	35	36.6	41.2	11.2	7.5
2001	21.8	63	12.7	37	34.5	39.1	11.8	8.1
2002	23.9	65	12.8	35	36.7	39.7	7.6	7.9
2003	22.3	65	11.9	35	34.2	37.5	8.8	8.0
2004	22.2	65	11.9	35	34.1	35	2.6	7.7
2005	23.9	67	11.9	33	35.8	38.5	7.0	7.8
2006	24.1	66	12.2	34	36.3	36.5	0.5	7.1
2007	21.5	65	11.7	35	33.2	35.1	5.4	7.1
2008	19.6	64	10.8	36	30.4	32.7	7.0	7.1
2009	20.8	67	10.3	33	31.1	32.7	4.9	6.7
2010	18.9	66	9.7	34	28.6	31.1	8.0	6.4
2011	20.9	67	10.5	33	31.4	32	1.9	5.4
2012	22.8	66	11.7	34	34.5	38.4	10.2	5.6
2013	20.8	67	10.5	33	31.3	35.4	11.5	5.9
2014	19.3	65	10.2	35	29.5	34.6	14.7	7.1
2015	18.6	64	10.3	36	29.0	31.8	9.0	7.3
2016	20.0	65	10.9	35	30.8	34.9	11.6	8.4
2017	19.8	65	10.6	35	30.3	34.2	11.3	9.0
2018	19.8	65	10.6	35	30.4	34.7	12.4	9.5
Average 2000-2018	**21.3**	**65**	**11.3**	**35**	**32.6**	**35.5**	**8.3**	**7.3**

3.3.1.1 Non-Revenue Water

Non-revenue water (NRW) is calculated as the difference between the average Lincoln Usage and the average sum of all metered usage over a given period. This component includes water used for flushing, firefighting, water main breaks, leakage and apparent losses (meter inaccuracies). This component was often referred to as unaccounted-for water (UFW) until 2003. In 2003, AWWA abandoned the use of the term UFW, because all volumes of water supplied go towards either beneficial consumption or water loss. All water sent into the distribution system can be accounted for. Today, the term NRW is the term favored by IWA and AWWA [*Best Practice in Water Loss Control: Improved Concepts for 21st Century Water Management, AWWA's Water Loss Control Committee*].

Previous master plans have used a percentage indicator as part of the methodology to project the non-revenue component of water. Although percentage indicators still exist in the industry, especially in projections for the non-revenue water use component, AWWA has discouraged the use of percentage indicators and will soon discontinue support of volumetric percentage performance indicators (VPPI). Upcoming materials which will soon be released by AWWA and will discontinue the use of VPPI include Version 6.0 of the Free Water Audit Software (expected to be released in 2020) and the next edition (5th) of the AWWA *M36, Water Audits and Loss Control* (expected to be released in 2021).

This update followed the same process as the *2014 Master Plan* to develop the non-revenue water component of the projections, by using percentage indicators. In order to shift away from percentage indicators in future planning efforts and transition to the methodology which will be presented in the upcoming AWWA materials, the planning study would need to include the evaluation of additional data and metrics. Additionally, the process to develop demand projections will need to be redefined starting at the population projections process. A few of these changes are listed below.

- Historical data will be needed for the average of number of service connections (both active and inactive) for each fiscal year to be evaluated.
- Authorized consumption must be categorized into billed metered, billed unmetered, unbilled metered, or unbilled unmetered.
- Projections must be developed for the number of service connections per year over for the planning horizon. This methodology differs significantly from a population-based approach to demand projections. However, population projections can still be used in the process to project other components of usage and a combined approach could be taken (i.e. population based to determine consumer usage with a non-revenue component based on projected number of service connections).
- If it is desired to evaluate and apply differing non-revenue characteristics by Service Level rather than a global value, the average number of service connections by Service Level for the historical period will need to be recorded and projections for the number of service connections must also be developed by Service Level.

As seen in Table 3-4, non-revenue water has varied significantly, ranging from approximately 2 percent (excluding Year 2006) to 15 percent. In recent years, the non-revenue running average has increased to over 9 percent. For planning purposes, a non-revenue water percentage of 9 percent was used in the demand projections.

In order to benchmark the City's non-revenue water against research provided by AWWA, it was necessary to obtain a losses per connection value using the number of service connections for the metered sales data from 2018 and the non-revenue water for that same year. This is because AWWA no longer provides benchmarks based on the volumetric percentage indicators. Table 3-5 shows the AWWA typical reported values for the current performance indicators.

Table 3-5 AWWA Performance Indicator Typical Values

INDICATORS	AWWA TYPICAL VALUE [1]
Non-Revenue Water (NRW) (MG)	-
Validation Score	60-70
Apparent Losses (gals/conn/day)	11.01
Real Losses (gals/conn/day)	66.97
Infrastructure Leakage Index (ILI)	3.13

[1] Median values as published by the AWWA Water Audit Data Initiative (WADI) 2016 dataset and The State of Water Loss Control in Drinking Water Utilities: A White Paper from the AWWA.

With the City's non-revenue water of 4.3 mgd during year 2018 and using the number of services of 85,103 from the metered sales data, the City's total non-revenue component was 50.5 gallons per service connection per day for this year. This relates to the values for the apparent losses plus the real losses shown in Table 3-5. When this comparison is made, the City's total loss per service connection of 50.5 gallons per service connection per day during 2018 is less than the sum of the apparent losses and real losses from the AWWA median values of approximately 78 gallons per service connection per day. This indicates that the City is on the lower side of water loss as it is currently quantified by AWWA.

3.3.1.2 Per-Capita Usage

Table 3-6 presents the per-capita usage characteristics (which are also illustrated in Figure 3-2). The difference between the total metered sales and the average day Lincoln usage is the non-revenue component. There has been a noticeable downward trend in per-capita usage over the period of historic data, but the downward trend appears to be flattening. Over the next decade, it is anticipated that a limit will be reached.

Table 3-6 Historical Per-Capita Usage

Year	Population	Residential Sales		Total Metered Sales		Average Day Lincoln Usage	
		Total, mgd	Per-Capita, gpcd	Total, mgd	Per-Capita, gpcd	Total, mgd	Per-Capita, gpcd
2000	225,581	23.7	105	36.6	162	41.2	183
2001	228,861	21.8	95	34.5	151	39.1	171
2002	232,141	23.9	103	36.7	158	39.7	171
2003	235,421	22.3	95	34.2	145	37.5	159
2004	238,701	22.2	93	34.1	143	35.0	147
2005	241,981	23.9	99	35.8	148	38.5	159
2006	245,261	24.1	98	36.3	148	36.5	149
2007	248,541	21.5	87	33.2	134	35.1	141
2008	251,821	19.6	78	30.4	121	32.7	130
2009	255,101	20.8	82	31.1	122	32.7	128
2010	258,379	18.9	73	28.6	111	31.1	120
2011	261,480	20.9	80	31.4	120	32.0	122
2012	264,618	22.8	86	34.5	130	38.4	145
2013	267,948	20.8	78	31.3	117	35.4	132
2014	271,216	19.3	71	29.5	109	34.6	128
2015	274,524	18.6	68	29.0	105	31.8	116
2016	277,872	20.0	72	30.8	111	34.9	126
2017	281,261	19.8	70	30.3	108	34.2	122
2018	284,691	20.0	69	30.4	107	34.7	122
Average 2000-2018	**255,021**	**21.3**	**84**	**32.6**	**129**	**35.5**	**141**

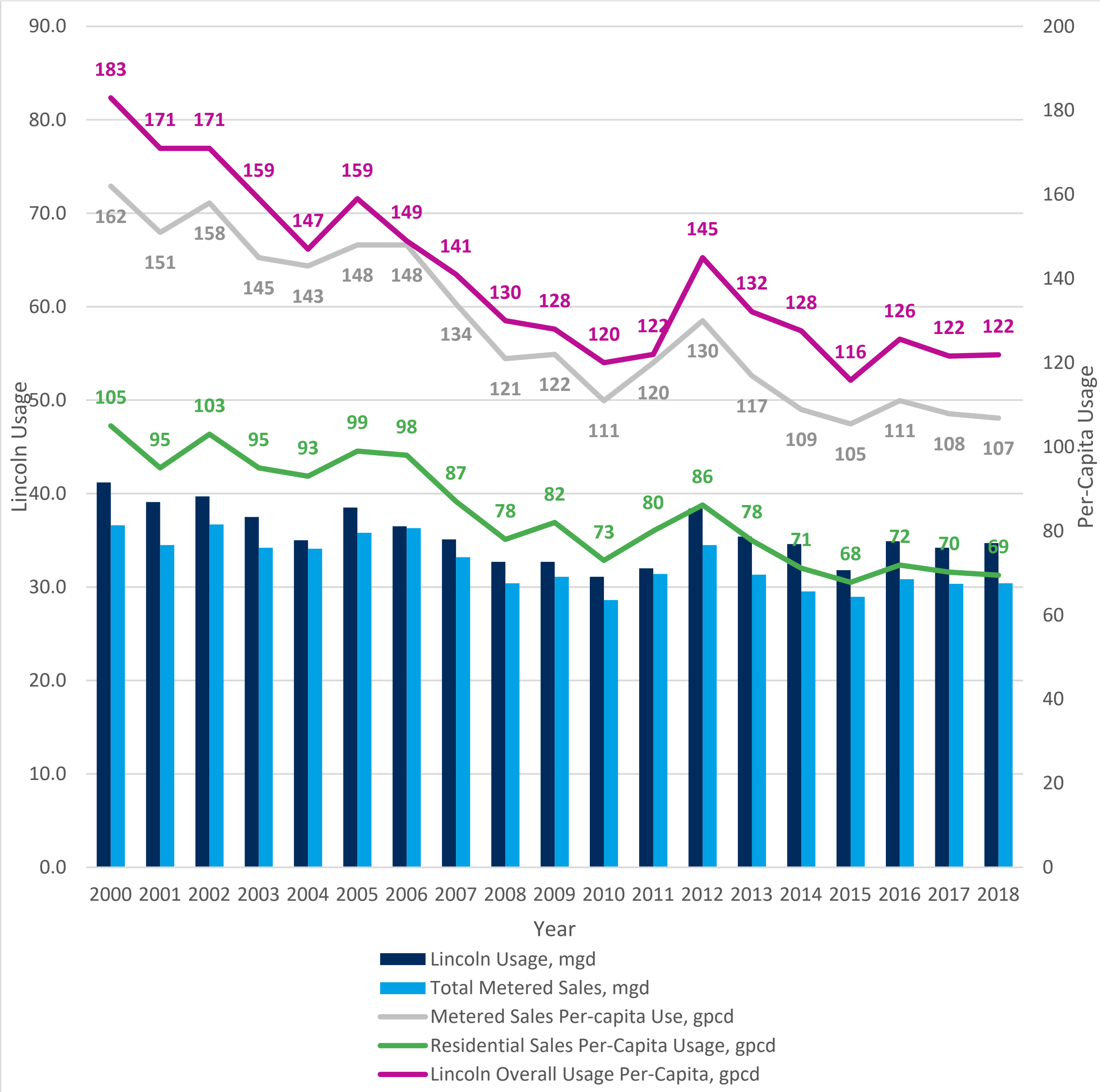

Figure 3-2 Historical Water Use and Per-Capita Usage

3.3.2 Historic Metered Sales by Service Level

The City provided Year 2018 metered data for all billing cycles for all accounts. Each meter was geocoded or matched to its location within the distribution system and assigned within the respective Service Level and TAZ geography. The data was pulled into a Power BI dashboard which allows for rapid filtering, slicing, and review of individual characteristics at the Service Level and even down to the TAZ geographies. In addition, the metered sales data was disaggregated for the entire year to develop the daily average metered usage curve by Service Level by Class. A total of 99 percent of the metered sales by usage were assigned a spatial location match by either geocoding, address matching, or linked to the service account for which there was a spatial location.

Figure 3-3 shows the metered sales breakdown by Service Level by Class for 2018 metered data. As noted, only 1-percent of the metered sales was not assigned to a metered location and this shows up with the "(Blank)" category. This figure presents a variety of information developed from the breakdown of metered sales by TAZ, by TAZ and Service Level, and the overall density of usage in terms of usage per acre for each TAZ which is described below:

- The map and graph on the left side of the dashboard shows the usage over the year within each Service Level with the map identifying the Service Levels.
- The data in the center of the dashboard presents the overall ratio of usage by type (Residential, Non-residential, and HUSER), the overall per-capita usage by Service Level and the percent of that use which is residential, and at the bottom shows the percentage of metered use by each Service Level.
- The map on the right shows the density of usage for each TAZ in gallons per acre per day.

A comparison of the per-capita usage characteristics obtained in the last two Master Plans against the 2018 metered data evaluation for per-capita usage characteristics is shown in Table 3-7. This table shows a declining per-capita usage in all Service Levels when compared against previous year per-capita usage data.

Table 3-7 Comparison of Per-capita usage derived from Metered Sales Breakdown

Service Level	Per-Capita Usage by Service Level		
	2006 Metered Sales	2012 Metered Sales	2018 Metered Sales
Northwest	170	130	106
Belmont	101	78	75
Low	67	60	57
High	92	90	65
Southeast	151	125	88
Cheney	211	175	113
Overall	64	86	70

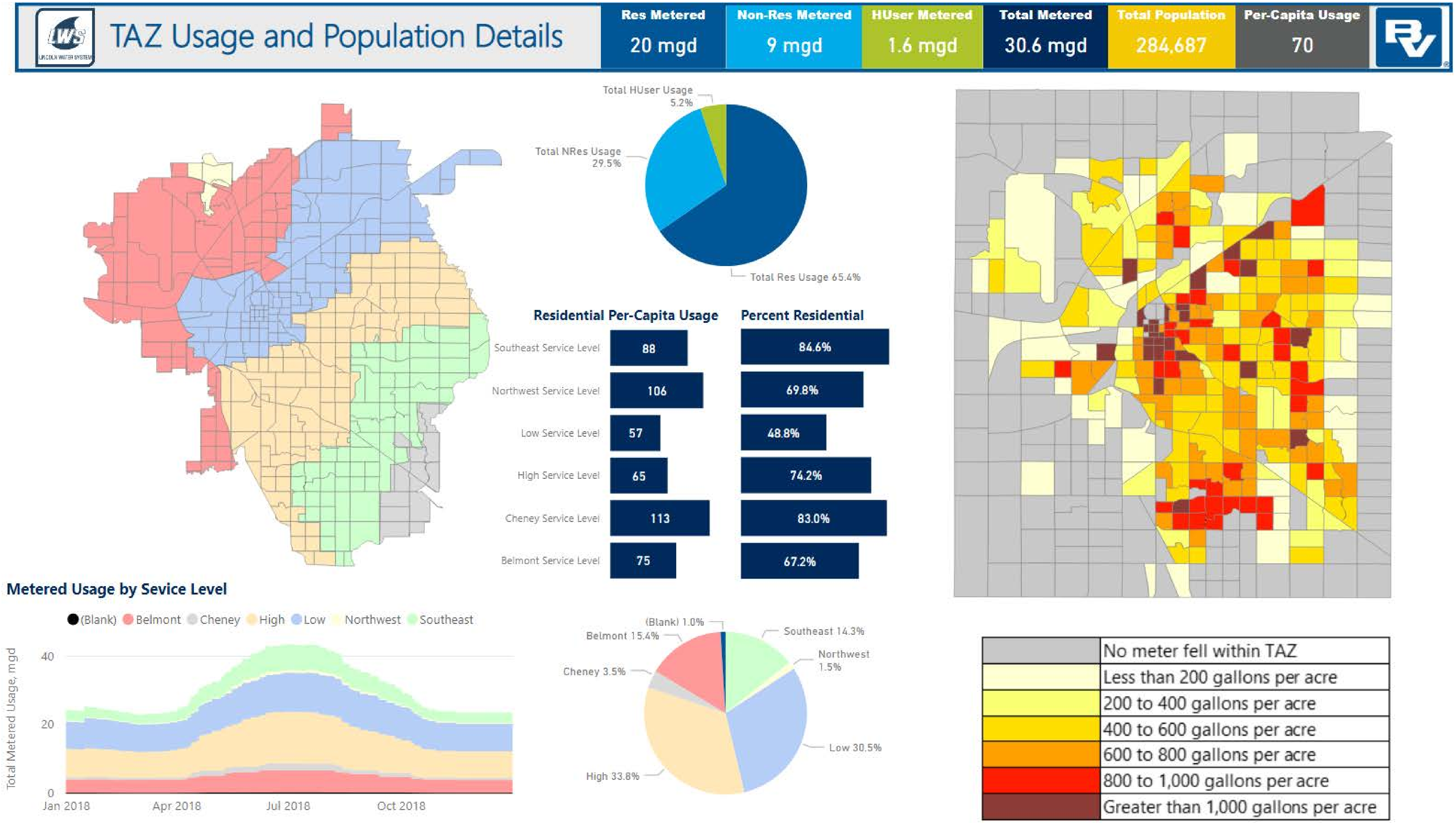

Figure 3-3 2018 Metered Usage Characteristics by Service Level

3.4 Water Demand Projections

Using the information presented in the previous sections, water demands were developed for the planning horizon for Years 2020, 2025, 2040, and 2060. Water demands for interim years (such as Year 2032, the 12-year modeling scenario) are interpolated between these planning years. The demand projections are based on the population forecasts, the residential per-capita usage, percentage residential usage, non-revenue water, and peaking factors.

There are two factors in the approach that are slightly different than the Previous Master Plan and include the evaluation of additional large use point loads north of I-80 that could represent future industrial or large user demands, and the adjustment of the seasonal 90-day peak well field pumpage based on climate data.

3.4.1 Large Use/Industrial Demands

Demands representing potential large use customers were added to the total average day, maximum day, and maximum hour projections. Table 3-8 provides the additional demands that are added to the projections based on the potential for large use customers to develop north of I-80.

Table 3-8 Potential Future Large Use Demands

Demand Condition	2020	2025 and Beyond
Average Day Demand	1.75 mgd or 25% of 7.0 mgd	7.0 mgd
Maximum Day Demand	2.7 mgd or 25% of 10.8	10.8 mgd
Maximum Hour Demand	2.7 mgd or 25% of 10.8	10.8 mgd
Seasonal Peak Demand	2.7 mgd or 25% of 10.8	10.8 mgd

3.4.2 Climate Change Impact

Evaluations for climate change were also performed during this Master Plan update. The full details of the climate change evaluation can be found in *Appendix A – Climate Change Assessment. T*he following is a high-level summary of the details found in this assessment:

- Temperatures are expected to increase for all seasons by 4 to 5 degrees (about 5 to 10 percent) for the mid-century time-frame (Years 2041 to 2070).
- Precipitation will increase in winter, spring, and fall by 15 to 20 percent for the mid-century time-frame.
- Precipitation will decrease for the summer by 15 to 20 percent for the mid-century time-frame.

In addition to the climate change assessment, historic peaking factors for the SP:AD were reviewed against the Palmer Modified Drought Severity Index (PMDSI) for the last 20 years of data to support increasing the seasonal peak design peaking factors based on climate change. The PMDSI is a relative scale that indicates how wet/mild or hot/dry conditions were during a specific time period by using temperature and precipitation. The lower the number (negatives) indicates a hotter-drier year and the high the number (increasing positives) indicates that the year was wetter and milder. Figure 3-4 shows a scatter plot of the SP:AD peaking factors vs. the PMDSI value of the last 18 years, for a month prior to and the 3 months of the seasonal peak 90-day demand during that year. Although more of a qualitative analysis, the general trend shows that seasonal peaking factor does increase with hotter-drier years as would be expected. With climate change, there is a higher probability that any given year will experience PMDSI values on the negative end of the scale, and could even be in the negative four to five range. Extrapolation of the trend line to these values lead to a SP:AD of almost 1.7, which is almost 10-percent higher than the design value of 1.56 shown in a previous section.

Based on the climate change model assessment, and the PMDSI vs. SP:AD evaluation, the SP:AD peaking factors were increased to account for climate change. Adjustments were made to the peaking factor to increase it by 8.5 percent through Year 2040, and then an additional 2.5 percent beyond Year 2040. The SP:AD peaking factors begin at 1.56 for the Base Year (2020), increase to 1.71 by Year 2040, and then increase again to 1.76 by Year 2060.

Maximum day and maximum hour peaking factors were not increased based on the climate data for this update. The reason is that it is uncertain how climate change will impact daily maximum usage. What is certain is that in any given year there will likely be more hot and dry periods leading to more hot and dry days during the 90-day seasonal peak demands.

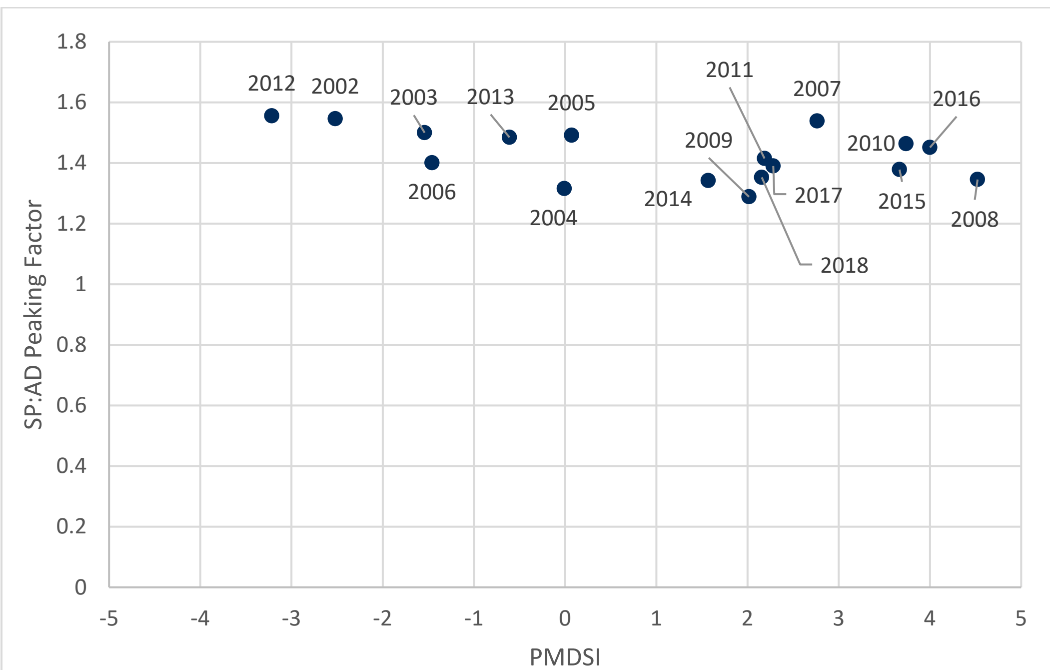

Figure 3-4 SP:AD Peaking Factors vs. PMDSI

3.4.3 Average Day Demand Projections

Design criteria for the average day demand projections is provided in Table 3-9 with a comparison to the previous Master Plans' design criteria. Design peaking factors are provided in Table 3-10.

Table 3-9 Average Day Demand Design Criteria

Description	2007 Master Plan	2014 Master Plan	2020 Master Plan Update
Per-capita Residential Metered Sales (gpcd)	96	90	85 trending down to 75 by 2032
Residential Sales as Percent of Total Metered Sales	65%	65%	65%
Per-capita Total Metered Sales (gpcd)	148	138	130 trending down to 120 by 2032
Non-Revenue Water (percent of Lincoln Usage)	6.25%	6.7%	9%
Total Lincoln Usage as Per-capita Usage (gpcd)	157	148	142 trending down to 125 by 2032
Plant Usage (%)	3%	6.9%	6.8%
Plant Usage (gpcd)	5	10	10
Well field Pumpage (gpcd)	162	158	152 trending down to 135 by 2032

Table 3-10 Maximum Day, Maximum Hour, and Seasonal Peak 90-day Peaking Factors

Description	2007 Master Plan	2014 Master Plan	2020 Master Plan Update
MD:AD Peaking factor	2.7	2.4	2.25
MH:AD Peaking Factor	4.4	4.3	4.3
SP:AD Peaking Factor	-	1.56 consistent through planning horizon	1.56 trending up to 1.76 by 2060
Maximum Day Demand (gpcd) (Lincoln Usage)	437	379	320
Maximum Hour Demand (gpcd) (Lincoln Usage)	693	636	615

Table 3-11 provides a summary of the updated demand projections based on the planning criteria, which are shown graphically in Figure 3-5.

Table 3-11 Future Demand Projections

Year	Estimated Population	Average Day Well Field Pumpage, mgd	Average Day Lincoln Usage, mgd	Maximum Day Well Field Pumpage, mgd	Maximum Day Lincoln Usage, mgd	Maximum Hour Lincoln Usage, mgd	Seasonal Peak 90-Day DemanD, mgd
2020 (Base year)	291,677	45.9	41.0	102.0	95.0	179.2	71.7
2025	309,902	47.1	40.1	108.3	101.0	183.1	79.7
2030	329,266	48.3	41.3	111.4	103.8	188.6	83.4
2032 (12-year CIP)	337,496	49.3	42.3	113.6	105.9	192.5	85.7
2040	371,700	53.4	46.4	123.5	115.1	210.1	95.7
2050	418,281	59.2	52.2	137.5	128.2	235.1	107.7
2060	470,700	65.7	58.7	153.3	142.9	263.2	121.5

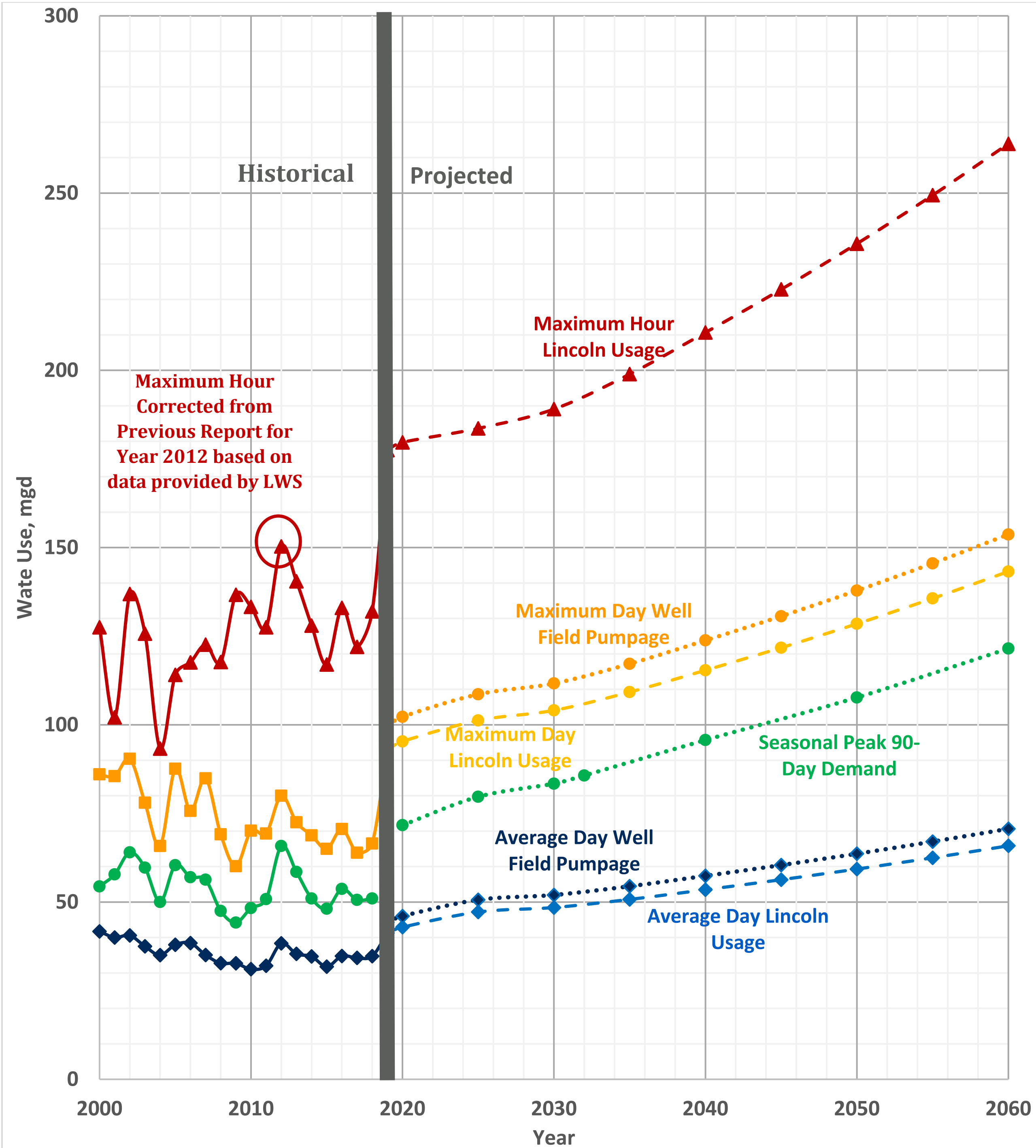

Figure 3-5 Future Demand Projections and Well Field Pumpage Requirements

3.5 Water Usage Projections by Service Level

Based on the total system projections and the data developed by Service Level detailed in a previous section, water demands were allocated to the Service Level basis. For each of the planning years, a balance between the overall design values, and the sum of the components of the Service Level demands was achieved by slight adjustments to individual service level characteristics based on the historical data. Table 3-12 presents the demand characteristics for average day by Service Level by class. Figure 3-6 shows the demands by Service Level graphically.

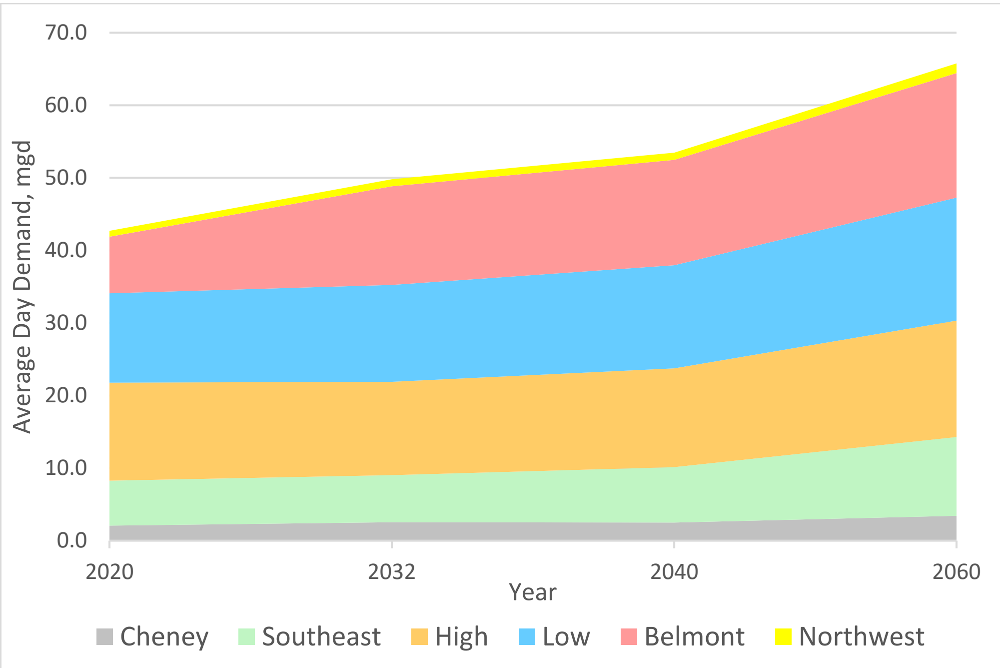

Figure 3-6 Average Day Demand by Service Level

Table 3-12 Average Day Projections by Service Level by Class

Service Level	Residential Per-capita Sales, gpcd	Residential Sales, mgd	Residential/ Total Sales, %	Non-Residential Sales, mgd	Total Sales, mgd	Non-revenue Water, %	Non-revenue Water, mgd	Average day usage, mgd
Base Year (2020)								
Northwest	130	0.5	65%	0.3	0.7	9%	0.07	0.8
Belmont	85	3.6	65%	1.9	5.5	9%	0.54	6.1
Low	70	5.6	50%	5.6	11.2	9%	1.11	12.3
High	80	8.9	72%	3.4	12.3	9%	1.22	13.5
Southeast	110	4.8	85%	0.8	5.6	9%	0.56	6.2
Cheney	125	1.5	80%	0.4	1.9	9%	0.19	2.1
Total	85	24.8	65%	12.5	37.3	9%	3.7	41.0
2032 (12-yr CIP)								
Northwest	110	0.6	65%	0.3	0.9	9%	0.09	1.0
Belmont	75	3.9	65%	2.1	6.0	9%	0.59	6.6
Low	70	6.1	50%	6.1	12.2	9%	1.20	13.4
High	70	8.4	72%	3.3	11.7	9%	1.16	12.9
Southeast	90	5.0	85%	0.9	5.9	9%	0.58	6.5
Cheney	100	1.9	80%	0.5	2.3	9%	0.23	2.6
Total	75	25.8	65%	13.1	39.0	9%	3.9	42.8
2040								
Northwest	100	0.6	65%	0.3	0.9	9%	0.09	1.0
Belmont	75	4.4	65%	2.4	6.8	9%	0.68	7.5
Low	70	6.5	50%	6.5	12.9	9%	1.28	14.2
High	70	8.9	72%	3.5	12.4	9%	1.22	13.6
Southeast	85	5.6	80%	1.4	7.0	9%	0.69	7.6
Cheney	85	1.8	80%	0.5	2.3	9%	0.22	2.5
Total	75	27.8	65%	14.5	42.3	9%	4.2	46.5
2060								
Northwest	100	0.8	65%	0.4	1.2	9%	0.12	1.3
Belmont	75	6.0	65%	3.2	9.2	9%	0.91	10.2
Low	70	7.7	50%	7.7	15.4	9%	1.53	17.0
High	70	10.5	72%	4.1	14.6	9%	1.44	16.0
Southeast	85	7.9	80%	2.0	9.9	9%	0.98	10.9
Cheney	85	2.5	80%	0.6	3.1	9%	0.31	3.4
Total	75	35.4	65%	18.1	53.5	9%	5.3	58.8

Updates were also made to individual Service Level peaking characteristics by class. Years 2014 through 2018 were used to benchmark the typical peaking factors seen by Service Level for MD:AD. Year 2018 SCADA data was used to develop the typical MH:AD peaking factors, specific to service level. Slight adjustments were made to the MD:AD and MH:AD peaking factors by Service Level through the planning horizon to ensure that the sum of the individual Service Levels matches the overall system demands. Table 3-13 provides the individual peaking characteristics by Service Level by Class. Design peaking factors are shown by a range because it was necessary to make slight adjustments in some years on the peaking factors to match the overall MD and MH demands for the system.

Table 3-13 Planning Peaking Factors by Class and Service Level

Service Level	2014-2018 Average MD:AD	Overall Design MD:AD	2018 MH:AD(1)	Overall Design MH:AD
Northwest	3.1	3.0 – 3.1	6.6	6.0 – 6.1
Belmont	1.8	1.8 – 2.1	3.1	2.8 – 3.0
Low	2.1	2.1 – 2.3	3.2	2.9 – 3.1
High	2.5	2.5 – 2.6	5.4	4.9 – 5.2
Southeast	2.7	2.7 – 2.8	7.0	6.5 – 6.6
Cheney	2.5	2.5 – 2.6	7.0	6.5 – 6.6
System Overall	**2**	**2.25**	**3.7**	**4.3**
(1)Obtained from SCADA data provided for 2018				

The maximum day and maximum hour demands by Service Level were calculated by applying the MD:AD and MH:AD peaking factors by Service Level to their respective average day demands. Table 3-14 presents the average day, maximum day, and maximum hour demands by Service Level.

Table 3-14 Projected Water Requirements by Service Level

Service Level	Average Day, mgd	Maximum Day, mgd	Maximum Hour, mgd
Base Year (2020)			
Northwest	0.8	2.5	5.0
Belmont	6.1	10.9	16.9
Low	12.3	25.9	35.7
High	13.5	33.8	66.2
Southeast	6.2	16.7	40.3
Cheney	2.1	5.2	13.5
Total	41.0	95.0	177.6
Year 2032 (12-yr CIP)			
Northwest	1.0	3.0	5.9
Belmont	6.6	13.9	19.8
Low	13.4	30.7	40.1
High	12.9	33.4	66.9
Southeast	6.5	18.1	42.7
Cheney	2.6	6.6	16.8
Total	42.8	105.8	192.2
2040			
Northwest	1.1	3.1	6.1
Belmont	7.5	16.1	22.6
Low	14.2	32.7	44.1
High	13.6	35.3	70.7
Southeast	7.6	21.4	50.4
Cheney	2.5	6.5	16.5
Total	46.6	115.1	210.3
2060			
Northwest	1.3	4.0	8.0
Belmont	10.2	22.1	29.5
Low	17.0	37.3	49.2
High	16.0	40.1	81.8
Southeast	10.9	30.4	71.6
Cheney	3.4	8.9	22.7
Total	58.8	142.8	262.7