FINAL
REPORT

CWLP Water Demand Analysis

City Water, Light, and Power
City of Springfield, IL

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Table of Contents

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List of Tables

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List of Figures

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Section 1

Introduction

The last water demand analysis performed by an outside firm for the City of Springfield City Water Light & Power (CWLP) service area was performed in 1991, although CWLP have develop numerous internal analyses. The US EPA and the US Army Corps of Engineers have requested that CWLP update the water demand analysis for the CWLP service area to assist in determining viable alternative water supplies. Furthermore, the analysis should include an estimation of water demand during a 100-year drought event.

This report presents the water demand analysis update as required and includes:

- Analysis of current and historical water use
- Future population projections for the service area
- Future water demand forecasts under baseline and drought conditions

CDM Smith has prepared a Microsoft Excel CWLP Water Demand Model for the development of the water demand forecasts. This Water Demand Model may be used by CWLP staff to develop other alternative demand forecast scenarios, and update as additional information regarding future conditions becomes available. The Excel CWLP Water Demand Model spreadsheet is submitted to CWLP staff in conjunction with this report, along with a User's Guide to the spreadsheet model.

A review of historic monthly water patterns show a distinct seasonality in water use in which the water use in summer months increases well above winter usage. The degree to which summer water use increases is exacerbated by dry and/or hot weather conditions. Similarly, cool and wet weather during the summer months dampens the increase in summer water usage. This seasonality and weather effect is observed in all sectors of water usage: residential, commercial, large users and wholesale customers.

Population growth projections for the City of Springfield are modest. Some outlying suburban areas (i.e., wholesale customers) are projected to have higher growth rates. To some extent, the recent recession and state government policies have dampened recent growth in the area, and thus may have influenced the lower population projections. Thus, an alternative forecast scenario with an additional 5 percent growth was evaluated to offset the effects of recent years on the long-range forecast.

A baseline forecast was developed assuming the past 10-year average weather conditions for all future years, in combination with Springfield-Sangamon County Regional Planning Commission (SSCRPC) projected population growth rates. Alternative forecast scenarios were developed to represent severe drought conditions, the effects of high growth, a combination of both high growth and drought conditions, as well as peak month water demand relative to the average demand of each scenario based upon historic fluctuations.

The projected baseline forecast represents the anticipated annual average water demand over time given normal weather conditions. One would expect actual water demand to fluctuate above and below this average in any given year as actual weather conditions deviate from average (normal) conditions. It is prudent in water supply planning to base designs on the high range that is estimated above the average in order to avoid years of under-supply. Realistically there may be unanticipated future events such as greater population growth, the addition of large customers, or more extreme weather events that could push water demand above and beyond the expected high range of this forecast. The likelihood of such events occurring in the future represents the level of risk that CWLP staff should be prepared to accept in terms of future water supply planning.

Section 2

Current and Historical CWLP Water Use

Historical data from 2004 through 2013 (ten years) was obtained from CWLP and evaluated. This section summarizes the historical water use patterns of the CWLP service area.

2.1 Total Water Use

Monthly volumes of water treated, delivered and metered from 2004 through 2013 were evaluated. The annual average volumes are listed in Table 1. The overall average for the 10-year period is about 22.3 mgd treated, 21.8 mgd delivered and 16.3 mgd metered. The difference between treated and delivered is less than 0.5 mgd, or about 2 percent of treated water. The difference between treated and metered water is about 5.9 mgd or 26 percent of treated, however this includes authorized unmetered uses as discussed in more detail in section 2.6.

Table 1. Annual Average Total Water Usage in MGD

Year	Treated	Delivered	Metered
2004	21.18	20.80	15.92
2005	22.93	22.42	16.98
2006	22.43	21.92	16.59
2007	23.63	22.83	17.05
2008	20.98	20.52	15.13
2009	21.52	21.09	15.52
2010	22.83	22.41	16.60
2011	23.25	22.85	17.07
2012	23.26	22.79	16.88
2013	20.91	20.56	15.76
Average	**22.26**	**21.79**	**16.33**
Maximum	+6.2%	+4.9%	+4.5%
Minimum	-6.1%	-5.8%	-7.3%

Over the last 10 years, the fluctuation in annual water demand has ranged from 23.6 to 20.9 mgd. This represents slightly more than plus or minus 6 percent of the average annual.

Note that in May 2012, Chatham ceased buying wholesale water from CWLP. Thus the 10-year average of 22.3 mgd shown in Table 1 would be 21.5 mgd (about 0.8 mgd less) if the historical water purchases by Chatham are excluded.

The monthly volumes of treated and metered water are shown in Figure 1. A very distinct seasonal pattern is evident in the monthly treated volumes with fairly consistent winter water use at, or below, 20 mgd with distinct summer seasonal spikes in water use. A drop in winter usage is apparent in the winter of 2012-13 after the City of Chatham ceased purchasing wholesale water from CWLP as of May 2012. The monthly metered volumes shown in Figure 1 are based upon billing dates and therefore show a slight lag in time from the treated volumes.

The 10-year average monthly volumes are shown in Table 2 and illustrated in Figure 2. Treated volumes in winter months average about 20 mgd and increase to almost 28 mgd in July and August. A similar pattern is observed in the average monthly metered usage except that the higher use appears in August and September due to the lag in meter billing dates relative to treatment volumes.

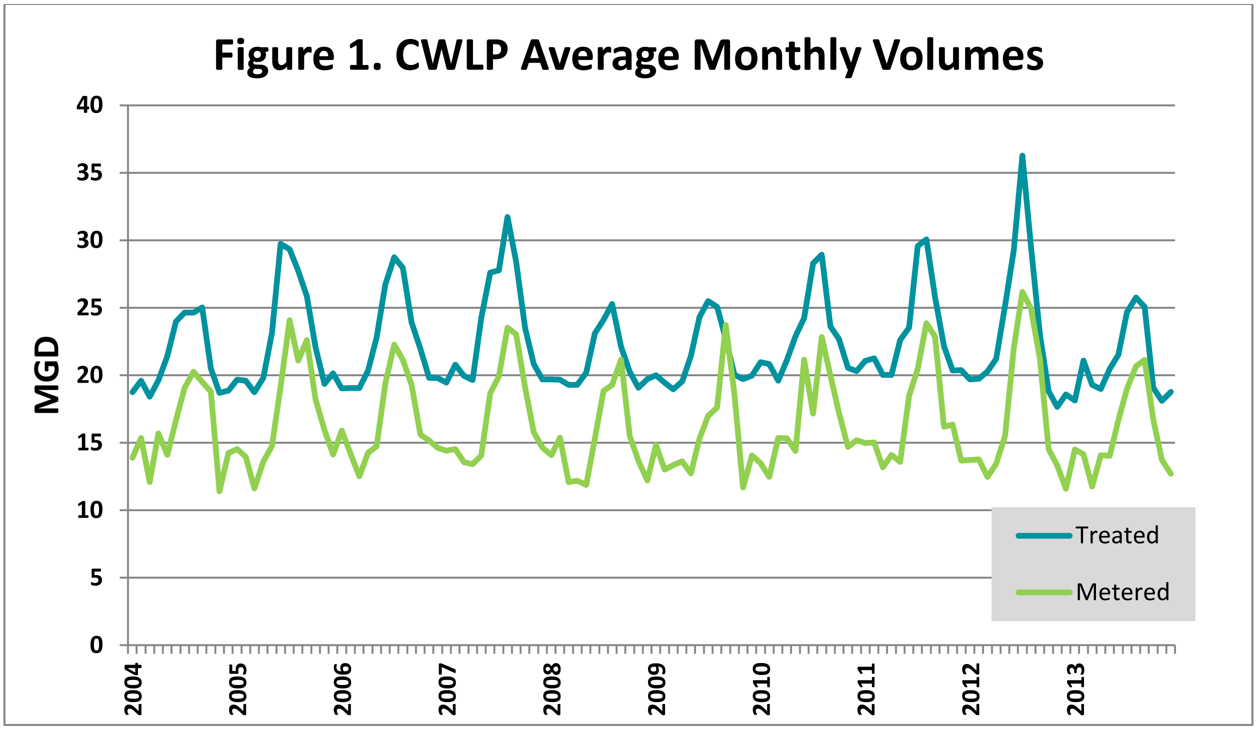
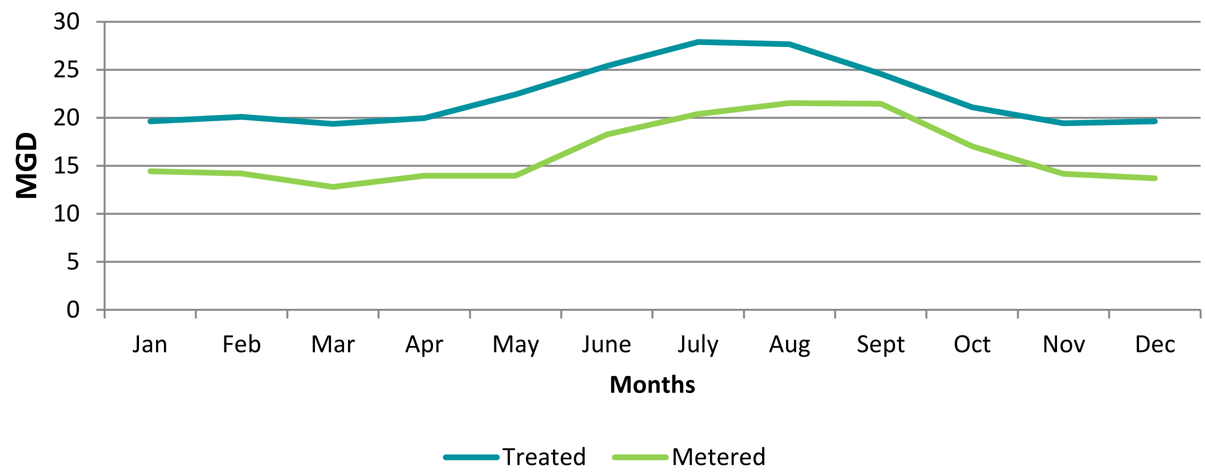


Table 2. Average Monthly MGD 2004-2013

Month	Treated	Delivered	Metered
Jan	19.64	19.18	14.43
Feb	20.11	19.65	14.18
Mar	19.36	19.02	12.80
Apr	19.96	19.58	13.97
May	22.44	21.84	13.98
June	25.40	24.92	18.28
July	27.89	27.39	20.39
Aug	27.67	27.21	21.52
Sept	24.55	24.10	21.45
Oct	21.10	20.38	17.05
Nov	19.42	18.94	14.17
Dec	19.62	19.27	13.71

Figure 2. Average Monthly Usage 2004-2013

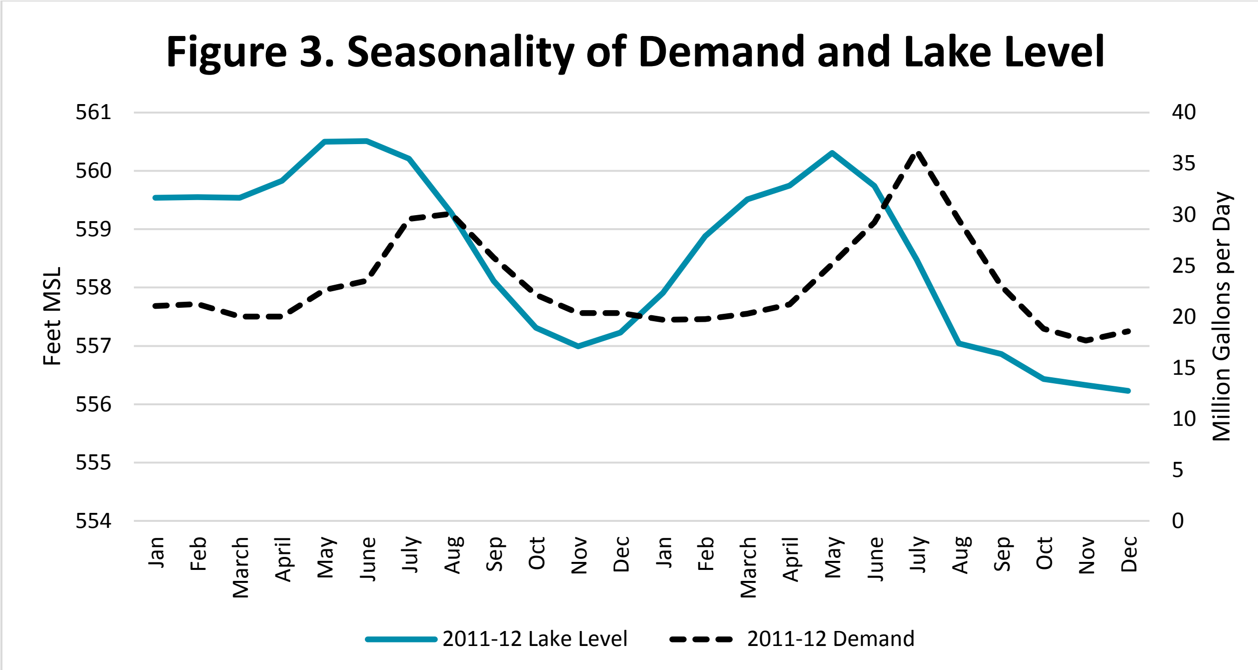


During the period from January 2004 to December 2013, the monthly peak demand averaged about 1.3 times the annual average demand. During this same period, the highest recorded monthly water demand occurred in July 2012 at 36.28 mgd. Note that this peak usage occurred after Chatham discontinued purchasing water from CWLP. This peak month usage was 1.56 times the 2012 annual average, and 1.69 times the 10-year average of 21.46 mgd as calculated without the historical Chatham purchases.

The analysis of peak demand is critical for water supply planning. Figure 3 illustrates the monthly water demand and monthly level of Lake Springfield for the years 2011 and 2012. This time period includes the peak monthly demand in July 2012. The usual summer peak in water demand occurs after the lake level reaches its peak in late spring. “Full pool” is about 560 feet msl (mean sea level). In late winter and spring, precipitation and snow melt fill the lake before the higher temperatures and reduced precipitation of summer increase water demand. Lake levels usually drop 2 to 3 feet due to the increase in summer demand, and typically remain low throughout the end of the year.

The historic drought of record (1953 to 1954, discussed in section 3.1.1) was a period when the winter and spring precipitation did not refill the lake and the lake level dropped about 12 feet (to 548 feet msl). It should be noted that CWLP available water supply from Lake Springfield is estimated to be 26.4 mgd under the 100-year drought conditions of 1953 to 1954.

This timing of peak demand with available supply is critical and can easily be overlooked when comparing annual average water demand with annual average supply availability.



2.2 Water Use by Meter Size

CWLP provided monthly billing data summaries by meter size for 2004 through 2013. Table 3 is a summary of the average annual number of customers and water use in gallons per day (gpd) by meter size. The small meters (5/8" and ¾") account for 89 percent of customers and 43 percent of metered water volume. Medium size meters (1" to 4") account for 11 percent of customers and 34 percent of metered use. The large meters (6" to 12") are few in number but account for 22 percent of metered water use. As discussed below in Sections 2.4 and 2.5, these large meters include wholesale customers and the CWLP power plant.

Table 3. Annual Average Number of Customers and Water Use (2004 - 2013)

Meter size	# Customers	GPD	gpd/cust
5/8"	36,663	5,914,580	161
3/4"	8,692	1,726,269	199
1"	3,070	1,078,320	358
1 1/2"	914	1,041,246	1,139
2"	724	1,424,461	1,975
3"	215	999,717	4,654
4"	86	1,051,794	12,226
6"	26	722,960	28,224
8"	4.0	1,487,386	374,021
10"	1.9	80,478	42,529
12"	1.1	767,341	709,209
	50,397	16,294,552	323

For purposes of this analysis the monthly billing data by meter size was "smoothed" or adjusted from the date of billing to the month of consumption. To do this, the volume of water billing in a given month was assumed to represent water consumption during both the preceding and current months. Thus, half of the billed volume was re-assigned to the prior month. This smoothing process facilitated the alignment of billed water volumes with monthly weather data as discussed in Section 3 below.

In addition, the billing data by meter size were aggregated into three groups: small (5/8" and ¾"), medium (1" to 4") and large (6" to 12"). The small meter sizes are predominately residential customers, thus this group is assigned the designation "RES" in the analysis and forecast model. Similarly, the 1" to 4" meters are predominately commercial, institutional and industrial customers and therefore designated as "CII".

Wholesale water use was separated from the analysis of billing data for the large users. Thus, the large user category includes the CWLP power plant, large hotels and commercial customers, parks district and golf courses, universities, and the state fair grounds.

The smoothed monthly billed water use of the RES, CII and Large customer groups is shown in Figure 4 in gallons per day. The average annual water use from 2004 through 2013 in gallons per day by customer group is listed in Table 4. The RES water use shows a gradual decline over this time period from over 8 mgd to less than 7 mgd, while the CII water use is relatively constant at about 5.6 mgd. Water use for the large customer group increased from 2.5 to 3.8 mgd when two 12" meters began to supply the CWLP power plant in 2009.

Table 5 shows the 2004 to 2013 monthly average volume by customer group. Each of the three customer groups show the seasonal pattern in which monthly average water use increases during the summer months relative to the winter months. For the RES customer group, the average monthly use peaks in July with an average volume about 1.4 times the winter average. For the CII and the large customers, the monthly average use peaks in August at about 1.6 and 1.7 times their respective winter averages.

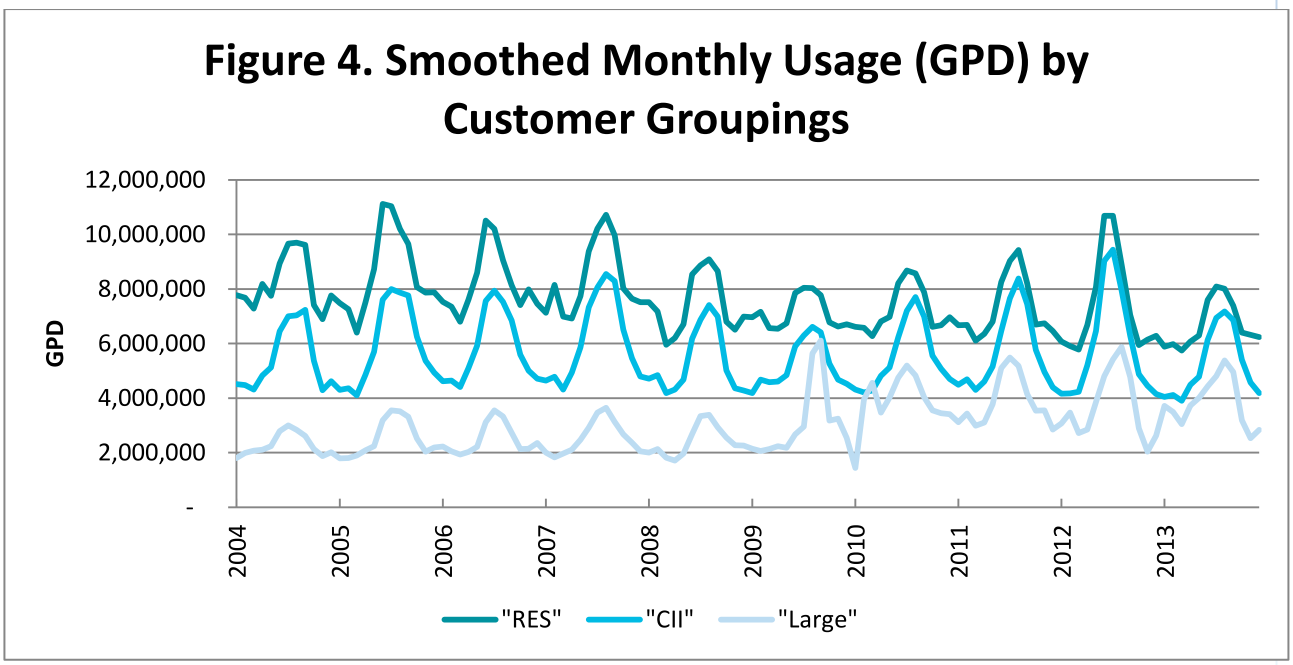
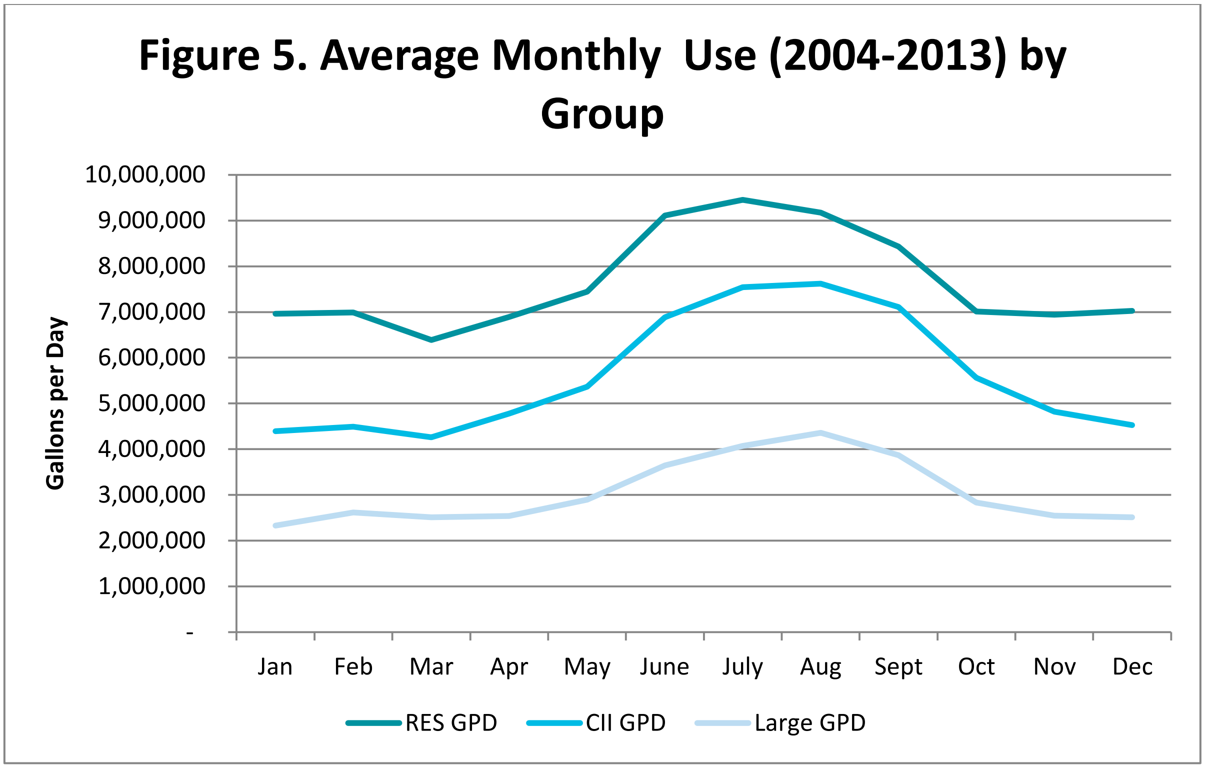


Table 4. Annual Average Use by Group

Year	RES GPD	CII GPD	Large GPD
2004	8,220,948	5,437,624	2,287,498
2005	8,598,516	5,924,617	2,509,699
2006	8,220,424	5,822,299	2,483,554
2007	8,364,809	6,124,592	2,549,974
2008	7,414,035	5,319,655	2,421,216
2009	7,150,349	5,214,997	3,089,631
2010	7,236,538	5,515,777	3,884,081
2011	7,286,279	5,690,257	3,856,164
2012	7,349,913	5,866,449	3,697,309
2013	6,669,448	5,216,767	3,841,631
Overall	**7,651,126**	**5,613,303**	**3,062,076**

Table 5. Average Monthly Use by Group

Month	RES GPD	CII GPD	Large GPD
Jan	6,962,058	4,397,034	2,330,359
Feb	6,991,627	4,494,754	2,619,810
Mar	6,388,520	4,260,794	2,512,098
Apr	6,889,464	4,776,014	2,540,882
May	7,441,325	5,364,030	2,896,402
June	9,108,896	6,886,103	3,645,752
July	9,451,783	7,539,934	4,073,785
Aug	9,169,664	7,620,059	4,359,922
Sept	8,431,633	7,110,881	3,871,530
Oct	7,013,306	5,559,620	2,833,750
Nov	6,940,205	4,821,961	2,549,928
Dec	7,025,031	4,528,459	2,510,691
Annual Average	**7,651,126**	**5,613,303**	**3,062,076**

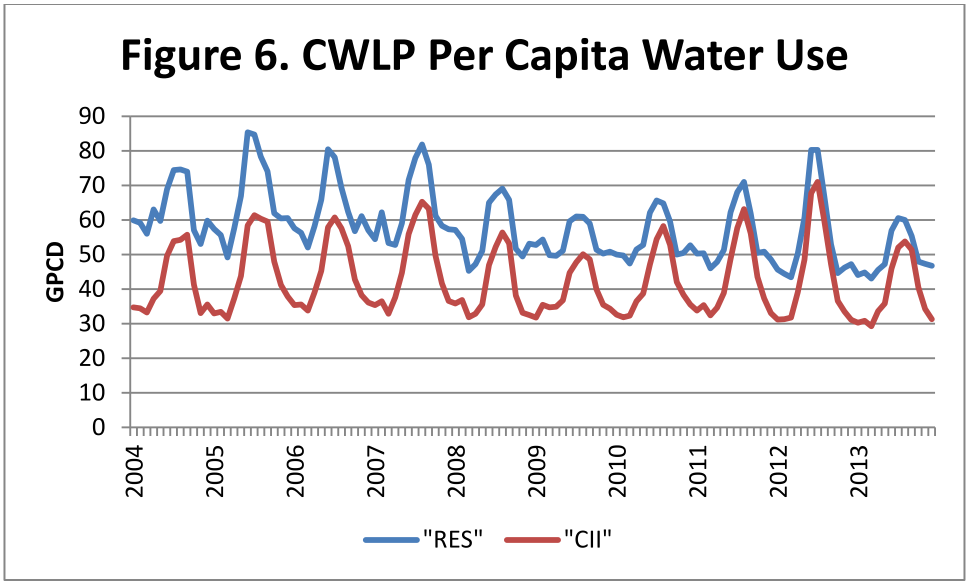


2.3 Water Use per Capita

Water use per person or "per capita" has been demonstrated to be a useful metric of water use over time within a given utility, although it may not be a helpful metric for comparing water use among different utilities (Water Conservation Measurement Metrics: Guidance Report, Dziegielewski and Kiefer, AWWA 2009). The CWLP small meter (RES) and medium meter (CII) historical water use from 2004 to 2013 was divided by the corresponding population of the service area for those years. The resulting per capita values (gallons per capita per day, or gpcd) are shown in Figure 6.

Per capita water use shows the same seasonal variation (low in winter and high in summer) as the total water use of each sector as previously shown in Figure 4. The overall average for RES water use per capita is about 58 gpcd, however there has been a decline in the winter per capita water use during this 10-year period. From 2004 to 2007 the winter RES per capita was about 53 gpcd, from 2008 to 2011 the winter average was about 48 gpcd, and for 2012 and 2013 the winter average was about 43 gpcd. Factors contributing to this declining trend are discussed in section 3.2 below.

The overall average CII per capita water use is about 43 gpcd. The winter average has been about 31 gpcd.



2.4 Large Water Users

Large water users are defined as water users with 6" to 12" meters. However, wholesale customers are served with meters in this size range. The major large water users that are not wholesale customers are listed in Table 6 with their corresponding historical (2004-2013) average water use in gallons per day. Note that the CWLP use at the top of the list includes the two 12" meters that supply Dallman power plant beginning in 2009, in addition to two existing 8" meters. Therefore the annual average shown for CWLP is only reflective of 2010 to 2013.

Note that the water volume assigned to the Water Park is an anticipated estimate volume of water that CWLP will provide to the water park when the water park transitions from their own wells to CWLP service in the near future.

Table 6. Large User Average Water Use

Customer	Annual GPD
CWLP	3,028,082
State of IL	158,957
St. Johns Hosp	689,434
Memorial Hosp	216,915
Park District	43,484
UIS	17,258
SIU	18,291
Hilton	86,225
Panther Creek CC	22,041
F W Means	71,058
Sangamon Co.	42,713
Abe Lincoln Hotel	61,739
Illini CC	18,298
Crowne Plaza	37,935
Horace Mann	32,470
Water Park*	10,247
TOTAL	**4,555,145**

*new customer

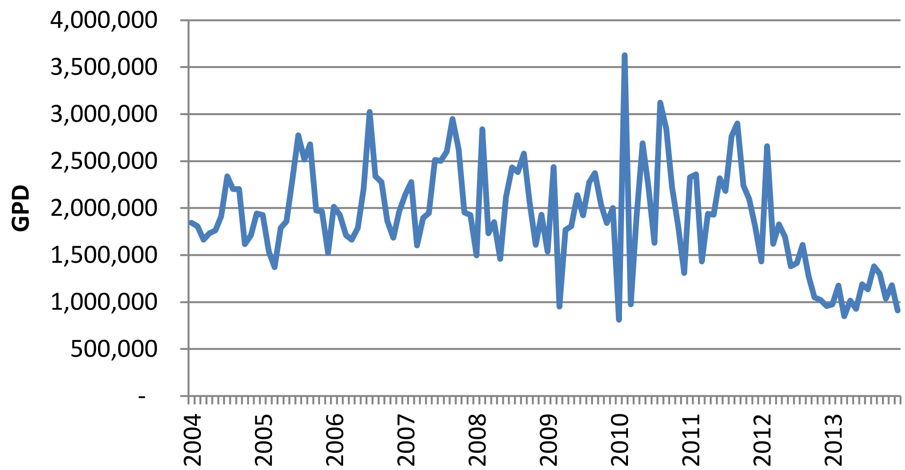
2.5 Wholesale Water Use

CWLP provides water to a number of wholesale customers. These customers are listed in Table 7, along with their historical average annual water use. The largest wholesale customer, Chatham, discontinued purchasing water from CWLP in May 2012. This drop in wholesale water use can be seen in the monthly historical water use shown in Figure 7.

Table 7. Wholesale Customer Average Water Use

Customer	Years	Average Annual GPD
SHERMAN-WILLIAMSVILLE	2004-2013	452,494
LOAMI	2004-2013	50,557
JEROME	2004-2013	89,504
GRANDVIEW	2004-2013	105,236
SUGAR CREEK	2004-2013	107,484
ROCHESTER	2004-2013	296,667
CURRAN GARDNER	2012-2013	8,014
ROUND PRAIRIE	2013	13,439
CHATHAM	2004-2011	944,287
TOTAL		2,067,683
Total without Chatham		**1,123,396**

Figure 7. Wholesale Water Usage



2.6 Non-Revenue Water and Unaccounted-for Water

Traditionally, the term “unaccounted-for water” (UAW) has been used to describe the difference between water produced into the system (input) and water delivered (output) to the users. However, this term has a variety of definitions and meanings. The International Water Association (IWA) proposed the term “Non-Revenue Water” (NRW) with a clear definition of NRW as the difference between total water produced and billed consumption, as shown in the lower right-hand portion of Figure 8. (See Alegre H. et al. 2000, *Manual of Best Practice: Performance Indicators for Water Supply Services*. IWA Publishing, London.) The NRW definition and water audit format was developed by the IWA in 2000 and later adopted by the American Water Works Association (AWWA).

<table>
<tr><th colspan="7">Figure 8. International Standard Water Audit Format</th></tr>
<tr><td rowspan="7">Own water</td><td rowspan="10">System input</td><td>Exported water</td><td rowspan="5">Authorized consumption</td><td rowspan="3">Billed consumption</td><td rowspan="3">Revenue water</td><td>Billed water exported</td></tr>
<tr><td rowspan="9">Water supplied to customers</td><td>Billed metered consumption</td></tr>
<tr><td>Billed unmetered consumption</td></tr>
<tr><td rowspan="2">Unbilled consumption</td><td rowspan="7">Non-revenue water (NRW)</td><td>Unbilled metered consumption</td></tr>
<tr><td>Unbilled unmetered consumption</td></tr>
<tr><td rowspan="5">Water losses (UAW)</td><td rowspan="2">Apparent losses</td><td>Unauthorized consumption</td></tr>
<tr><td>Meter inaccuracies and data errors</td></tr>
<tr><td rowspan="3">Imported water</td><td rowspan="3">Real losses</td><td>Leakage on mains</td></tr>
<tr><td>Leakage and overflow at storage</td></tr>
<tr><td>Leakage on service connections</td></tr>
</table>

Each column in Figure 8 represents the same total volume of water (100 percent) in the system; the differences among the columns involve various ways to categorize the total volume for analysis. The right column includes detailed classifications of water volumes. The water volumes are not illustrated to scale. Ideally, revenue water should represent the majority of water in the system while non-revenue water is minimized.

Components of non-revenue water include unbilled consumption and water losses. Water loss is comprised of *apparent loss* and *real loss*. As defined by IWA, apparent loss consists of unauthorized consumption (including theft), meter inaccuracies and data errors. Apparent losses can be reduced through better management practices, enforcement, and a program of meter testing and replacement. The reduction of apparent loss leads to increased revenues as this water becomes properly metered and billed.

Real loss consists of leakage on mains, leakage and overflows at storage, and leakage at service connections. Real losses from leaks can be further categorized between reported, unreported, and background leaks. Reported leaks are visible leaks and broken mains that can be quickly repaired thus resulting in short duration loss. Unreported leaks are generally not visible at the surface and only detected through line surveys. These leaks are generally sustained loss and therefore larger volume losses before they are repaired. Background leaks are small leaks at joints and fittings and typically not cost-effective to repair. The reduction of real loss does not directly increase revenue (except that more water is available within the system, and operating costs may be reduced), however there are real savings in water.

Water use for firefighting, line flushing and other authorized, but unbilled uses is classified as neither real nor apparent loss, but is included in the computation of NRW as unbilled (and authorized) consumption.

NRW is usually estimated as a percent of total production (NRW%) and is calculated as the difference between revenue-generating billed consumption (water sold) and total production, divided by total production. Similarly, if the volume of authorized and unbilled water use is estimated, then the UAW% can be calculated as the difference between authorized consumption (water sold + authorized unbilled) and total production, divided by total production.

CWLP maintains monthly records of water sold and estimates of authorized use. The authorized uses include fire-fighting, street cleaning, and CWLP use for line flushing. From 2004 to 2013 the authorized uses average about 2.2 percent of billed metered (sold) water usage. The UAW (which accounts for both water sold and authorized use) averages about 14.3 percent of total water production. The NRW (which includes authorized use as the non-revenue water) averages about 16.2 percent of total water production. The differences between total water production (treated) and water sold (metered) from 2004-2013 can be seen in Figure 1 on page 4. Because CWLP maintains separate estimates of the authorized water use, the UAW estimate is the more accurate estimate of water losses in the CWLP distribution system. Some of the unaccounted for water is attributed to the high service flow meters that were over-registering water flows and have all been replaced.

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Section 3

Analysis of Trends

A number of factors affect water use patterns among the different groups of CWLP water customers. Foremost among these is monthly weather patterns. Much of the seasonality in water use patterns presented in the previous section is related to seasonal weather patterns.

Water use can also be affected by changes in demographics, economic conditions, and the water rates that customers pay.

3.1 Additional Data

This section discusses additional historical data that were collected and incorporated into the analysis of water use patterns presented in the next section.

3.1.1 Weather Data

Water use typically increases as temperatures increase during the summer months as more water is used for irrigation and cooling purposes. Conversely, water use decreases with higher precipitation during these months. Also, consecutive months of below average precipitation can result in higher water use for irrigation during the summer months.

Historical monthly weather information was obtained by CWLP from the National Weather Service for the years 1901 to2013 as recorded at the Springfield airport. The data included:

- Monthly average of daily maximum temperatures (F)
- Number of cooling degree days (cumulative degrees above 65F for the month)
- Number of days with precipitation greater than 0.01"
- Monthly total precipitation (inches)

The monthly averages (average of monthly average maximum temperature and average monthly total precipitation) from 2004 to 2013 are listed in Table 8 and illustrated in Figures 9 and 10. These 10-year average values for each month are used in the forecasting model to represent the "normal" weather conditions in future years under the Baseline forecast scenario.

The Illinois State Water Survey (ISWS) defines the 100-year drought for the Springfield area as the period of April 1953 to March 1954. The monthly values for maximum temperature and precipitation for this time period are also listed in Table 8 and the following figures. The monthly values from April 1953 to March 1954 are used in the forecasting model (discussed in Section 5) to represent weather conditions in future years under the 100-year drought condition scenario. As noted in Section 2.1, the 100-year drought conditions have a significant impact on water supply in addition to increasing the summer demand for water.

For comparison, monthly values for the year 2012 are also shown in Table 8. July 2012 was the hottest month on record, precipitation in June and July was far below average, and 2012 was the hottest year on record. However, annual precipitation for 2012 was not as severe as the 100-year drought period due to the higher precipitation amounts earlier in the year. Thus, while April 1953 to March 1954 was the driest 12-month period, the summer of 2012 was the driest summer. As a result, the climatic conditions of April 1953 to March 1954 had significant impacts on available water supply, while conditions during the summer of 2012 had a significant impacts on water demand.

Table 8. Monthly Weather Values

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
2004-2013 Average													
Maximum Temp[1]	36.4	39.4	54.5	66.5	75.7	83.8	86.8	85.9	80.0	66.5	54.1	39.1	64.05
Total Precip[2]	2.23	2.10	2.72	3.95	4.68	4.56	3.49	2.12	3.23	3.77	2.70	2.71	38.26
100-yr Drought (Apr 1953 to Mar 1954)													
Maximum Temp	38.5	49.4	47.5	58.7	75.5	89.2	89.1	87.0	82.0	72.7	54.8	42.3	65.56
Total Precip	0.85	1.15	1.54	1.85	1.33	3.30	3.88	0.65	1.92	1.18	0.78	1.37	19.80
2012													
Maximum Temp	43.6	46.7	69.0	69.2	81.2	85.2	95.8	89.5	78.9	63.7	54.3	45.9	68.58
Total Precip	1.48	1.59	1.68	4.48	4.28	0.94	0.34	2.94	2.89	5.03	1.13	3.28	30.06

1 Monthly average of daily maximum temperatures

2 Monthly total precipitation

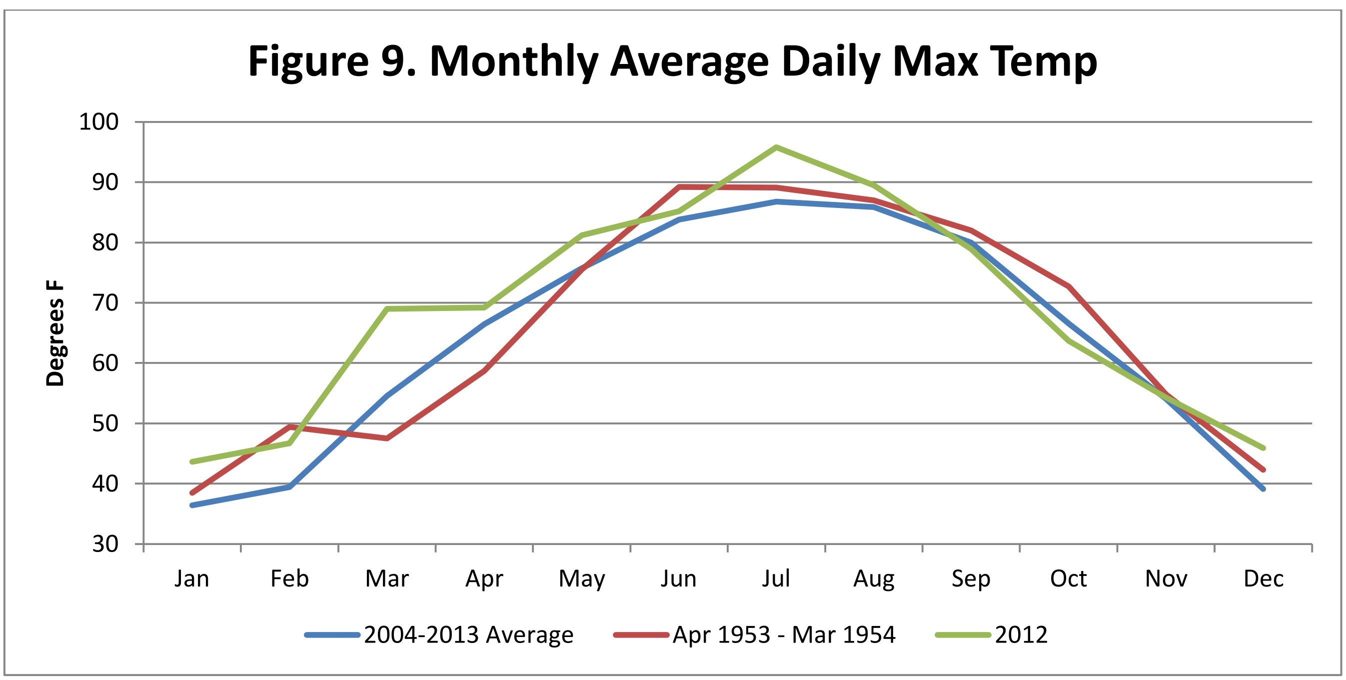
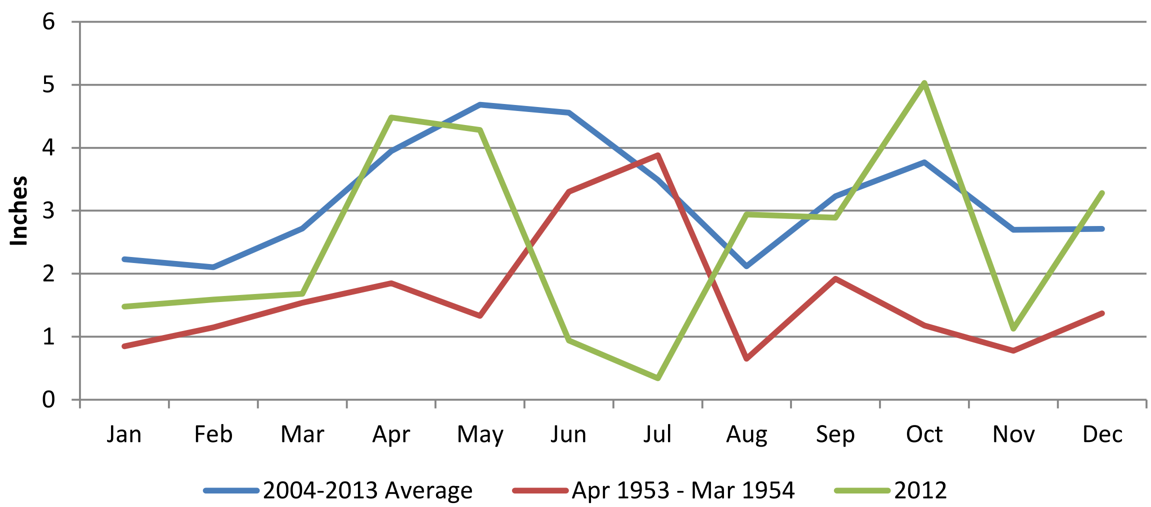


Figure 10. Monthly Total Precipitation



3.1.2 Water and Sewer Rates

For many years economic research has shown there to be an inverse relationship between the price of water and water consumption. As price increases, water use decreases. This is especially evident among residential customers who are more sensitive to water and sewer rates than businesses or industries. Because sewer service charges are also based upon water consumption volume, and customers typically respond to the total water and sewer charges, it is standard practice to evaluate the per volume rate of both water and sewer service.

CWLP water rates for 5/8" and ¾" meters inside the city have separate rates for three tiers of monthly consumption: up to 5 ccf, 5-10 ccf, and over 10 ccf (1 ccf = one hundred cubic feet = 748 gallons). Sewer rates are separate for water volume up to 3 ccf and over 3 ccf. Given that the average monthly billed water volume of 5/8" and ¾" meters is between 6 – 8 ccf per month, the second tier rate of both the water rate and sewer rate structures were used as representative of the unit rate faced by the average customer.

The CWLP "nominal" (i.e. published) water and sewer second tier rates were added together as the "marginal" rate. The marginal rate was determined for each month from January 2004 to December 2013. Monthly Consumer Price Index (CPI) values were obtained from the US Bureau of Labor Statistics for these same months. The ratio of the CPI in a given month to the CPI of July 2010 was used to convert the nominal marginal price values to year 2010 "constant dollar" ($2010), or inflation adjusted values. The July nominal marginal price, CPI, and $2010 marginal price history is summarized by the July values in Table 9.

The 2013 marginal price of water and sewer service is used in the forecast model as representative of future rates in constant dollars ($2010). This implies that water and sewer rates as represented in the forecast will only increase in the future due to inflation without increases in "real" value.

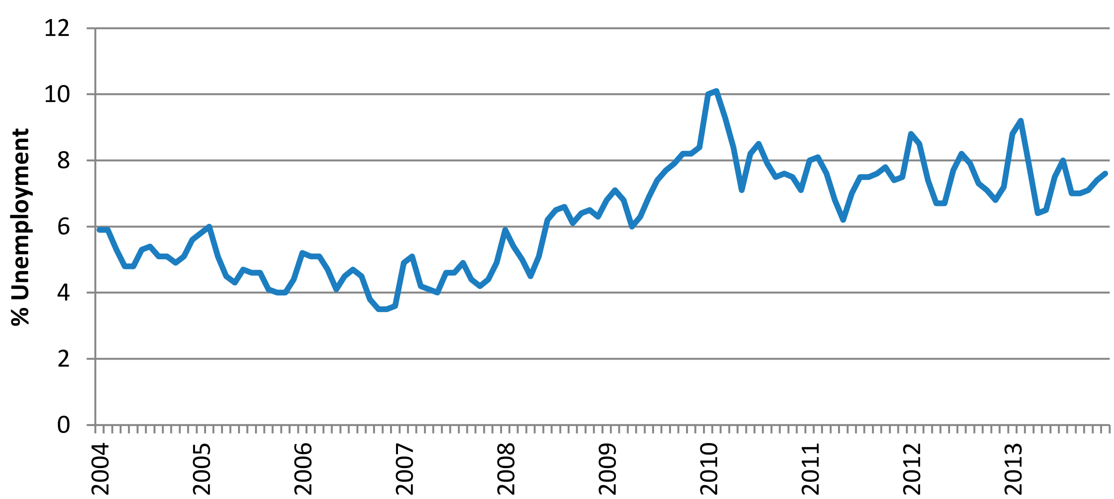
Table 9. CWLP Marginal Rate of Water and Sewer Service

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Nominal	$1.90	$1.97	$1.97	$1.97	$2.49	$3.01	$3.54	$4.13	$4.59	$4.71
CPI	189.4	195.4	203.5	208.3	220.0	215.4	218.0	225.9	229.1	233.6
$2010	$2.19	$2.20	$2.11	$2.06	$2.47	$3.05	$3.54	$3.99	$4.37	$4.40

3.1.3 Unemployment

Most water utilities in the US experienced effects of the "Great Recession" that began in 2008. A recession is defined as three or more consecutive months of decline in the gross domestic product (GDP). Although the recession officially ends when the GDP begins to increase again, the effects of the economic recession linger much longer. The monthly unemployment rate is a better metric of the effects of the recessionary period. The historical monthly unemployment rates were obtained from the US Bureau of Labor Statistics and are illustrated in Figure 11. During recessionary periods, such as when the unemployment rate is above 6 percent, water use may decrease as consumers are watchful of discretionary spending, there are fewer new housing starts, and business activity slows down. Before the recession (i.e., 2004 to 2007) the average unemployment rate was 4.7 percent. In the forecast model, the unemployment rate is assumed to be 4.7 percent in future years, which assumes that the economy of Springfield will return to pre-recession conditions.

Figure 11. Unemployment Rate 2004-2013



3.2 Statistical Analysis of Water Use Trends

CWLP historical water use data described in section 2 was evaluated in conjunction with the historical weather, demographic, and economic data described in section 3.1. Statistical relationships (i.e., correlations) between the average monthly water use of each sector and various factors were identified as explained below for each sector. Multiple regression analysis is a statistical procedure that is able to assess the strength of correlations of multiple factors on the "dependent" variable (i.e., the average sector water use). One underlying premise of multiple regression analysis is that the values of the dependent variable and the "explanatory" variables should follow a normal distribution. If the data are not normally distributed, then it is common to convert the data into the natural log form which then becomes normally distributed without changing the relationship between variables. Thus the statistical analysis of the sector water use relationships were evaluated with the data in natural log form.

The statistical water use model developed for each sector is incorporated into the Microsoft Excel forecasting model in order to compute estimates of future water demand for each sector. Weather variables are included in these statistical models of each sector so that the effects of alternative future weather conditions on water demand can be simulated, such as the reoccurrence of 100-year drought conditions in future years. In addition, other statistically significant explanatory variables are included in the model for each user group.

3.2.1 RES per Capita Water Use

Monthly RES (5/8" and ¾" meter) water use per capita data was evaluated with respect the variables described in section 3.1. The variation in monthly water use per capita was found to have statistically significant correlations with monthly maximum temperature, monthly precipitation, the marginal price of water & sewer service, and the monthly unemployment rate. The coefficients of this model are shown in Table 10.

The statistical analysis indicates the long-term responsiveness of the gallons per capita per day (gpcd) use to different factors. The variation in residential per capita water use during the historical period was previously shown in Figure 6. The response of residential gpcd to weather as estimated in the statistical analysis is in addition to the summer seasonality indicated by the month variables in Table 10. Seasonality and weather "explain" the height of summer peaks as seen in Figure 6. The influence of marginal price and unemployment factors "explain" the long-term downward trend of the troughs (i.e., winter demand) as seen in Figure 6.

The relationship between residential per capita use and maximum temperature is positive (meaning that as temperature increases, water use increases) as expected. The coefficient of 0.042 indicates that a one percent increase in monthly average daily maximum temperature is associated with a 0.04 percent increase in gpcd. Alternatively, as monthly precipitation increases, monthly gallons per capita per day water use goes down. A one percent increase in monthly precipitation results in a 0.03 percent decrease in gpcd. Again, these weather variables are in addition to the monthly seasonal increase in water use for May through September. The other significant variables show negative relationships indicating that as marginal price increases, or unemployment rate increases, the monthly gallons per capita per day water use goes down. A one percent increase in the marginal price results in a 0.16 percent decrease in gpcd, and a one percent increase in unemployment results in a 0.14 percent decrease in gpcd.

Thus the overall average residential water use per capita varies during the summer months along with variations in monthly maximum temperature and monthly precipitation, as well as with longer term trends in water rates and unemployment. Some of the apparent decrease in residential water use per capita correlated with rate increases over the last ten years may be due to participation in CWLP conservation programs that have promoted household water use efficiency, or reactions of residential customers to periodic water use restrictions.

Note that the regression model was estimated in log form, thus the model intercept value of 4.24 is interpreted as $e^{4.24}$ or about 69.5 gpcd. The coefficients associated with the months of May through

September are added to this intercept value for each of these months. Thus, the intercept value for May would be $e^{4.24 + 0.12}$ or about 78.5 gpcd.

Table 10. Regression Model for RES GPCD

Variable	Coefficient
Intercept	4.24120
May	0.12131
June	0.26384
July	0.29683
August	0.25155
September	0.16972
LN(max temp)	0.04244
LN(precip)	-0.03201
LN(marginal price)	-0.16277
LN(unempl rate)	-0.13862

3.2.2 CII per Capita Water Use

The variation in monthly CII (1' to 4"meter) water use per capita was found to have statistically significant correlations with monthly maximum temperature and monthly precipitation. The relationship between per capita use and maximum temperature is positive while the relationship with precipitation is negative, as would be expected. Monthly increases in the intercept value are significant for June through September, as shown in Table 11.

Table 11. Regression Model for CII GPCD

Variable	Coefficient
Intercept	2.56944
June	0.24937
July	0.32218
August	0.32473
September	0.28357
LN(max temp)	0.26443
LN(precip)	-0.03219

3.2.3 Large Users per Capita Water Use

Monthly water use in gallons per capita per day (gpcd) among the large water customers (6" to 12" meters) was evaluated relative to weather patterns. As with the previous sectors, the variation in monthly per capita water use is significantly higher in June through September and is positively associated with increases in maximum temperature. Unique to this historical data period was the start of service to CWLP Dallman power plant #4, which started consuming large volumes of water in mid-2009. A control variable was added to the equation to account for this increase in water use in the historical period with a value of zero in months prior, and a value of one in months after the Dallman service came on-line. The coefficient is added to the equation for future water demand with a value of one in all future years.

Table 12. Regression Model for Large Users GPCD

Variable	Coefficient
Intercept	2.1100
June	0.255835
July	0.364598
August	0.389407
September	0.279215
LN(max temp)	0.209105
Dallman online	0.418931

3.2.4 Wholesale Monthly Water Use

As with the large water users, monthly variation in wholesale water use was evaluated relative to historical weather patterns. In addition to the summer monthly seasonality as seen in the other water use sectors, the wholesale water customers experience a consistent and significant increase in water use during the month of February. As expected, wholesale water use also increases in response to increases in monthly maximum temperature. A unique feature of the wholesale water use data during the historical period of analysis was the discontinuance of service to Chatham, which occurred in May 2012. A control variable (with a value of one in months with service to Chatham, and a value of zero in months after service ended) was included in the equation to account for this one-time shift in the water use pattern.

Table 13. Regression Model for Wholesale GPD

Variable	Coefficient
Intercept	13.130778
February	0.318931
June	0.162786
July	0.190453
August	0.290236
September	0.296437
LN(max temp)	0.166754
Chatham	0.585243

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Section 4

Population Projections

Historical population for the CWLP service area and wholesale customer service areas was provided by the Springfield-Sangamon County Regional Planning Commission (SSCRPC) as shown in Table 14. In addition, CWLP staff provided historical population data for Loami, Sugar Creek, Curran-Gardner, and Round Prairie service areas (SA). The annual growth rate from 1990 to 2010 is shown for each community.

Table 14. Census Population

	1990	2000	2010	Annual Growth 1990-2010
Springfield	105,227	111,454	116,250	0.50%
Chatham	6,074	8,583	11,500	3.24%
Clear Lake*	193	267	229	0.86%
Curran*			212	
Grandview	1,647	1,537	1,441	-0.67%
Jerome	1,206	1,414	1,656	1.60%
Leland Grove	1,679	1,592	1,503	-0.55%
Riverton*	2,638	3,048	3,455	1.36%
Rochester	2,676	2,893	3,689	1.62%
Sherman	2,080	2,871	4,148	3.51%
Southern View	1,906	1,695	1,642	-0.74%
Spaulding*	440	559	873	3.49%
Williamsville	1,140	1,439	1,476	1.30%
SSCRPC Total	126,906	137,352	148,074	0.77%
Curran Gardner SA	2,692	3,308	3,584	1.44%
Loami SA	966	1,038	970	0.02%
Round Prairie Phase I SA	780	799	741	-0.26%
Round Prairie Phase II SA	172	255	246	1.81%
Sugar Creek SA	1,087	822	773	-1.69%
TOTAL	132,603	143,574	154,388	0.76%

*Not included in the CWLP service area and therefore not included in the forecast.

SSCRPC also provided population projections for the year 2040 for each community using three different projection techniques: building permit method, birth death method and straight line projection. The building permit method is based upon the number of building permits from 2009 to 2012 within each community. The birth death method is based upon number of births and deaths recorded in each community from 1990 to 2010. The straight line projection method is based upon the census population of 1990, 2000 and 2010 of each community. Finally, SSCRPC took an average of the projected 2040 population estimate of each community. Table 15 shows the 2040 average and the associated annual growth rate from 2010 to 2040 for each community. Note that the building permit method is most likely biased downward by the recession as it is based upon data from 2009 to 2012. Similarly, the other methods could be influenced in part by the recession, thus the 2040 population projections may represent a lower growth scenario for the future if population growth trends were to return to pre-recessionary levels. Also, being the state capitol, Springfield is susceptible to political trends. State government has been downsized and de-centralized in recent years, thus affecting the population and housing market of Springfield. Such trends could possible reverse during the 2010 to 2065 planning horizon of this forecast.

Table 15. SSCRPC Population Projections

	2010	3 Method Average 2040	Annual Growth 2010-2040
Springfield	116,250	132,867	0.45%
Chatham	11,500	18,799	1.65%
Clear Lake*	229	247	0.25%
Curran*	212	318	1.36%
Grandview	1,441	1,304	-0.33%
Jerome	1,656	1,870	0.41%
Leland Grove	1,503	1,661	0.33%
Riverton*	3,455	4,179	0.64%
Rochester	3,689	4,632	0.76%
Sherman	4,148	6,114	1.30%
Southern View	1,642	1,484	-0.34%
Spaulding*	873	1,155	0.94%
Williamsville	1,476	1,787	0.64%
Total	148,074	176,417	0.59%

*Not included in the CWLP service area and therefore not included in the forecast.

The population projections provided by SSCRPC did not include projections for the smaller wholesale customers Loami, Sugar Creek, Curran-Gardner, and Round Prairie. In collaboration with CWLP staff it was decided to assume no additional growth for Loami, 1 percent annual growth for Sugar Creek and Curran-Gardner, and 1 percent growth for Round Prairie until 2025.

CDM Smith interpolated population values for the interim forecast years of 2015, 2025, and 2035 based upon the 2010 and 2040 population values. CDM Smith also extended the population growth rate from 2040 to 2045, 2055 and 2065. These population projections are shown in Table 16.

As an alternative planning scenario, the SSCRPC population projections for 2040 were increased by 5 percent to simulate a High Growth planning scenario. The interpolated and extrapolated values were adjusted upward accordingly.

CDM Smith

Table 16. Population Projections to 2065 based upon SSCRPC projections for 2040

	2010	2013	2015	2025	2035	2045	2055	2065
CWLP Service Area*	132,286	133,491	133,555	133,873	134,192	134,510	134,829	135,147
ROCHESTER	3,689	3,928	3,980	4,241	4,502	4,762	5,023	5,284
GRANDVIEW	1,441	1,412	1,404	1,364	1,324	1,284	1,244	1,204
JEROME	1,656	1,729	1,739	1,791	1,844	1,896	1,949	2,001
SHERMAN-WMSVILLE	5,624	6,018	6,158	6,855	7,552	8,250	8,947	9,644
SUGAR CREEK	1,252	1,269	1,281	1,294	1,307	1,320	1,333	1,347
LOAMI	1,070	1,150	1,150	1,150	1,150	1,150	1,150	1,150
CURRAN-GARDNER	3,584	3,620	3,656	3,693	3,730	3,767	3,804	3,843
ROUND PRAIRIE	987	997	1,007	1,017	1,017	1,017	1,017	1,017
TOTAL	**151,589**	**153,613**	**153,930**	**155,278**	**156,617**	**157,956**	**159,296**	**160,636**

*Includes Inside City, Outside City and Sothern View.

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Section 5

Water Demand Forecasts

The statistical water use equations described in Section 3 were used in conjunction with assumptions about future conditions and the population projections described in Section 4. Assumptions used in developing these forecasts are described below.

5.1 Forecast Assumptions

The estimates of future water demand are built upon the following assumptions:

- Water use patterns in future years are represented by water use patterns observed from 2004 to 2013.
- Average weather patterns observed from 2004 to 2013 are representative of normal weather patterns in future years.
- Weather patterns observed from April 1953 to March 1954 are representative of 100-year drought conditions that could re-occur in any given year in the future.
- Water and sewer rates will remain the same as 2013 in real terms (i.e., nominal rates will only increase over time to adjust for inflation).
- Unemployment rates will return to 2004 to 2007 average of 4.7 percent in future years.
- Large and wholesale customers will remain without major additions or loss of customers in future years.
- Authorized unmetered water use will remain at about 2.2 percent of metered use and unaccounted for water will remain at about 14.3 percent of total production.
- Population growth will occur in future years as projected for both the baseline and high growth scenarios.

5.2 The Baseline Forecast

The baseline forecast of future water demand assumes that future weather conditions are represented by the 2004 to 2013 average conditions, and the population projections as provided by SSCRPC. Under these conditions and the forecast assumptions described above, the anticipated water demand for the CWLP service area including wholesale customers is estimated to reach 22.9 mgd in the year 2065, as shown in Table 17. Note that the water demand for 2010 shown in Table 17 includes the water volume provided to Chatham within the Wholesale water use, which discontinued in 2012. This results in a drop in total water demand from 2010 to 2015 in Table 17.

This baseline forecast is an estimated annual average water demand based on average (normal) weather conditions. Furthermore, the models described in Section 3 replicate the response of average water usage to changes in average conditions (i.e., model inputs). One would expect actual water demand to fluctuate above and below this average estimated water demand in any given year as actual weather conditions and other factors deviate from average (normal) conditions. In fact, one might expect actual water demand to be above the baseline forecast 50 percent of the time and below the baseline forecast 50 percent of the time. Therefore, it is prudent in water supply planning to base designs on a high range that is estimated above the average (see Section 5.6) in order to avoid years of under-supply.

Table 17. Baseline Forecast in MGD

	2010	2015	2025	2035	2045	2055	2065
RES	7.072	7.388	7.405	7.423	7.440	7.458	7.476
CII	5.547	5.630	5.643	5.657	5.670	5.683	5.697
Large Users	4.452	4.507	4.518	4.529	4.539	4.550	4.561
Retail	17.072	17.524	17.566	17.608	17.650	17.692	17.733
Wholesale*	2.015	1.126	1.198	1.269	1.341	1.413	1.484
Sold	19.086	18.650	18.764	18.877	18.991	19.104	19.218
Authorized	0.496	0.410	0.413	0.415	0.418	0.420	0.423
Unaccounted For	3.268	3.180	3.200	3.219	3.239	3.258	3.277
TOTAL	**22.850**	**22.241**	**22.376**	**22.512**	**22.647**	**22.782**	**22.918**

*2010 includes Chatham

5.3 100-Year Drought Forecast

The water demand for the 100-year drought scenario assumes the weather conditions of April 1953 to March 1954 as conditions in each future forecast year. Other assumptions remain as per the baseline forecast. This scenario results in an estimated water demand of 23.4 mgd in 2065. The water demand by sector under this scenario is shown in Table 18.

As noted in Section 3.1.1, the 100-year conditions do not exhibit the same summer month conditions as occurred during the summer of 2012. A forecast assuming year 2012 weather conditions for the future years results in an estimated demand of 23.445 mgd in 2065.

Table 18. 100-Year Drought Forecast in MGD

	2010	2015	2025	2035	2045	2055	2065
RES	7.072	7.574	7.592	7.610	7.628	7.646	7.664
CII	5.547	5.804	5.818	5.832	5.846	5.859	5.873
Large Users	4.452	4.532	4.543	4.554	4.564	4.575	4.586
Retail	17.072	17.910	17.953	17.996	18.038	18.081	18.124
Wholesale*	2.015	1.132	1.204	1.276	1.348	1.420	1.492
Sold	19.086	19.042	19.157	19.272	19.386	19.501	19.616
Authorized	0.496	0.419	0.421	0.424	0.427	0.429	0.432
Unaccounted For	3.268	3.247	3.267	3.286	3.306	3.326	3.345
TOTAL	**22.850**	**22.708**	**22.845**	**22.982**	**23.119**	**23.256**	**23.393**

*2010 includes Chatham

5.4 High Growth Forecast

The water demand for high growth scenario assumes the average 2004 to 2013 weather as conditions in each future forecast year in conjunction with a 5 percent increase in the 2040 estimate of population provided by SSCRPC. Other assumptions remain as per the baseline forecast. This scenario results in an estimated water demand of 25.1 mgd in 2065. The water demand by sector under this scenario is shown in Table 19.

Table 19. High Growth Forecast in MGD

	2010	2015	2025	2035	2045	2055	2065
RES	7.072	7.415	7.570	7.726	7.881	8.036	8.191
CII	5.547	5.651	5.769	5.887	6.006	6.124	6.242
Large Users	4.452	4.524	4.619	4.713	4.808	4.903	4.998
Retail	17.072	17.590	17.958	18.326	18.694	19.063	19.431
Wholesale*	2.015	1.126	1.218	1.310	1.402	1.494	1.586
Sold	19.086	18.715	19.176	19.636	20.096	20.557	21.017
Authorized	0.496	0.412	0.422	0.432	0.442	0.452	0.462
Unaccounted For	3.268	3.192	3.270	3.349	3.427	3.506	3.584
TOTAL	**22.850**	**22.319**	**22.868**	**23.417**	**23.966**	**24.515**	**25.064**

*2010 includes Chatham

5.5 High Growth with 100-Year Drought Forecast

This scenario combines the higher population growth rate with the 1953 to 1954 weather conditions depicting 100-year drought conditions. This scenario results in an estimated water demand of 25.6 mgd in 2065, as shown in Table 20.

In Section 5.3, a forecast under 2012 weather conditions was also estimated in place of the 100-year drought conditions. Combining the high growth conditions with the 2012 weather conditions results in an estimated demand of 25.6 mgd in 2065.

Table 20. High Growth and 100-Year Drought Forecast in MGD

	2010	2015	2025	2035	2045	2055	2065
RES	7.072	7.602	7.762	7.921	8.080	8.239	8.398
CII	5.547	5.826	5.948	6.070	6.192	6.314	6.436
Large Users	4.452	4.549	4.644	4.739	4.835	4.930	5.025
Retail	17.072	17.977	18.353	18.730	19.106	19.482	19.859
Wholesale*	2.015	1.132	1.224	1.317	1.409	1.502	1.595
Sold	19.086	19.109	19.578	20.047	20.516	20.984	21.453
Authorized	0.496	0.420	0.431	0.441	0.451	0.462	0.472
Unaccounted For	3.268	3.259	3.339	3.419	3.499	3.579	3.658
TOTAL	**22.850**	**22.788**	**23.347**	**23.906**	**24.465**	**25.025**	**25.584**

*2010 includes Chatham

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Section 6

Summary

The last water demand analysis performed by an outside firm for the City of Springfield City Water Light & Power (CWLP) service area was performed in 1991, although CWLP have developed numerous internal analyses. The US EPA and the US Army Corps of Engineers have requested that CWLP update the water demand analysis for the CWLP service area to assist in determining viable alternative water supplies. Furthermore, the analysis should include an estimation of water demand during a 100-year drought event. The Illinois Water Survey previously identified the period of April 1953 to March 1954 as representative of 100-year drought conditions. In addition, the CWLP system experienced its highest ever water demand in the summer of 2012 as a result of weather conditions in July of that year.

This report presents the water demand analysis update as required and includes the analysis of current and historical water use and the development of future water demand forecasts under baseline, higher growth and drought conditions. CDM Smith prepared a Microsoft Excel CWLP Water Demand Model for the development of the water demand forecasts. This Water Demand Model may be used by CWLP staff to develop other alternative demand forecast scenarios, and update as additional information regarding future conditions becomes available.

A review of historic monthly water patterns show a distinct seasonality in water use in which the water use in summer months increases well above winter usage. The degree to which summer water use increases is exacerbated by dry and/or hot weather conditions. Similarly, cool and wet weather during the summer months dampens the increase in summer water usage. This seasonality and weather effect is observed in all sectors of water usage: residential, commercial, large users and wholesale customers.

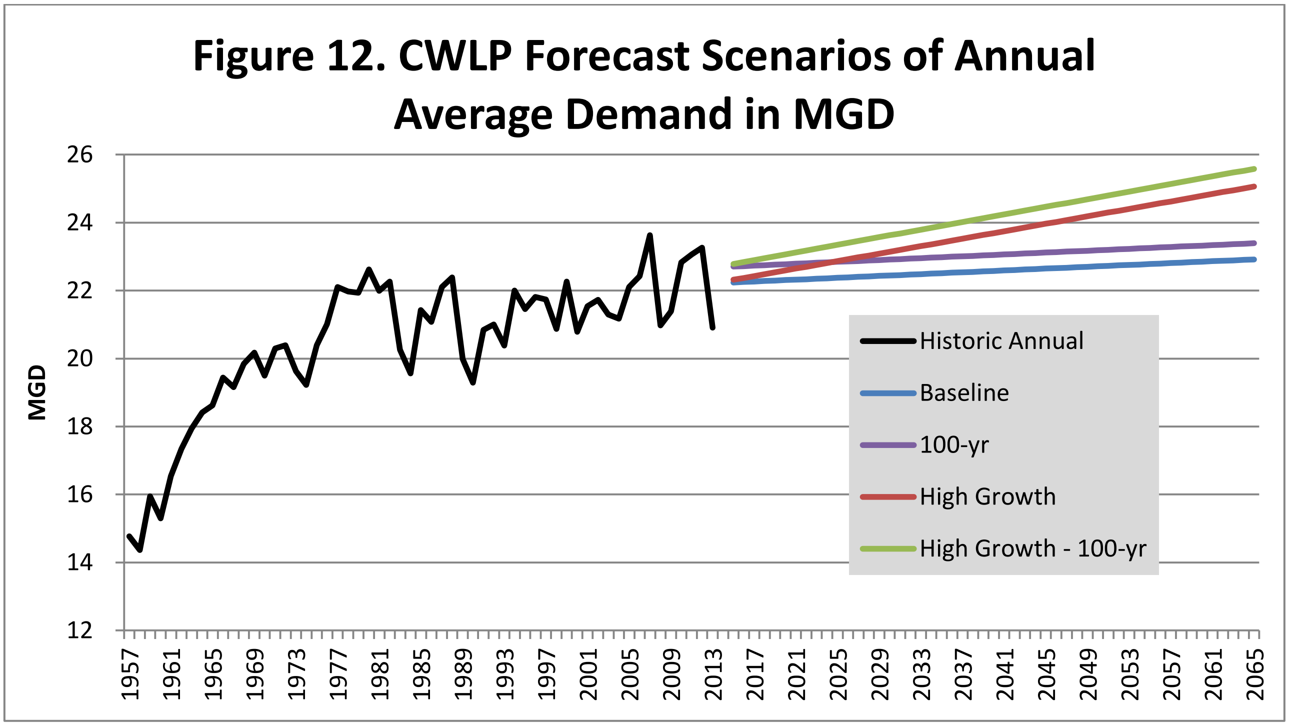
Population growth projections for the City of Springfield are modest. Some outlying suburban areas (i.e., wholesale customers) are projected to have higher growth rates. To some extent, the recent recession and state government policies have dampened recent growth in the area, and thus may have influenced the lower population projections. Thus, an alternative forecast scenario with an additional 5 percent growth was evaluated to offset the effects of recent years on the long-range forecast.

A baseline forecast was developed assuming the past 10-year average weather conditions for all future years, in combination with SSCRPC projected population growth rates. Alternative scenarios include: the effects of April 1953 to March 1954 weather conditions on the forecast (i.e., the 100-year drought scenario), the effects of the additional 5 percent growth (i.e., the high growth scenario), and a combination of both the high growth and 100-year drought conditions. The total water demand of each scenario (i.e., the estimated annual average demand) is shown in Table 21 in mgd. Figure 12 illustrates the baseline and alternative scenarios relative to the historic record of CWLP annual water demand and historic peak month demand.

Table 21. Comparison of CWLP Forecast Scenarios in MGD

	2010*	2015	2025	2035	2045	2055	2065
High Growth/ 2012 Weather	22.850	22.836	23.397	23.958	24.519	25.079	25.640
High Growth/100 Yr	22.850	22.788	23.347	23.906	24.465	25.025	25.584
High Growth/Normal	22.850	22.319	22.868	23.417	23.966	24.515	25.064
Year 2012 Weather	22.850	22.756	22.894	23.032	23.169	23.307	23.445
100-yr Drought	22.850	22.708	22.845	22.982	23.119	23.256	23.393
Baseline	22.850	22.241	22.376	22.512	22.647	22.782	22.918

*2010 includes Chatham



The projected baseline forecast represents the anticipated annual average water demand over time given normal weather conditions. One would expect actual water demand to fluctuate above and below this average in any given year as actual weather conditions deviate from average (normal) conditions. Therefore, it is prudent in water supply planning to base designs on a higher range above the average in order to avoid years of under-supply. Realistically there may be unanticipated future events such as greater population growth, future wholesale and/or industrial customers, or more extreme weather events that could push water demand above and beyond the expected water demand. The likelihood of such events occurring in the future represents the level of risk that CWLP staff should be prepared to accept in terms of future water supply planning.

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