CHAPTER 3. WATER SYSTEM DESCRIPTION

The purposes of this chapter are to (1) provide a general overview of the wholesale agencies water systems; (2) provide a general overview of the City of Lincoln's existing water system; and (3) provide a detailed assessment of specific components of the City's system. This chapter also serves as a reference guide for future water system engineers, staff, and managers so that those persons might more easily identify and address planning and engineering issues in the City's water conveyance system. The size and complexity of the City's water system is best understood through a GIS system integration tool – linking the City's water model with various geographical components – but this document serves as a substantive reference for the key system components outside a fully functioning GIS system.

3.1 Wholesale Water Facilities from PCWA and NID

The City of Lincoln takes its surface water deliveries through the Placer County Water Agency (PCWA) water system. As described in **Chapter 5** surface water supply, the City's water supplies that are delivered through the PCWA system include PCWA's surface water rights, Nevada Irrigation District's (NID) surface water rights, and Pacific Gas & Electric Company's (PG&E) water supplies that are contracted to both PCWA and NID. All of these surface water rights encompass the vast majority of the City's potable water supplies.[1]

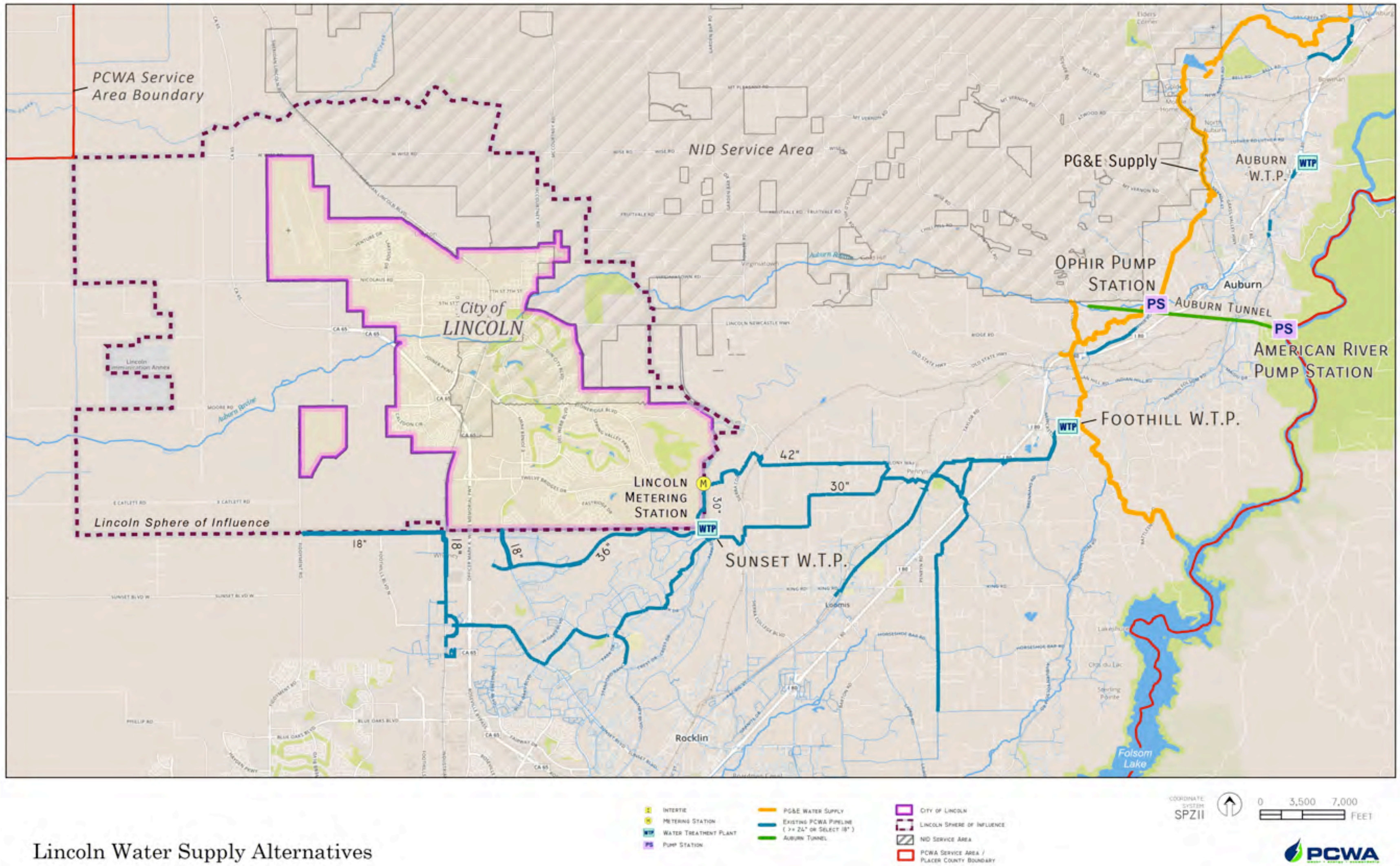
PCWA's water system starts in the Sierra Nevada mountain range. Diversions of raw water to feed the system are derived from water assets in both the American River watershed and Yuba-Bear Rivers watershed. On the American River side, raw water is diverted under PCWA's water rights from the American River at the American River Pump Station as well as PG&E water delivered through the PG&E South Canal. The diverted water is pumped up to the Auburn Tunnel and eventually flows to PCWA's Foothill Water Treatment Plant. Raw water originating in the Yuba-Bear system is derived from PG&E water supplies through PCWA and NID water rights and is delivered via the PG&E South Canal to the Foothill Water Treatment Plant (Foothill Plant).

Raw water is treated at the Foothill Plant and delivered, via gravity flow, through a series of potable water transmission pipes to the City of Lincoln. The treated water is received by the City of Lincoln at the Lincoln Metering Station. When the water passes through the Lincoln Metering Station, the wholesale water delivery from PCWA ends and the

[1] As noted in **Chapters 5** and **6**, the City also uses groundwater to augment its water supply portfolio.

City's retail water delivery system begins. As detailed in **Chapter 5**, the City receives both "regulated" and "unregulated" flow from the PCWA system for delivery to the City's retail customers. The unregulated flows move into the City's upper water system while the regulated flows move to the City's lower water system. **Figure 3-1** depicts the entire PCWA delivery system.

Figure 3-1 – PCWA Existing Transmission Facilities

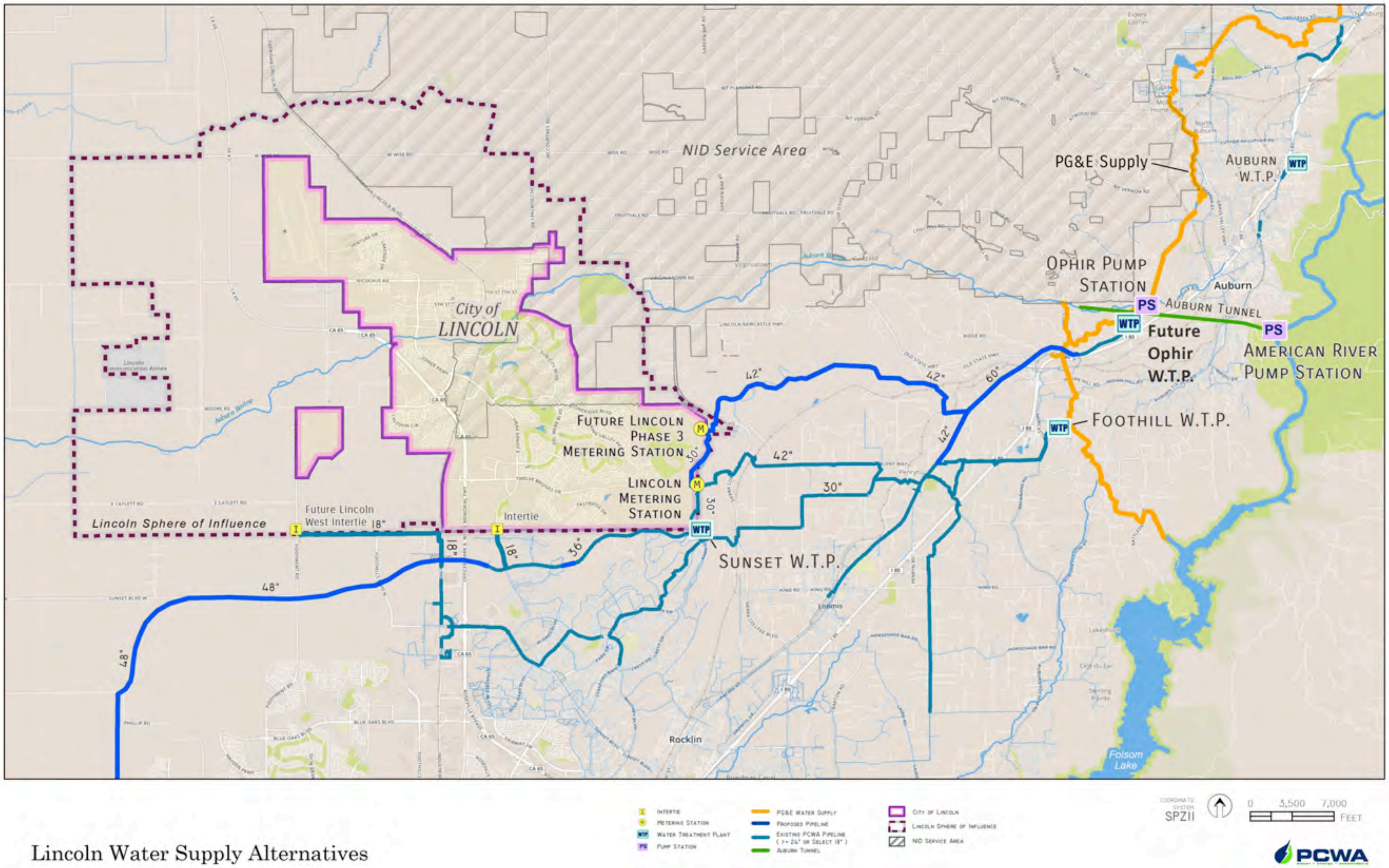


Both PCWA and NID plan to expand and upgrade their respective water systems in the future. In order to accommodate planned growth in Western Placer County, PCWA anticipates not only expanding treatment capacity at its existing treatment facilities (Foothill and Sunset) but also constructing a new water treatment plant and associated infrastructure. The Ophir Water Treatment Plant (Ophir Plant) is planned for construction at approximately the location where the Auburn Tunnel intersects the PG&E South Canal near Highway 80 off of Ophir Road. The Ophir Plant is planned for 30 million gallons per day (30 mgd) of treatment capacity, but can be expanded to 60 mgd. PCWA is working on a project partnership with several regional water purveyors including the City of Roseville, Cal-American Water Company, and the City of Lincoln to develop and finance the Ophir Plant.

PCWA also seeks to build additional infrastructure to deliver the treated water supplies to the City of Lincoln. This infrastructure includes large diameter pipes, like the Bickford Pipeline, flowing from the Ophir Treatment Plant to the City's borders. PCWA also plans to construct a new metering station as well as a connecting line to the existing metering station. Collectively, these system investments will greatly expand PCWA's water system. Total costs for this project were estimated in 2015 at $289.3 Million or approximately $9.6 million per million gallons of capacity.[2] PCWA's planned water infrastructure improvements are shown in **Figure 3-2**.

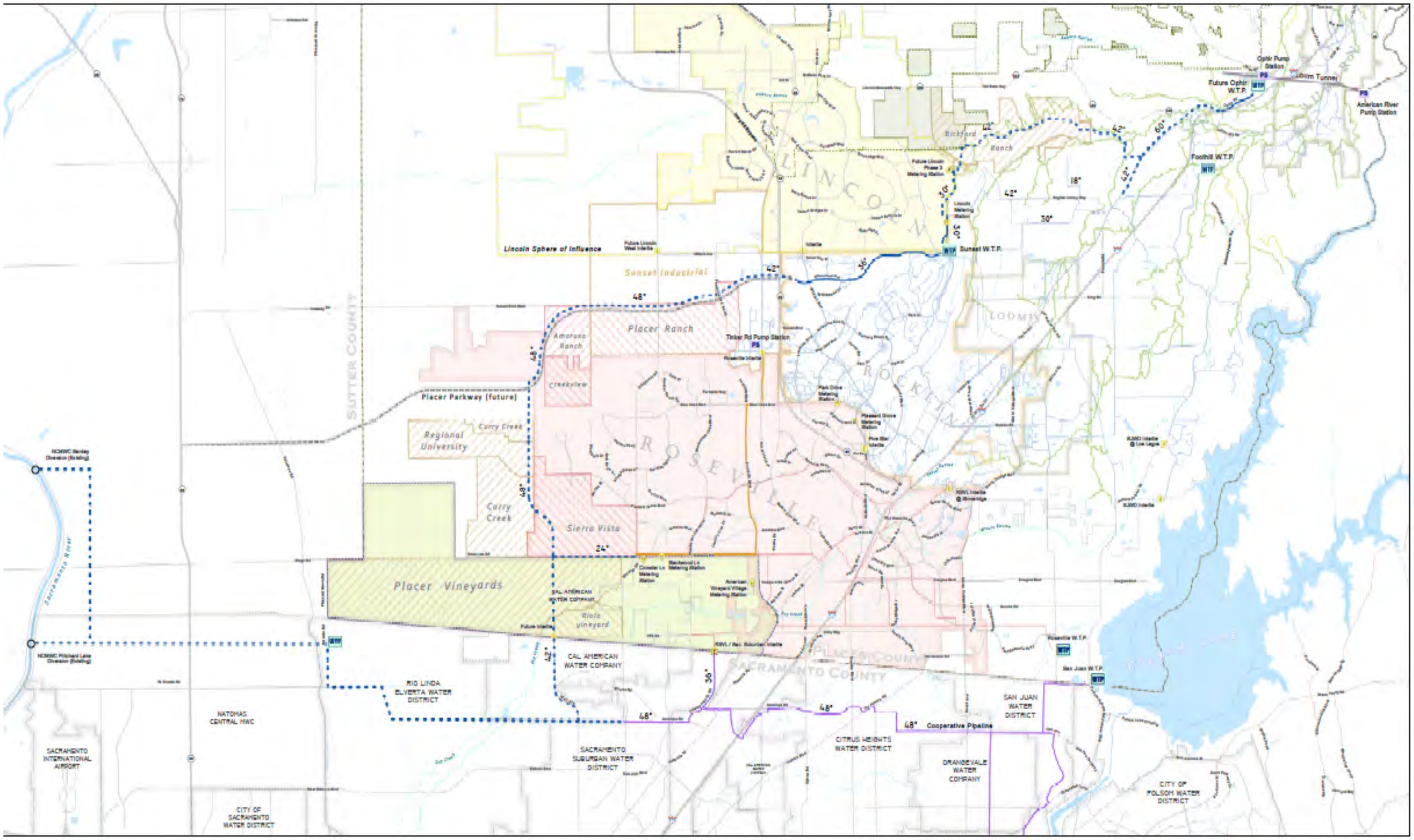
[2] This cost assessment was first presented to the City Council on August 21, 2015. PCWA is currently revising its cost estimates.

Figure 3-2 – PCWA Future Transmission Facilities



PCWA has also developed preliminary plans for additional water supplies derived from the Sacramento River. This project is known as the RiverArc Project (formerly Sacramento River Regional Water Supply Project). PCWA anticipates assigning a portion of its American River water rights and entitlements to the Sacramento River in order to divert those supplies for use in the most western areas of PCWA's service area. Specifically, PCWA is considering diverting water at two locations on the Sacramento River and delivering those supplies as far east as the westerly border of the City of Lincoln. **Figure 3-3** shows the preliminary outlay for the RiverArc Project.

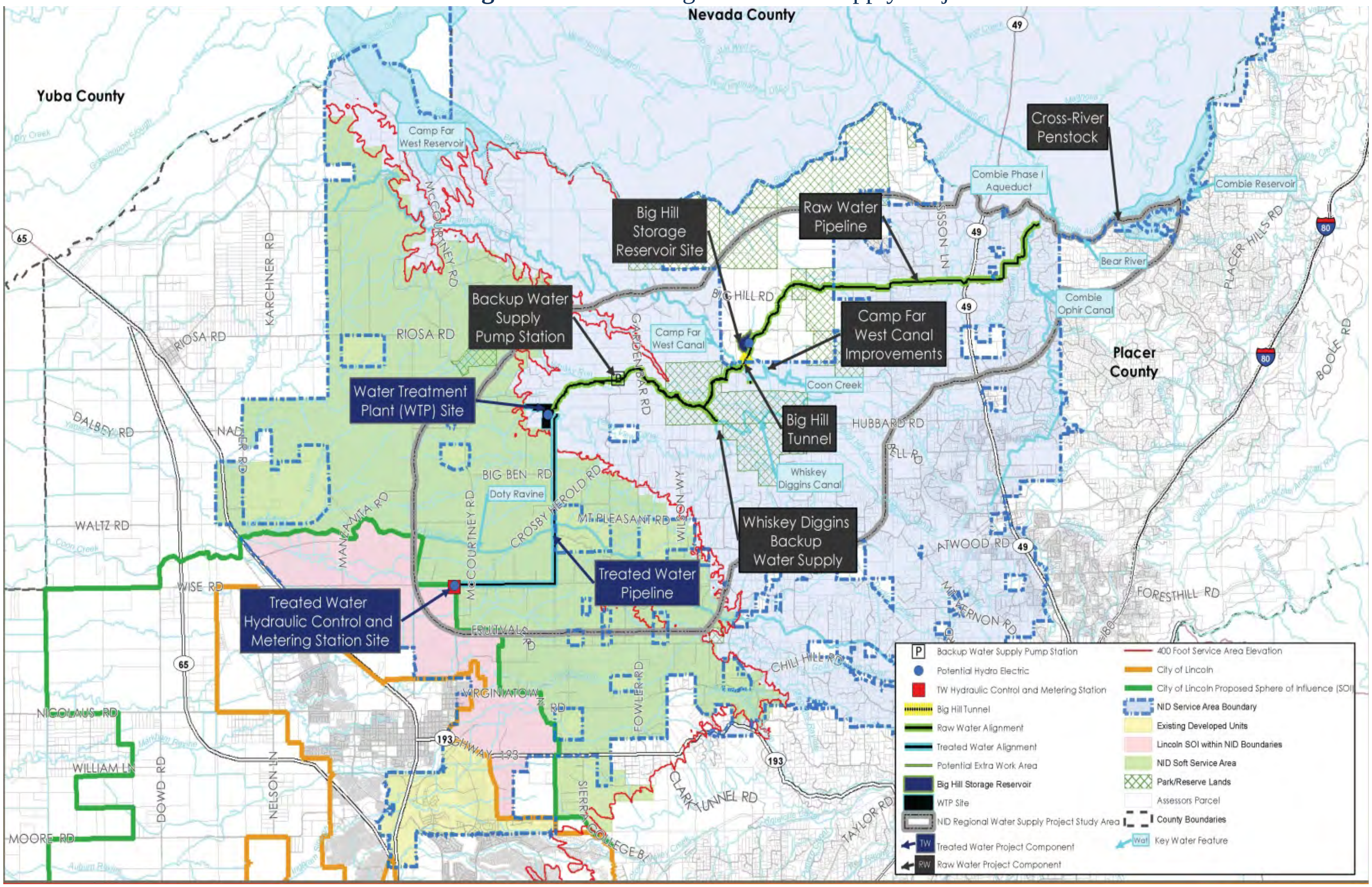
Figure 3-3 – Sacramento River Regional Water Supply Project



Nevada Irrigation District anticipates constructing its own water treatment facility in order to deliver NID treated water assets to the NID service area in and around the City of Lincoln. Presently, NID water assets are delivered to PCWA for eventual delivery into the City's water system at the Lincoln Metering Station. NID's water assets are accounted for based upon the measured demands in the NID service area within the City boundaries. NID anticipates building the Regional Water Supply Project (RWSP) to take raw water from the Yuba-Bear Rivers Watershed and NID facilities in both Placer and Nevada Counties and deliver that water to urban areas contained within NID's boundary. NID's service area includes those areas within NID's service area that are also incorporated into the City of Lincoln and its Sphere of Influence.

The RWSP is planned to commence construction within 5 to 10 years and will be located inside the NID service area west of the District's major reservoirs. The RWSP is currently sized at 40 million gallons of capacity and would serve both NID's "soft service area" – urban areas other than the City in NID's service area boundary – as well as the City of Lincoln. The first phase of the project would deliver approximately 10 mgd of treated water capacity. Up to Twenty-five million gallons of the 40 mgd are earmarked for the City of Lincoln. Additional facilities are also planned for development as part of the project – including a raw water pipeline that would deliver water from Combie Reservoir and Combie Aqueduct to the water treatment plant as well as a treated water pipeline that would deliver treated water to a metering station at the north end of the City of Lincoln. The total cost of the project is estimated at $265.7 Million or $6.60 Million per mgd. **Figure 3-4** shows the major components of NID's RWSP project.

Figure 3-4 – NID Regional Water Supply Project



As described in **Chapter 4**, the City's anticipates needing approximately 67 million gallons per day (mgd) of water capacity and an annual total of approximately 37,000 acre-feet of water. Approximately 57 mgd of capacity will be needed to meet potable demands while the remaining 10 mgd of capacity will be needed to meet non-potable demands which may be derived from separate non-potable systems (raw water or recycled water). The potable supplies will be derived from PCWA's facilities, NID's facilities, and groundwater. The City's current water model – which is detailed in **Chapter 9** – has infrastructure components built into the model that allow for a combination of water supply alternatives that will meet both long-term demand and emergency conditions.

3.2 City of Lincoln's Current Retail Water Distribution System

This section describes the City's current retail water distribution system. This system is derived from two main potable water sources – wholesale water delivered at the Lincoln Metering Station and groundwater derived from the City of Lincoln's groundwater system. These water assets are delivered through an infrastructure system that transverses the entire City boundary. **Figure 3-5** shows a map depicting the City's water infrastructure.

Figure 3-5 – Diagram of Main Water System

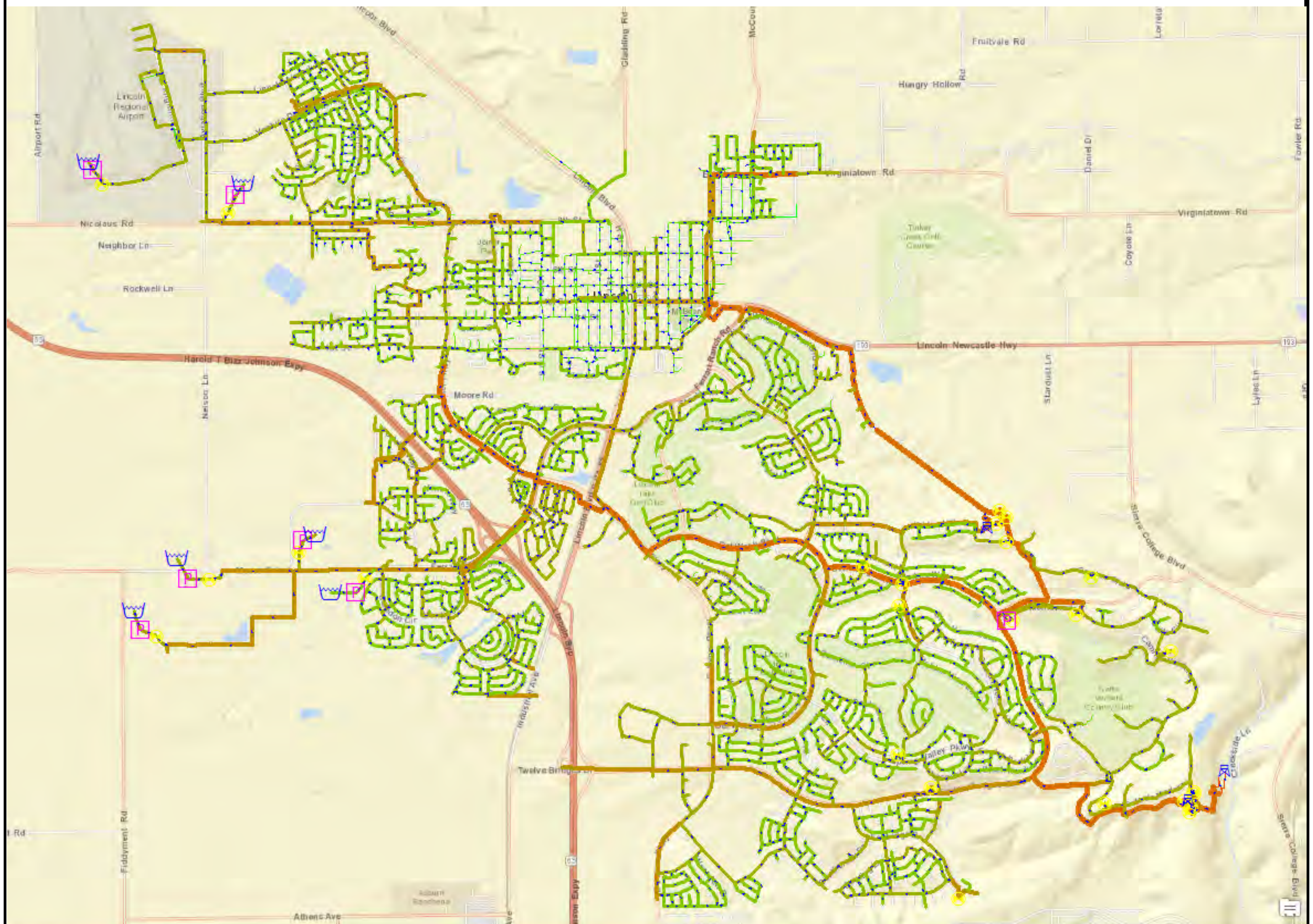


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Image Sources:
City Water System GIS, Licensed ESRI ArcGIS
City Water Model, Innovyze InfoWater

As shown in **Figure 3-5**, the City's infrastructure is depicted down to the individual street level. This level of detail is further refined with data input recognizing the physical details of each pipe in the system (diameter and length) as well as the age of each pipe in the system.[3] The information related to the water system model in terms of pipe diameter, length, and ages is more fully developed in **Chapter 9**.

The City's system is further split into essentially two sub-systems. The first system is that area located in the eastern part of the City that receives unregulated water deliveries that are managed by Placer County Water Agency. This area is commonly referred to as the Catta Verdera area. In that area, PCWA uses its treatment and delivery system to deliver the flows of water in order to meet system demands. The second system is the remaining area served by regulated deliveries derived from PCWA water that the City "regulates" in order to make water available to its customers. In some places in the City, the two systems overlap as described in more detail in the pages below. **Figure 3-6** and **Figure 3-7** depict maps of the unregulated and regulated areas in the City of Lincoln.

Figure 3-6 – Unregulated Surface Water Delivery Area

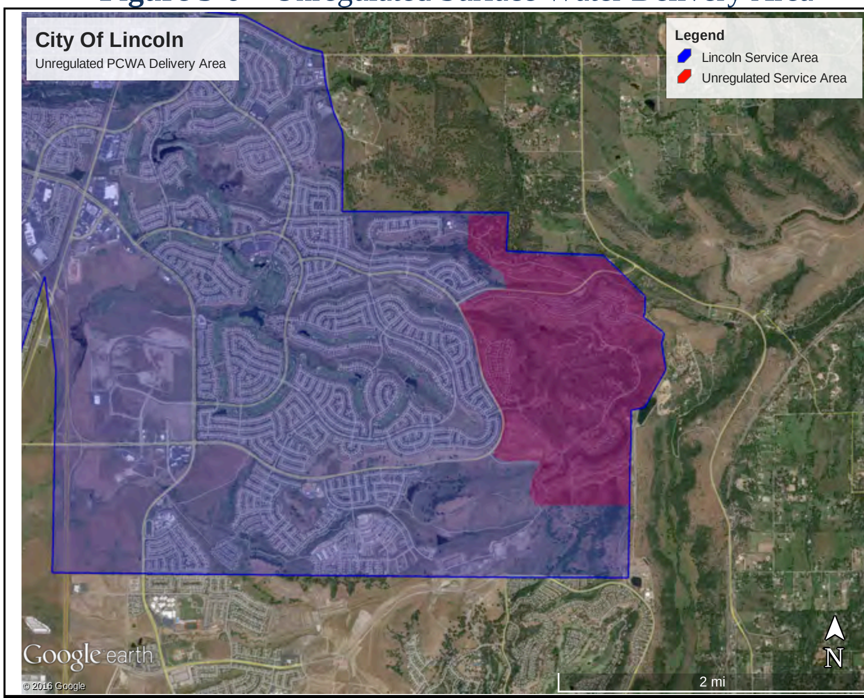

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Image Sources:
Google Earth Pro

[3] The system depiction is based upon the best available information. In some instances, the ages of the pipes in the system are unknown.

Figure 3-7 – Regulated Surface Water Delivery Area

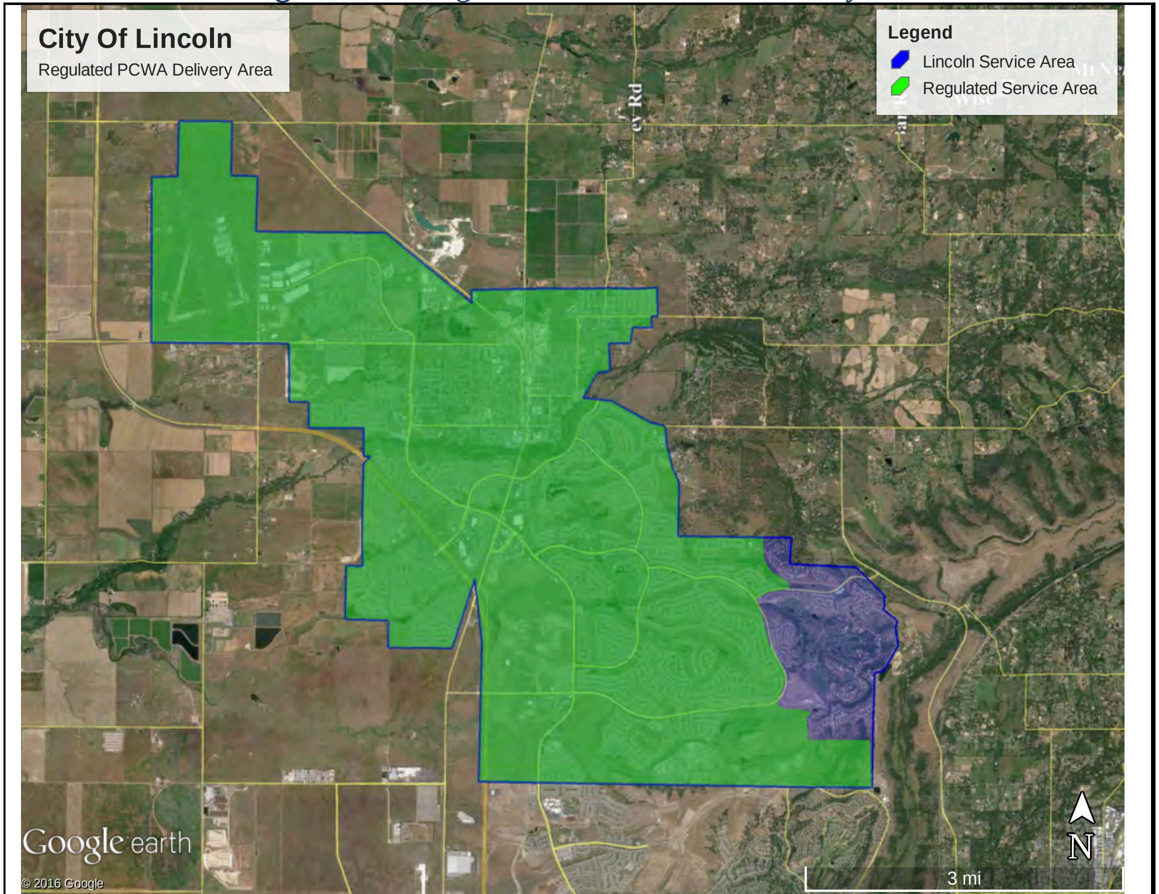
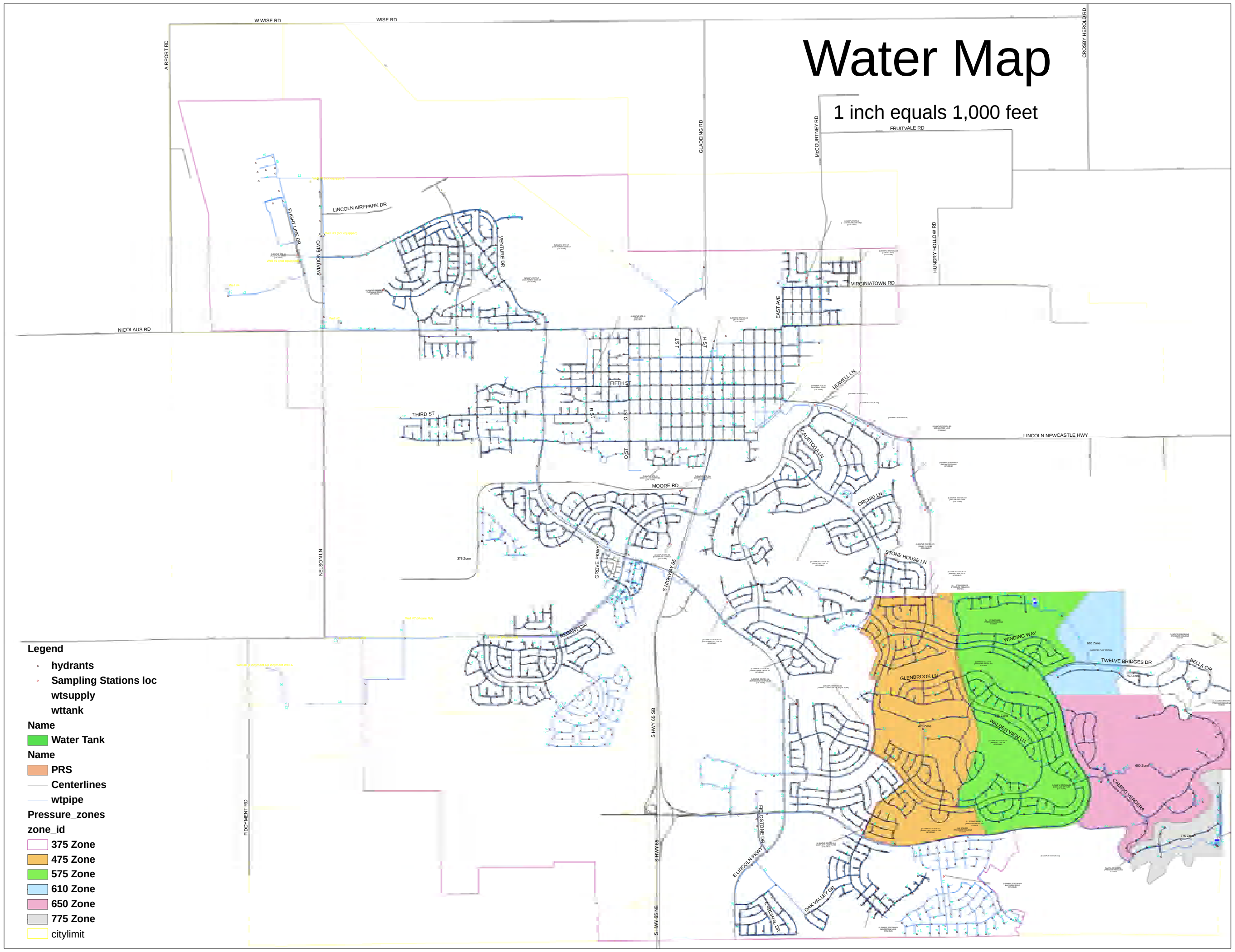


Image Sources:
Google Earth Pro

3.2.1 Pressure Zones

The City of Lincoln's unregulated and regulated systems can also be divided into areas that are defined by pressure zones. The map depicting the City's Pressure Zones is shown below in **Figure 3-8**.

Figure 3-8 – Pressure Zone Map



3.2.2 System Supply Infrastructure

This section provides detail on the various major components of the City's water system that allow the City to deliver water to meet end user demands as well as fire safety conditions. As described in **Section 3.1** above, the surface water delivered to the City's system is delivered by PCWA to the Lincoln Metering Station (See **Figure 3-2**). At this location, the City takes control of the water and delivers the water to the City's residential, commercial, industrial, and recreational retail customers.

3.2.2.1 Lincoln Metering Station at Reservoir #2

The Lincoln Metering Station (LMS) is a facility that is owned and operated by Placer County Water Agency. The LMS is located adjacent to the 5 MG City Tank at Catta Verdera South (Reservoir #2 site). **Figure 3-9** below shows the LMS.

Figure 3-9 – Lincoln Metering Station

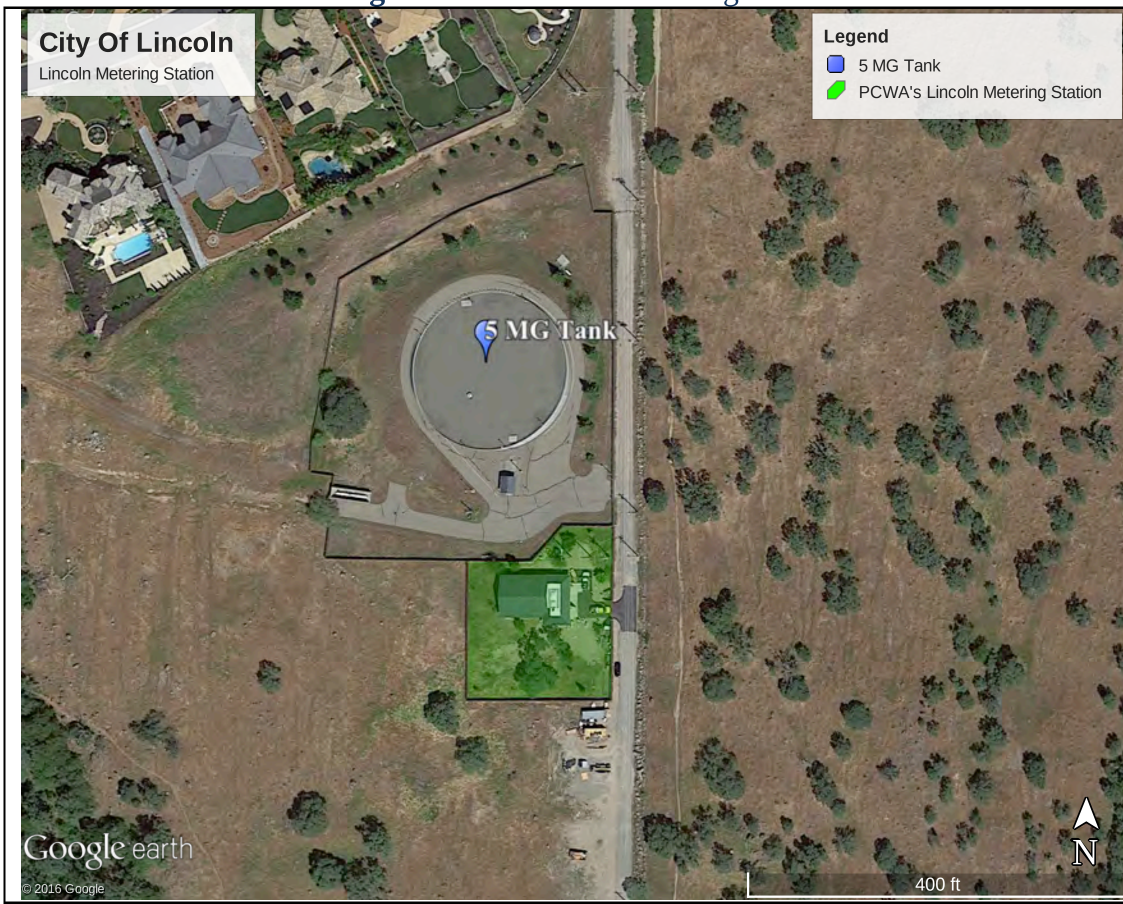


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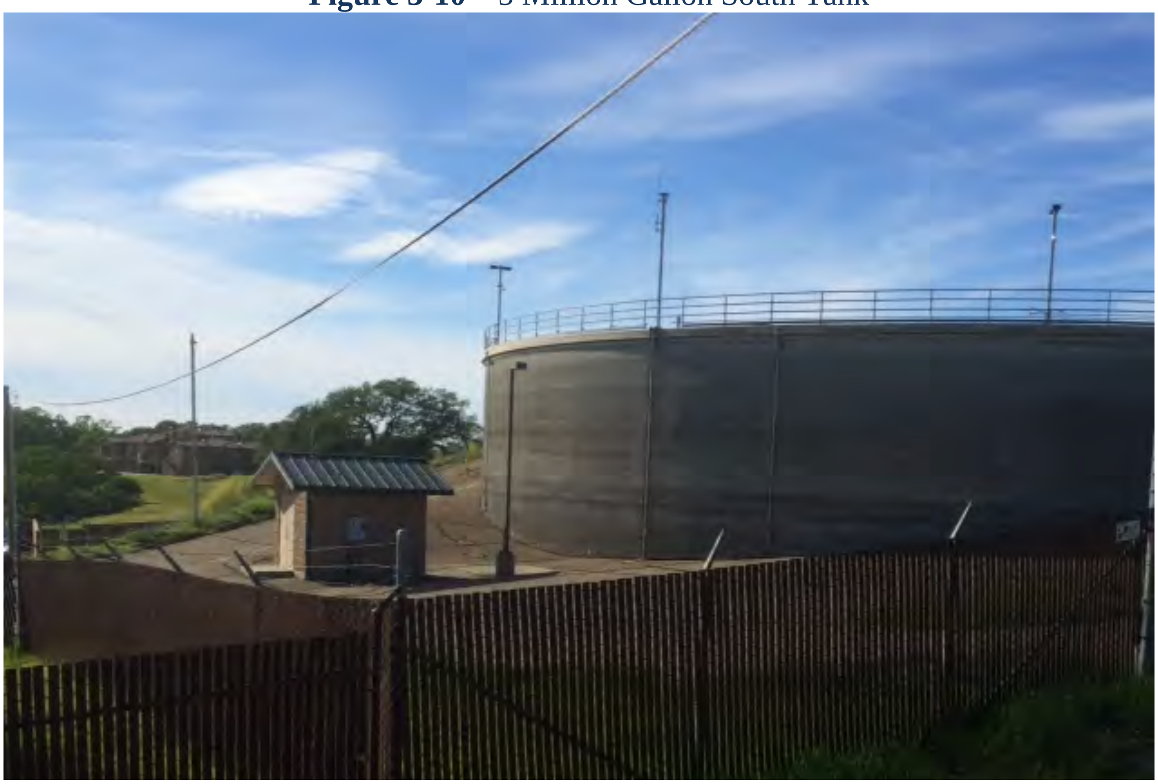
Image Sources:
Google Earth Pro

The LMS splits the water received by PCWA to serve the unregulated side as well as the regulated side. A 16-inch diameter pipe leads from the unregulated side to serve Catta Verdera. A 30-inch diameter pipe leads from the regulated side to serve the lower part of the City's system. The Metering Station also includes pressure reduction valves. In 2015 PCWA installed a small hydrogeneration facility at the LMS to take advantage of the excess pressure delivered to the site which then must be reduced in order to meet the City's delivery pressure criteria for the unregulated service.

3.2.2.2 5 MG Tank – Catta Verdera South (Reservoir #2)

The Catta Verdera south 5 million gallon (MG) concrete, gravity water storage tank was installed on City property in 2004. The water supplied to this tank comes through PCWA's LMS. The purpose of this tank is to assist the City in managing pressures and flows in the City's water system during peak demand periods. At an elevation of 565 feet the tank is capable of supplying operational pressures from 40 psi to 130 psi to the City's regulated system. All water metered and delivered via PCWA's LMS for the City's regulated system passes through this tank under normal operating conditions. Flows delivered through the regulated meter are at a set flow rate. Water flows from the LMS into a 30-inch transmission pipeline and is measured by PCWA at the metering station. **Figure 3-10** depicts the City's 5 MG Tank.

Figure 3-10 – 5 Million Gallon South Tank



3.2.2.3 MG Tank – Reservoir 1

The 3 million gallon (MG) steel water storage tank was installed at the City's old Reservoir 1 site in 2003. The tank is supplied water through gravity flow. At an elevation of 366.1 feet, the tank is capable of supplying operational pressures, 40 psi to 130 psi, to the majority of the regulated system in the City including the lower portions of the Del Webb and Twelve Bridges developments. The 3 MG tank is supplied from the 5 MG Catta Verdera South tank through a combination of 12-inch, 16-inch, 20-inch and 36-inch pipelines. An altitude valve controls the flow rate from the 30-inch under pressure from the 5 MG Catta Verdera South tank, into the 3 MG tank to maintain a preset water level and to prevent overflow,. Flow out of the 3 MG tank into the 16-inch and 20-inch pipelines is measured by 16-inch and 20-inch mag flow meters owned by the City. **Figure 3-11** depicts the City's 3 MG tank.

Figure 3-11 – 3 Million Gallon Tank

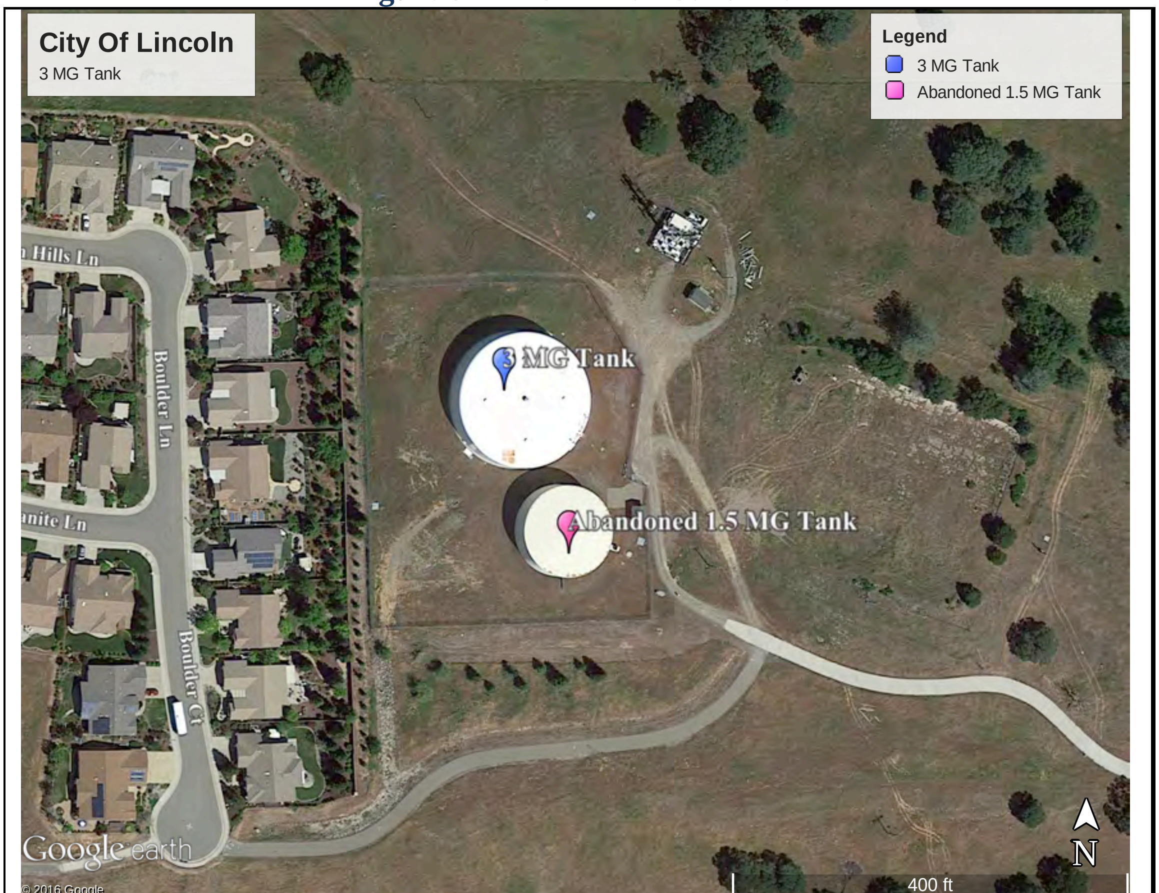


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Image Sources:
Google Earth Pro

3.2.2.4 Catta Verdera Temporary Booster Pump Station (Booster Pump Station)

The Booster Pump Station was constructed to accommodate City service to high elevation lots in the Catta Verdera Development that could not be served from the existing unregulated service from the PCWA Lincoln Metering Station. The Booster Pump Station was considered temporary as it would be needed until the PCWA Phase 3 - 30 inch pipeline and new metering station could be built to serve the City through the eastern side of the Catta Verdera development. The Booster Pump Station is supplied water from the 5 MG Catta Verdera South Tank at elevation 565 feet via a 24-inch pipeline and is boosted by one to three pumps, depending on demand, to a service elevation of 750 feet. The Booster Pump Station will be placed in standby mode when the new 30-inch line and the PCWA metering station are completed in the Catta Verdera North area. **Figure 3-12** shows the Catta Verdera Temporary Booster Pump Station.

Figure 3-12 – Booster Pump Station @Intersection of Twelve Bridges Drive and Stoneridge

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Image Sources:
Google Earth Pro

3.2.2.5 City Wells

The City of Lincoln currently operates 5 wells as shown on the Well Map in **Figure 3-13** below. The total production is limited to about 10% of annual City demand but wells are operated primarily in the summer to help balance water pressures and peak demands. The wells are generally located on the western side of the City in the more productive groundwater aquifer. **Table 3-1** summarizes the well characteristics. **Chapter 6** of the Water Master Plan provides additional information on individual wells, the North Basin Aquifer, and the regional governance of groundwater.

Table 3-1 – City of Lincoln's Active Groundwater Wells

Well Name	Max Production	Year Built/ Upgraded	Status
Well No. 2 – Nicolaus Rd	900	1984/90/15	Operational
Well No. 6 – Westwood	1,000	2000	Operational
Well No. 7 – Moore Rd	1,000	2002	Operational
Well No. 8 – Fiddyment	1,400	2004	Operational
Well No. 9 – Nelson	1,500	2005/2014	Operational
Subtotal	**5,800**		
Well #4	n/a	1999	Inactive
Well #5	n/a	1999	Inactive

Figure 3-13 – City Well Locations

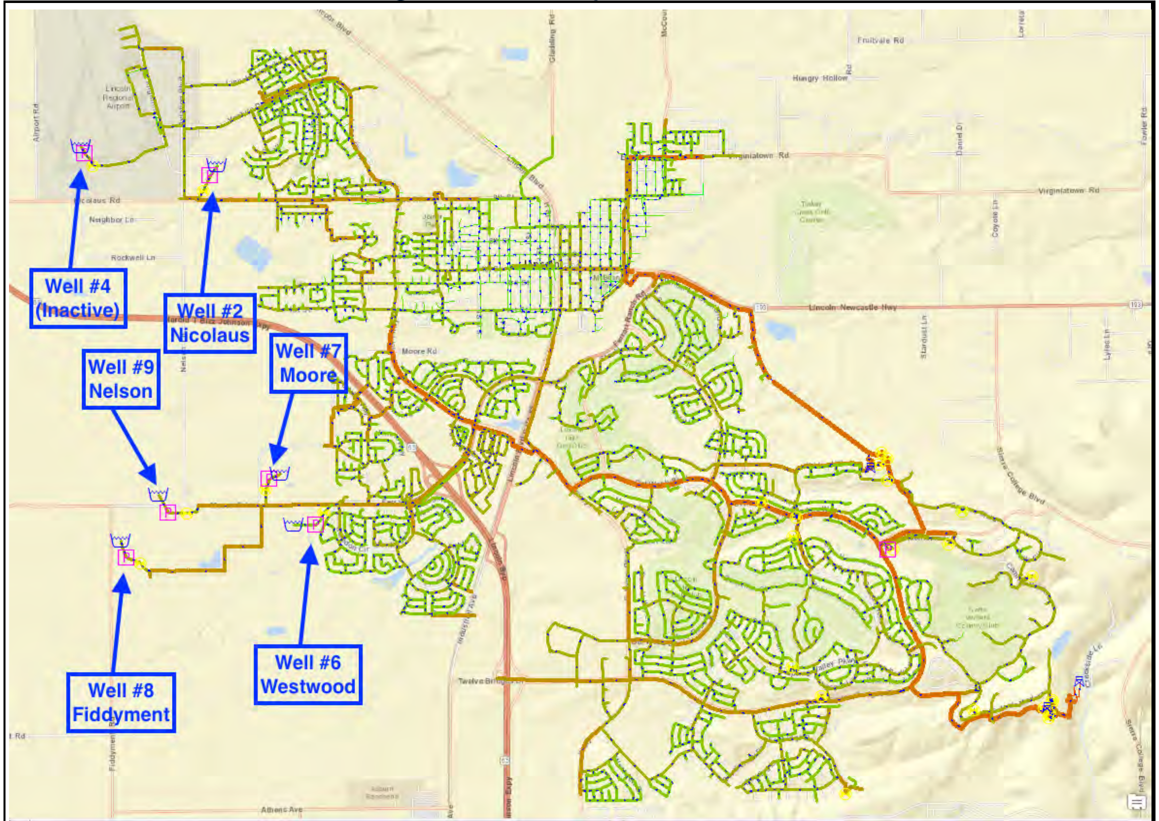

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Image Sources:
City Water System GIS, Licensed ESRI ArcGIS
City Water Model, Innovyze InfoWater

Currently, the City wells are operated during high use periods to maintain pressures within the City. Well usage is generally rotated among the wells with one or more wells left in reserve to meet potential backup needs. The operations staff chooses which wells to operate who maintain working knowledge of the current well system conditions. Wells must be taken offline for inspection and repairs regularly. Conservative long-term planning of well production for the system provides the basis for assessing water volumes in this WMP.

3.3 Additional Important Water Infrastructure

This section details other important water infrastructure features of the City water system that are crucial for operation, backup, or management of the water system. This section contains diameters of vital pipes as well as locations of specific infrastructure pieces. Additional existing system infrastructure components in need of replacement or undersized for optimal system operations are also detailed in this section.

3.3.1 City Meter out of 5 MG Tank

The purpose of the 16-inch City meter on the discharge side of the 5 Million Gallon South Tank described in **Section 3.2.2.2** is primarily to quantify the peak outflows and verify metered daily flows as recorded by PCWA into the tank. The 16-inch diameter meter is too small to adequately record the current peak demands as the meter's registering capacity is periodically exceeded during peak seasonal demands. However, the meter feeds the 30-inch pipeline into the City. The 30-inch pipeline is the only supply line to the majority of the City, and thus cannot be taken out of service for meter replacement until the new PCWA Metering Station is in service to the City. The new metering station is incorporated into the Phase III 30-inch pipeline and metering station that is currently being developed by PCWA.

3.3.2 Altitude Valve, City Meter out at 3 MG Tank

The altitude valve into the 3 MG tank at altitude 366 feet (described in **Section 3.2.2.3**) is on the 30-inch pipeline that is supplied from the 5 MG South Tank, located at elevation 565 feet, that operates at a higher pressure. The altitude valve is necessary to reduce line pressure into the 32 foot high gravity tank to about 30 feet of head at elevation 395 feet. The City meters on the 16-inch and 20-inch pipelines exiting the 3 MG Tank are designed to summarize and record daily peak flows out of the tank.

3.3.3 5 MG and 3 MG Tank Bypasses

Both the 5 MG storage tank and the 3 MG storage tank contain a bypass system and related control system. The 5 MG has a bypass line that relies upon adequate pressure reduction and flow control from the adjoining PCWA valves. The bypass allows for isolating the 5 MG tank for maintenance purposes. The 3 MG has a bypass line that includes control valves for isolating the 3 MG tank for maintenance. Both of these bypass systems require regular upkeep in order to allow for tank maintenance at both locations.

3.3.4 Pressure Reducing Stations (PRSs)

The City's potable water system includes nine pressure-reducing stations. **Table 3-2** lists these 9 stations and **Figure 3-14** shows their locations. The purpose of the below-grade, concrete vault stations is to adjust the system operating pressures in various pressure zones in the regulated system in the City to between 40 psi and 130 psi. The current operating PRSs were installed in 1997 during the period when the City was experiencing rapid urbanized growth. The typical PRS shown in **Figure 3-15** includes the following major, generic components: full diameter, manually operated valved bypass of the PRS based on the size of the pipe main associated with the PRS; a high flow pressure reducing control valve with associated piping connected to the pipe main and sized to pass to estimated maximum flow available from the upstream reach of pipe main; a smaller pressure reducing valve for lower flows, i.e. night time, for more efficient pressure control in that flow range; telemetry (SCADA) elements that allow monitoring and remote control of the downstream discharge pressure leaving the PRS and corresponding flow through the PRS.

Table 3-2 – City's Pressure Reducing Stations

PRS Name	Location	System	Current Setting
Stoneridge	Stoneridge Drive	Regulated	Some PRV Settings May Change Seasonally See Operations Staff for Current Settings
Spring Valley #1	North	Regulated	
Spring Valley #2	South	Regulated	
Wildomar	Wildomar Drive	Regulated	
12 Bridges	12 Bridges Drive	Regulated	
CVIL 13	Vista De Madera	Unregulated	
CVIL 17	Camino Verdera	Unregulated	
CVIL 18	Monteverde	Unregulated	
CVIL 19	Camino Cielo	Unregulated	

Figure 3-14 – Pressure Reducing Station Locations

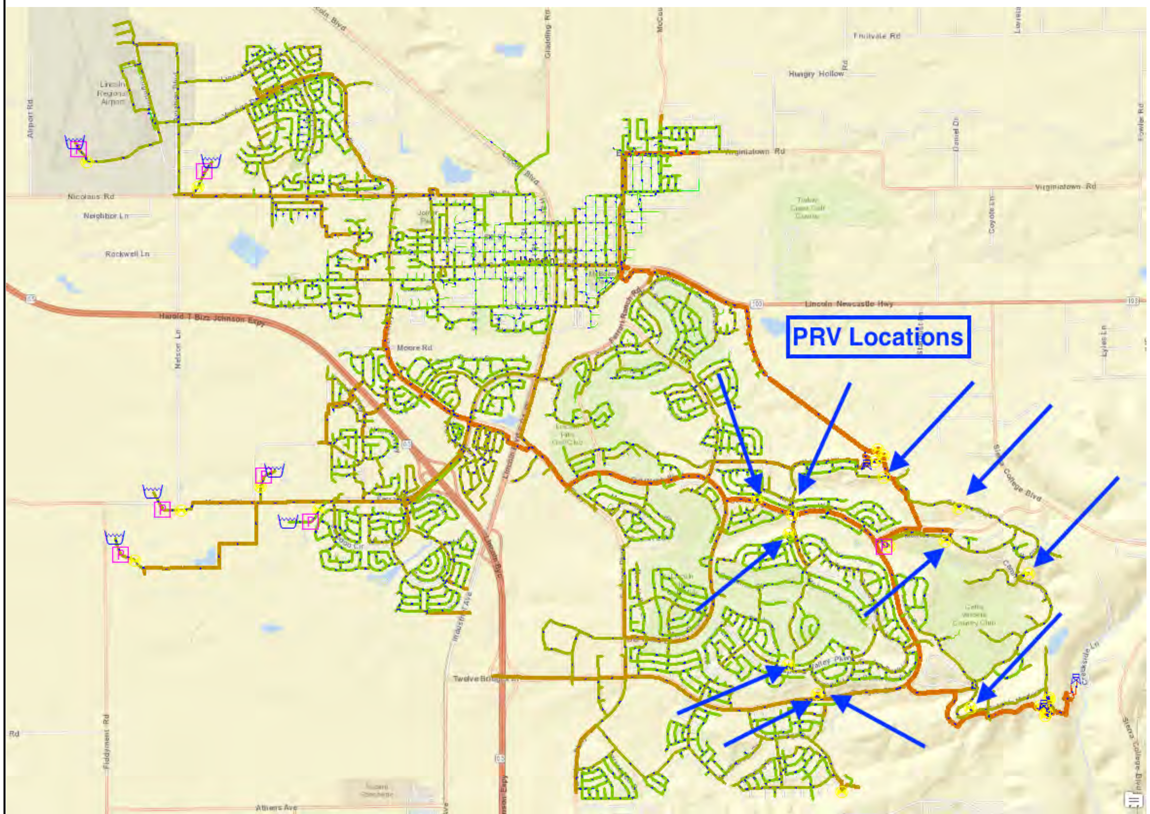
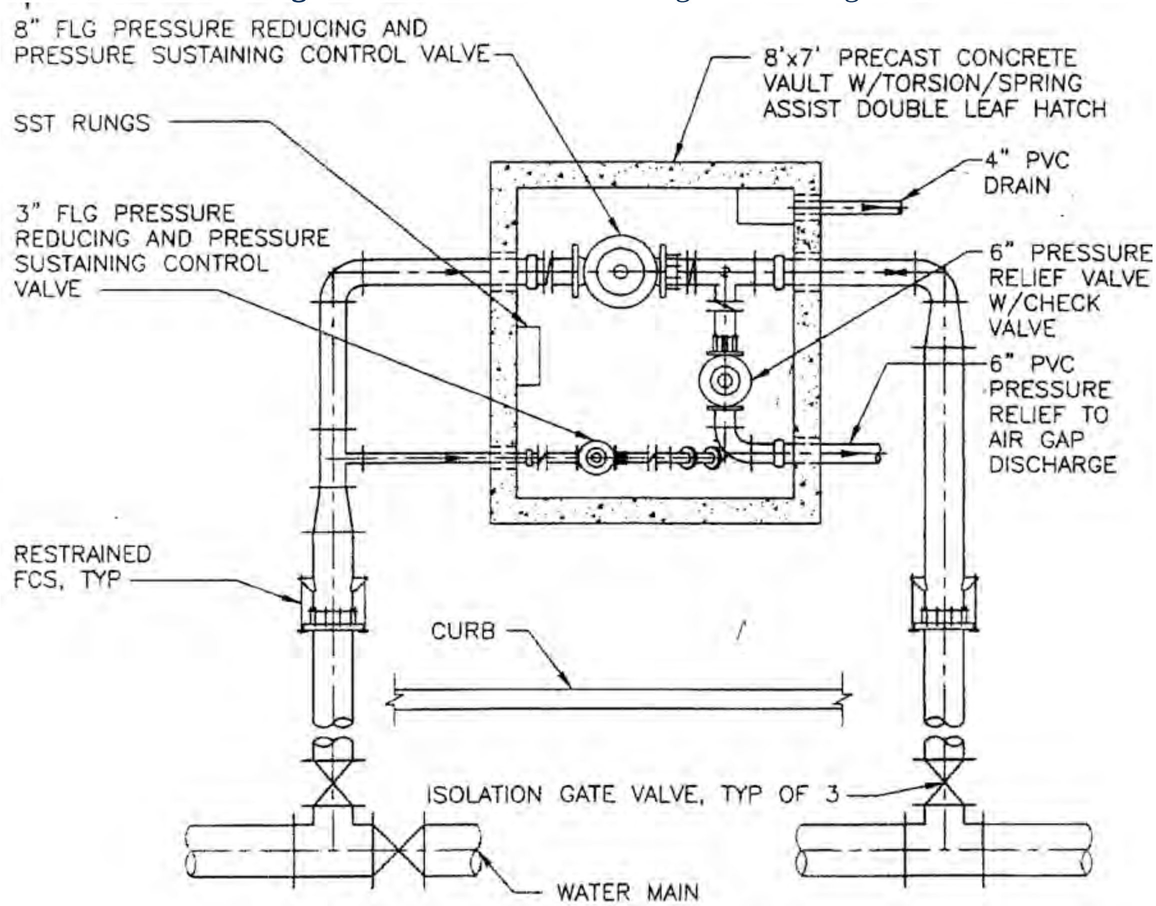


Image Sources:
City Water System GIS, Licensed ESRI ArcGIS
City Water Model, Innovyze InfoWater

Figure 3-15 – Pressure Reducing Station Diagram



3.3.5 Highway Crossings

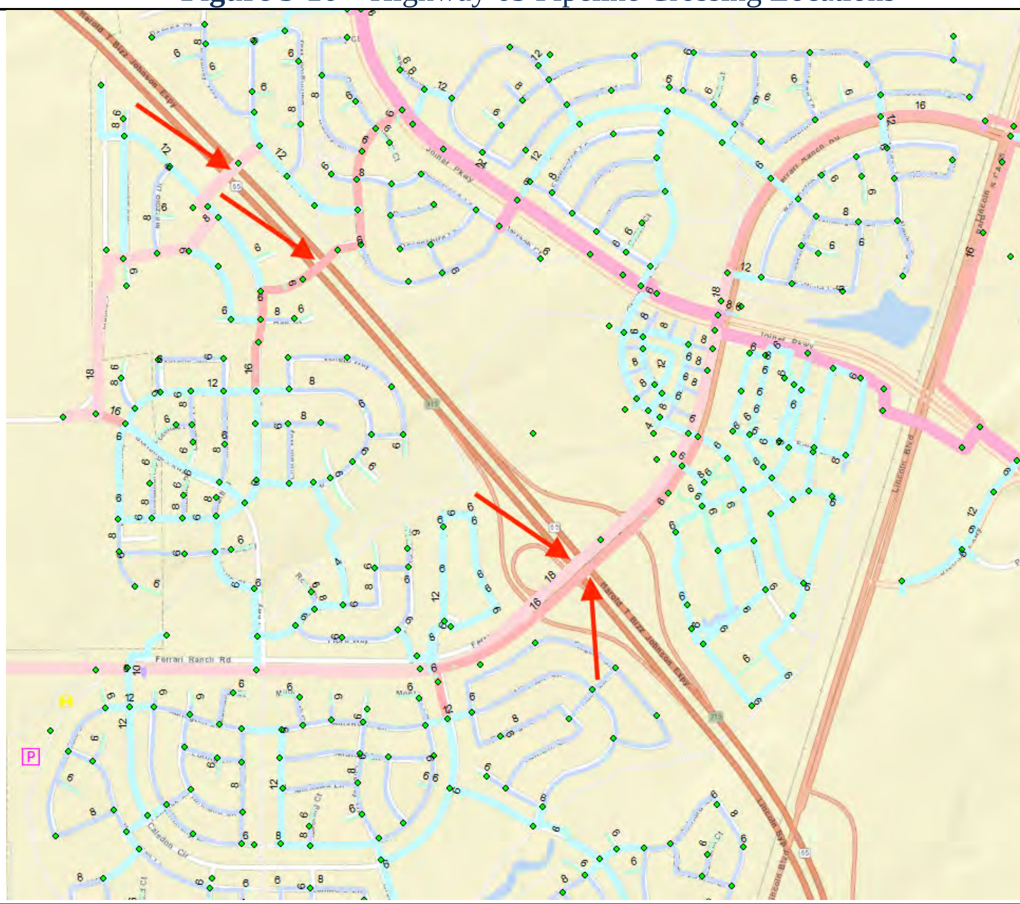
The City of Lincoln currently has 6 water infrastructure pipelines planned to cross Highway 65. Of the 6 pipelines, only 4 have been built and are operating. The 4 in use were built as part of the Lincoln Crossing and Three D developments. A 16-inch water line was built and installed with the Twelve Bridges Drive Overpass but is not being used at this time. The recently completed Nicolaus Overpass was completed with utility easements and conduits in the Nicolaus Overpass bridge but Cal-Trans shows the conduits as only being 14-inches in diameter. The 14-inch sizing of this conduit may limit the utility of this crossing in the future. Outside of the diameter limits in the Nicolaus Overpass crossing yet to be used, the age and materials used in the existing crossings should provide long-term reliable service. **Table 3-3** shows the details of the Highway 65 pipe crossings.

Table 3-3 – Highway 65 Pipeline Crossings

Location	Diameter	Material	Year Installed
Ferrari Ranch	16”	PVC	2000
Ferrari Ranch	18”	PVC	2000
Three D North	18”	PVC	2005
Three D South	16”	PVC	2005
12 Bridges Drive	16” Reported		
Nicolaus Overpass	14” Conduit	Not Installed	Not Installed

Figure 3-16 shows the locations of the Highway 65 pipe crossings described above. Each crossing is located in an area where there is a physical structure (bridge) associated with traffic management.

Figure 3-16 – Highway 65 Pipeline Crossing Locations



Tully & Young Comprehensive Water Planning	Image Sources: City Water System GIS, Licensed ESRI ArcGIS

3.3.6 Auburn Ravine Crossings

The City of Lincoln currently has 3 pipelines that cross Auburn Ravine. Like the Highway 65 crossings, the Auburn Ravine possesses significant technical and financial difficulties when traversing with water utilities. The three pipelines that cross Auburn Ravine are the Joiner Parkway pipeline, the Lincoln Boulevard pipeline, and the McBean Park Drive pipeline. The age of these pipelines and the materials used in constructing these pipelines should provide long-term reliable service for the City of Lincoln's water system. Furthermore, as Village 1 is constructed, the City will have another Auburn Ravine pipeline crossing at extension of Oak Tree Lane capable of providing redundant service to the existing downtown areas. **Table 3-4** shows the details of the Auburn Ravine pipeline crossings.

Table 3-4 – Auburn Ravine Pipeline Crossings

Location	Diameter	Material	Year Installed	Method of Crossing
Joiner Parkway	24"	DIP	2002	Bridge Hung
Lincoln Blvd	16"	PVC	1998	Buried
McBean Park Dr.	24"	PVC	2003	Buried

Figure 3-17 shows the locations of the Auburn Ravine Pipeline Crossings

Figure 3-17 – Auburn Ravine Pipeline Crossing Locations

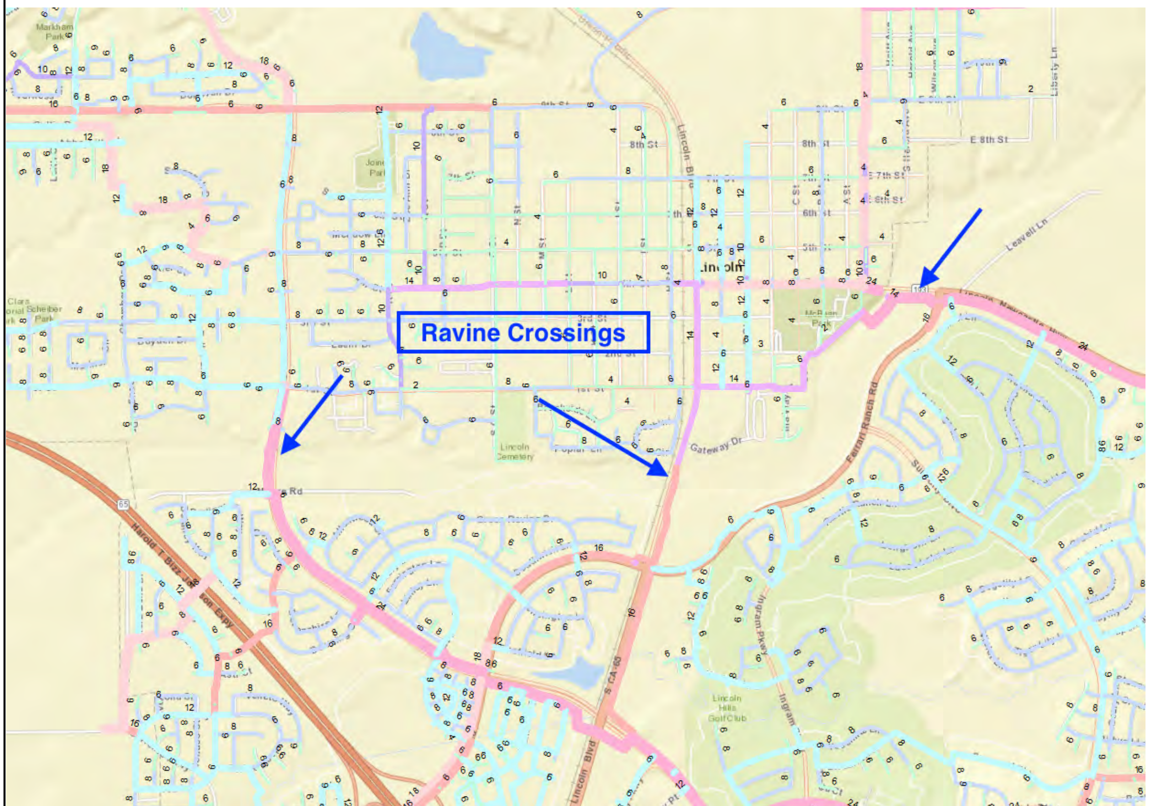


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Image Sources:
City Water System GIS, Licensed ESRI ArcGIS
City Water Model, Innovyze InfoWater

3.3.7 Railroad Track Crossings

The City of Lincoln currently has 7 pipelines that cross the Railroad Tracks. Similar to highway crossings, the railroad crossings present significant technical and financial difficulties when trying to traverse with water utilities. These seven railroad crossings also cross the old Highway 65 (Lincoln Blvd.) that bisects the middle of downtown Lincoln. With the completion of the Highway 65 bypass, water utility crossings on Lincoln Blvd. have become less burdensome. Nevertheless, these railroad crossings represent a significant deficiency in the City infrastructure. Specifically, many of the crossings are undersized to handle the legally required fireflows and several are very old. Only 3 of the crossings are less than 50 years old and larger than 12-inches in diameter. **Table 3-5** shows details of the railroad pipeline crossings.

Table 3-5 – Railroad Pipeline Crossings

Location	Diameter	Material	Year
Gladding & 9th	8"	ACP	1960
7th	8"	ACP	1959
5th	6"	CIP	1929
4th	14"	DIP	1994
1st	6"	CIP	1929
Ferrari Ranch	16"	PVC	2000
Joiner Parkway	24"	PVC	2006

Figure 3-18 shows the locations of the Railroad Pipeline Crossings. As expected, the undersized and aging pipeline are associated with the older parts of the City of Lincoln – pre-dating more stringent modern water system standards.

Figure 3-18 – Railroad Pipeline Crossing Locations

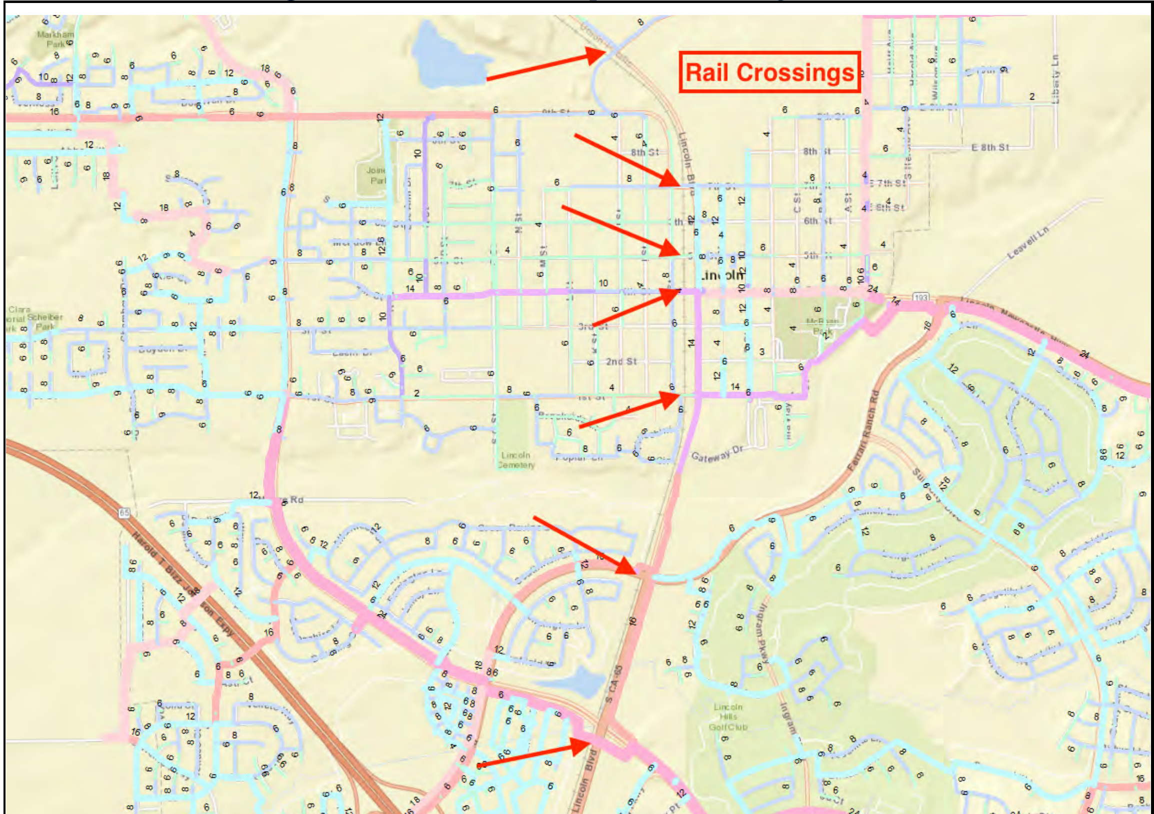

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Image Sources:
City Water System GIS, Licensed ESRI ArcGIS
City Water Model, Innovyze InfoWater

3.3.8 Transmission Main – 30-inch at Reservoir 2

The 30-inch water transmission line out of the Reservoir 2 tank was built shortly after the tank was constructed. The 30-inch line delivers water down the hill to the main transmission loop on Twelve Bridges Drive. This 30-inch water line is slightly undersized for the amount of flow that it transmits during a peak hour in the middle of the summer. The City is currently planning on redundant transmission mains in its water system in order to accommodate future growth while avoiding the option to upsize or duplicate this water line. Water velocities in this line have been shown to be controllable in all stages of future growth, including final build-out. However, this 30-inch line will regularly be near operational limits during peak use periods during the height of the summer water demand. City staff is advised to monitor the condition of this pipeline due to the high operational stresses it sees and current lack of redundancy. Augmenting the City's water delivery system to reduce pressures in this pipeline is a priority future action. **Figure 3-19** shows the location of the 30-inch transmission main.

3.3.9 Transmission Main – 18-inch Twelve Bridges Drive South

The 18-inch transmission main that runs from the intersection of the 30-inch Reservoir 2 South tank transmission main to highway 65 along Twelve Bridges Drive was built in 2001. This 18-inch transmission line is adequately sized for current water system operation as well as planned future City growth. Some sections of the transmission main, where there is no parallel flow through the neighborhood systems, will have high velocities during peak flows as the City approaches build-out. The sections of line that do not have parallel lines may need to be upsized in order to best meet the water transmission and fire safety needs. Improving the entire line by increasing the capacity would likely be constrained by the capacity to cross Highway 65. **Figure 3-19** below shows the location of the 18-inch Transmission Main.

3.3.10 Transmission Main – 20-inch Reservoir 1 3 MG tank to Oaktree Lane

The 20-inch Reservoir 1 Transmission Main runs down the hill from the Reservoir 1 site at the 3 MG Tank to Highway 193. This 20-inch line is one of the older components of the City's water system dating back to the City's own open reservoir treatment (See **Chapter 1**). The 20-inch pipe is known to be in a degraded condition and the easement in place limits the City's ability to perform repairs. This 20-inch transmission line will be up-sized and replaced in the near future as part of the Village 1 development. Current infrastructure plans will have this pipeline re-routed to allow for development grading and placement on a wider, and less-conditioned, easement. **Figure 3-19** shows the location of the 20-inch Reservoir 1 Transmission Main.

Figure 3-19 – Additional Significant Water Infrastructure Components

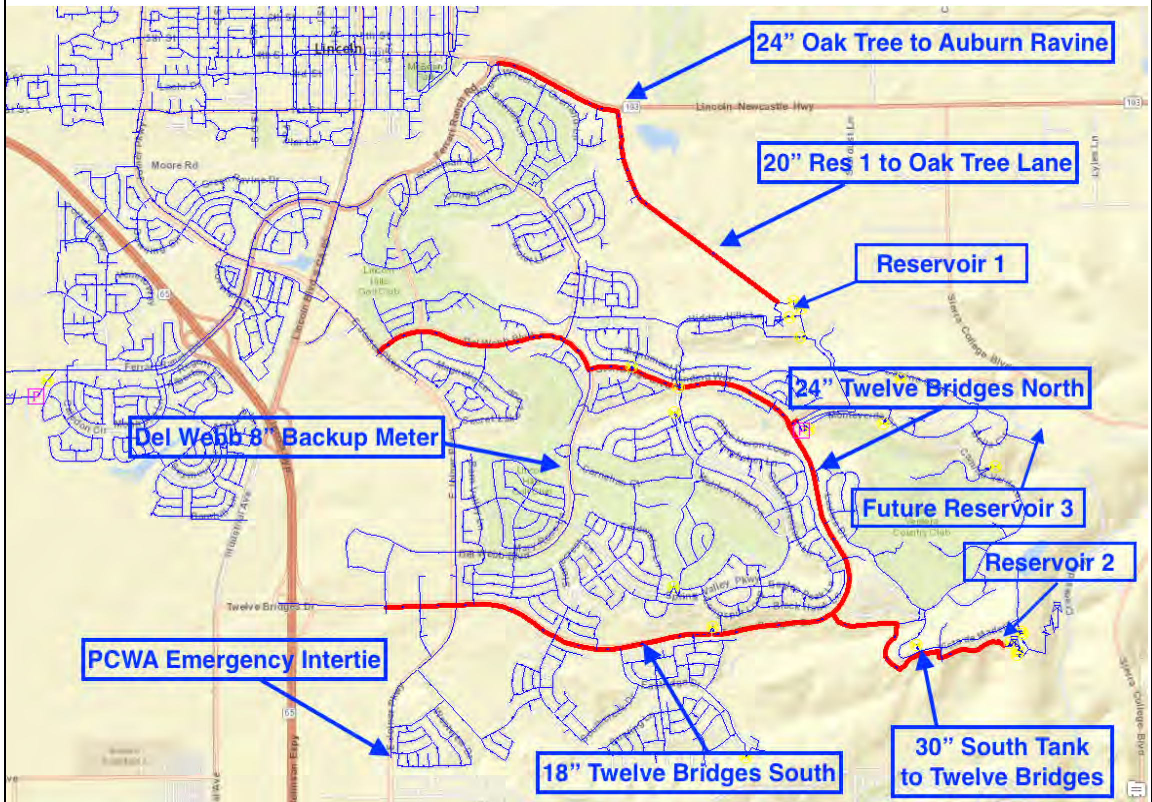

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Image Sources:
City Water System GIS, Licensed ESRI ArcGIS
City Water Model, Innovyze InfoWater

3.3.11 Transmission Main – 24-inch Twelve Bridges

The 24-inch Twelve Bridges Drive transmission main runs from the existing 30-inch transmission main north along Twelve Bridges Drive, continues onto Stoneridge Drive, and then turns north on Del Web Boulevard to Joiner Parkway. This 24-inch line is currently of adequate size but will see high velocities when the City completes the Reservoir 3 10MG tank project at Catta Verdera North. Following completion of the Reservoir 3 tank, a 36-inch pipeline will run down a different portion of Twelve Bridges Drive and meet the existing 24-inch pipeline at the Twelve Bridges and Stoneridge intersection. The extra pressure and flow supplied by this 36-inch pipeline will require pressure reduction valve to limit the velocities in the latter part of this main. The City should upsize or parallel this line any time a section needs repair or maintenance. **Figure 3-19** above shows the location of the 24-inch Twelve Bridges Transmission Main.

3.3.12 Transmission Main – 24-inch Oaktree Lane

The 24-inch Oaktree Lane Transmission Main was built in 2003 and connects to the old 20-inch Transmission Main from Reservoir 1 at the south end of Oak Tree Lane. This 24-inch Transmission Main runs north to 193 and then west to the McBean Park Drive Bridge at Auburn Ravine. This line is currently adequately sized will need to be paralleled with an 18-inch line at some time in the future before build-out. **Figure 3-19** above shows the location of the 24-inch Oaktree Lane Transmission Main.

3.3.13 PCWA Emergency Intertie

The City of Lincoln maintains an emergency intertie with PCWA's treated water system. This 18-inch intertie is located on East Lincoln Parkway at the southern edge of the City Limits. This intertie could receive treated water delivered from the Sunset Treatment Plant and into the City. This emergency intertie has not been used. **Figure 3-19** above shows the location of the PCWA Emergency Intertie.

3.3.14 Del Webb Backup Meter

The City of Lincoln, per the Developer Agreement with the Del Webb Corporation and its successors-in-interest, maintains an 8-inch water meter connected to the City's potable water system. This water meter would allow potable water to discharge into a drainage way, under emergency conditions, to help maintain water flows through the wetlands and golf course areas of the Del Webb development. The 8-inch meter installation is manually operated and has not been in use since its installation. If this meter were turned on and water discharged into the wetlands area, the City's overall water demands would greatly increase and it could jeopardize the City's ability to meet its gallons per capita per day (GPCD) targets as required by law. Further evaluation of the Del Webb Backup Meter is warranted.[4] The location of the Del Webb Backup Meter is shown in **Figure 3-19** above.

3.4 Older City Infrastructure

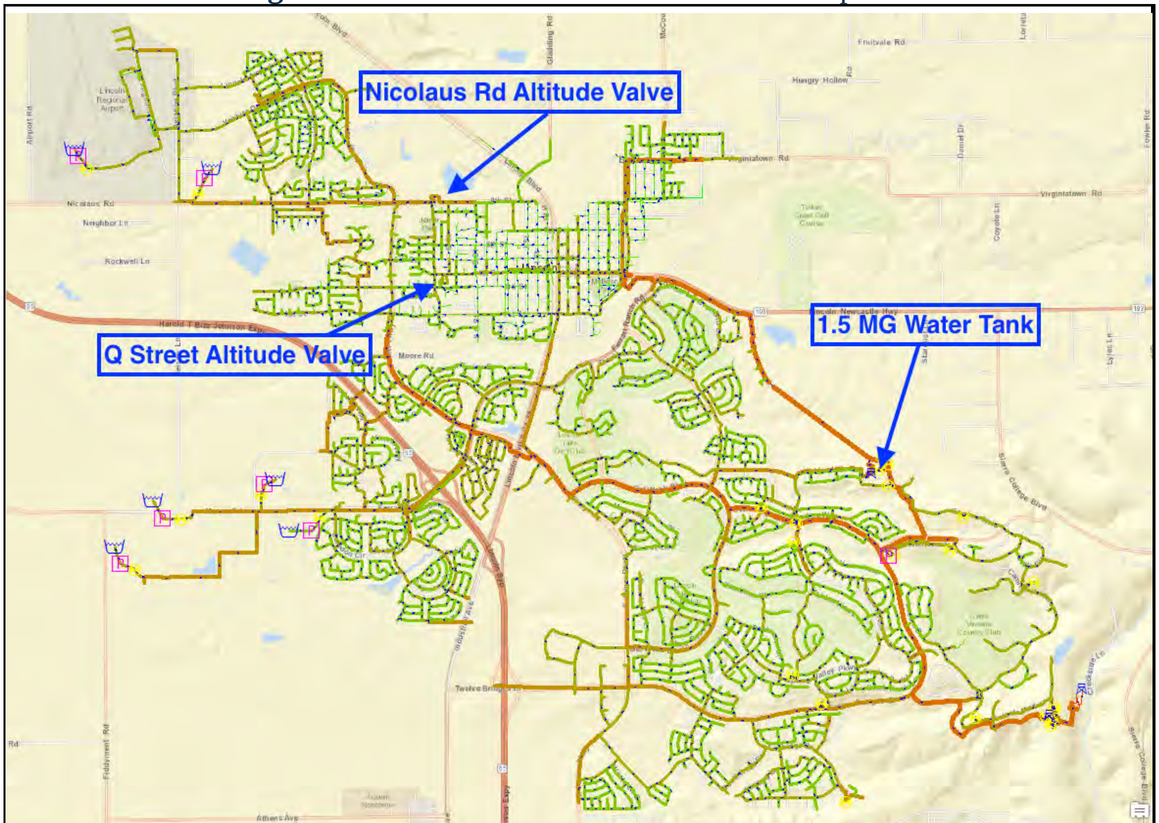
The City of Lincoln has a number of older infrastructure items in its water system that implicate long-term reliability as further developed in **Chapter 7**. Although the replacement schedule for these items is more fully discussed in **Chapter 10**, this section identifies the main time-worn components. These components include altitude valves, transmission mains, and a water tank.

[4] This potential water service to Del Webb is also discussed in both **Chapters 5** and **7** of this CWMP.

3.4.1 Nicolaus Road and Q Street Altitude Valves

The City has two older altitude valves. The first altitude valve is located near Log Deck in Nicolaus road. This non-operational, bypassed altitude valve is a remnant of the pressure reduction system that used to separate the PCWA surface water supplied area from other areas in the City. Specifically, it historically separated the PCWA delivery area from the airport area. In 2002, with the installation of the 24-inch pipeline from the Del Webb development, looping into the southwestern portion of the City north of the Auburn Ravine via Joiner Parkway, the altitude valve installation became obsolete. The second altitude valve that is obsolete is located near Q and 4th Streets. This altitude valve also became obsolete upon the installation of the 24-inch pipeline from the Del Webb development. These two altitude valves are shown in **Figure 3-20**.

Figure 3-20 – Older Water Infrastructure Components



Tully & Young Comprehensive Water Planning	Image Sources: City Water System GIS, Licensed ESRI ArcGIS City Water Model, Innovyze InfoWater

3.4.2 1.5 MG Water Tank

The existing 1.5 MG steel gravity storage tank at the Reservoir 1 site was used in the City's older water infrastructure and distribution system. The 1.5 MG tank was operated successfully until the 3 MG replacement tank was completed (this tank is more fully described in **Section 3.2.2.3**). At that time, the 1.5 MG tank was taken off-line and dewatered due to concern related to its structural integrity. Specifically, damage was caused to the tank from seismic activity and corrosion. The tank will not be returned to potable water service and should be removed in the future.

3.5 Fire Hydrants

The City of Lincoln has 1998 fire hydrants mapped in GIS and additional fire hydrants that have not yet been mapped in that system. **Figure 3-21** shows the location of all fire hydrants mapped in the City's GIS database. Due to fire code changes, newer developments have more hydrants spaced closer together. The fire hydrants and their associated installation dates are listed in **Table 3-6** below. The fire hydrants listed have installation times dating back to 1929. However, many of these older hydrants have been replaced yet those replacements have not been updated in the GIS database.

Figure 3-21 – City of Lincoln Fire Hydrant Locations

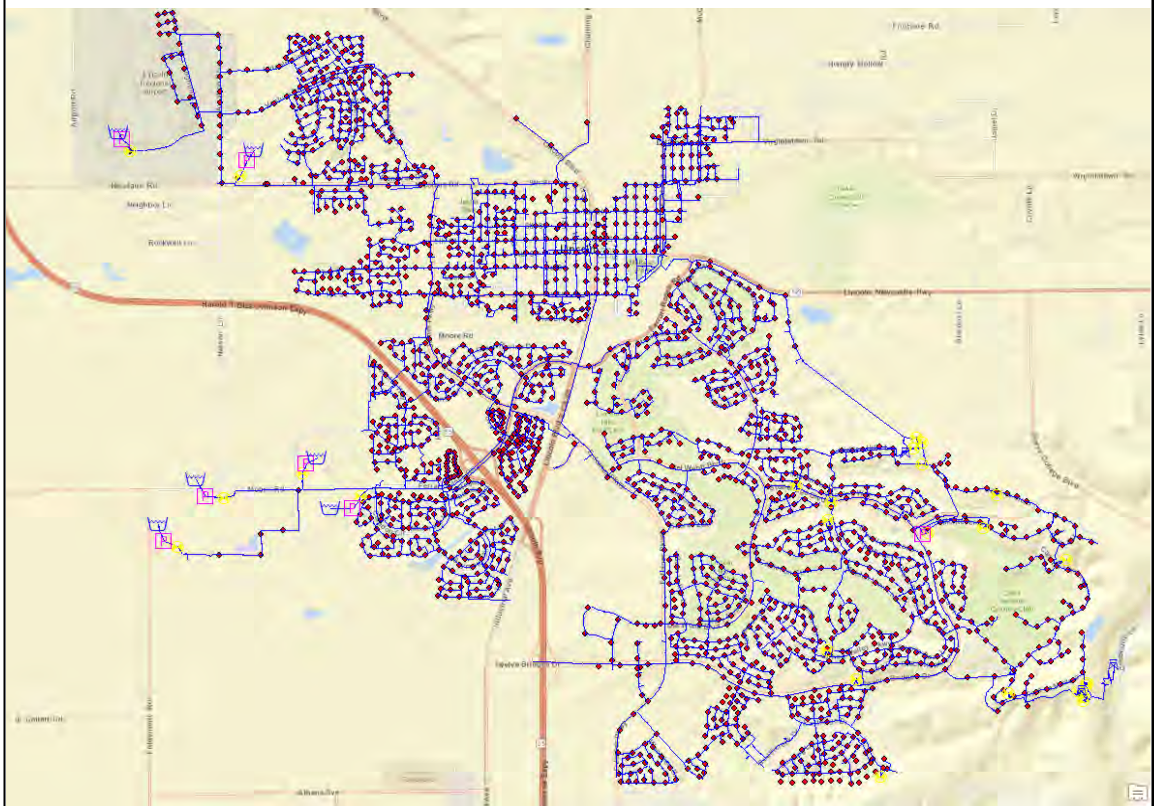


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Image Sources:
City Water System GIS, Licensed ESRI ArcGIS
City Water Model, Innovyze InfoWater

Table 3-6 – Fire Hydrants and Installation Dates

Year Installed	Count
__-1929	43
1930-1959	48
1960-1979	70
1980-1989	122
1990-1999	353
2000-2009	1362
Total	**1998**

CHAPTER 4. WATER DEMAND CHARACTERISTICS

Understanding water demand characteristics is essential to enable the City of Lincoln to reliably forecast future customer water demands and then plan for and secure reliable water supplies. Further, securing water supplies that is based on the demand calculations requires the City to plan and budget for the necessary improvements to the delivery system infrastructure. This section characterizes the City's forecast water demands to build-out[1] and discusses the translation of that annual demand forecast into values important for infrastructure planning. This chapter is organized as follows:

- *Existing Customer Demand and Characteristics* – This section presents customer demands from the past several years, characteristics that affect these existing demands, and a discussion of likely reduction in demands due to on-going water use efficiency efforts.

- *Future Demand Forecasts* – This section describes the detailed assessment of anticipated growth, likely demand factors, and the resulting expected incremental expansion in demand over the next 50 years.

- *Relationship Between Demand Forecasts and Infrastructure Planning* – This section describes how annual demand relates to infrastructure sizing and planning, current water supply contract language, and the impacts of recent and expected conservation on previous planning and infrastructure investments.

- *Recommendations* – This subsection provides recommended actions that will continue to inform the City during on-going and future master planning efforts.

4.1 Existing Customer Demand and Characteristics

Over the past several years, the City has served about 10,000 acre-feet per year (af/yr) on average to a population of over 45,000 through approximately 17,700 single-family residential connections, over a thousand multi-family units, and over 500 non-residential parcels. As shown in **Table 4-1**, the City's "gross water use" – defined as the water entering the distribution system to meet the demands of its customers – has dropped significantly in 2014 and 2015 compared to 2012 and 2013 even with a slight increase in the population. This drop, however, is fully attributable to the significant drought that began in 2013, causing concerns throughout California that resulted in the Governor mandating all water purveyors meet prescribed conservation targets. The City was tasked with meeting a 32 percent conservation goal between June 2015

[1] This information is consistent with the City's recently adopted 2015 Urban Water Management Plan (UWMP), but extends the demand forecast beyond 2040 to buildout. The UWMP limited the demand forecast to 2040.

and February 2016. Through December 2015, the City successfully achieved a 33.3 percent cumulative savings (compared to 2013 conditions – which was the State's baseline).[2]

Table 4-1 – Recent City Population and Annual Water Demand

Year	Population	Gross Water Use (af/yr)
2010	42,819	9,203
2011	43,142	9,481
2012	43,915	10,091
2013	44,336	10,858
2014	45,259	8,948
2015	45,837	7,628

Because of the annual variance driven by external forces, a representative existing demand for the City was established as 10,174 acre-feet per year (see **Table 4-2**). As explained below, the derivation of this representative value is intended to provide the City with an understanding of "current" conditions so it can assess how the future demand of those existing customers may change over time – a value that is added to the forecast demands of future customers (explained in the next section).

Table 4-2 – Representative "Existing" Customer Demand

Land-class	Representative Unit Counts	Current Demand Factors (af/account)	Representative Demand (af/yr)
Multi-Family	1,873	0.30	562
Single Family	16,486	0.46	7,584
Commercial	247	0.99	245
Industrial	7	2.15	15
Public	23	2.57	59
Parks/Landscapes	186	3.73	694
		Subtotal	9,158
		System Loss (at 10%)	1,017
		Total	10,174

The "representative unit counts" for the residential customers in **Table 4-2** were derived from the Department of Finance (DOF) population and housing data as of January 1, 2015. Specifically, the "single family" classification includes only single family, detached units. All single family

[2] Based on report from the SWRCB available at: http://www.waterboards.ca.gov/water_issues/programs/conservation_portal/docs/2016feb/suppliercompliance_020216.pdf.

attached, small condos, apartments and mobile homes are combined under the "multi-family" class. This readily available DOF data groups together different home-types, home ages, lot densities, and occupancy rates, resulting in the need for a representative unit demand factor that also blends these factors to also be used. Using findings from the City's meter studies (discussed in **Section 4.2**), a single demand factor was developed that was consistent with the meter study findings, yet allowed the total estimated water demand to fall within the range of recent water use as shown in **Table 4-1**. The chosen representative demand factor for each land-use class is presented as "current demand factors" in **Table 4-2**. For the two residential land-use classes, the current demand factors use the highest value for each class from those determined during the meter studies for each similar class (e.g. the meter studies reflected at least three separate demand factors to represent different future lot densities, the highest of these was used to reflect the current single family use factor).

The City also recognizes that the existing customer demand factors are not static and are expected to lessen over the next few decades as existing customers continue to use water more efficiently. Existing customers' future unit demand factors are assumed to change mostly from demand drivers such as general homeowner fixture replacements and upgrades, increased awareness and management by homeowners of landscape irrigation scheduling, the City's conservation awareness and incentive programs, and other factors affecting a general increased awareness of water conservation. The future unit demand factors for existing customers reflect a reduction from the current value in **Table 4-2**, but are still within the range of factors determined during the City's meter studies.

4.2 Future Demand Forecasts

This section provides the detailed basis for incremental demand forecasts that form the foundation for securing water supplies and constructing necessary delivery infrastructure. The key factors driving the forecasts include: (a) land-use based demand factors, (b) characteristics of anticipated growth, and (c) system losses. This section is organized to provide the details for each of these factors.

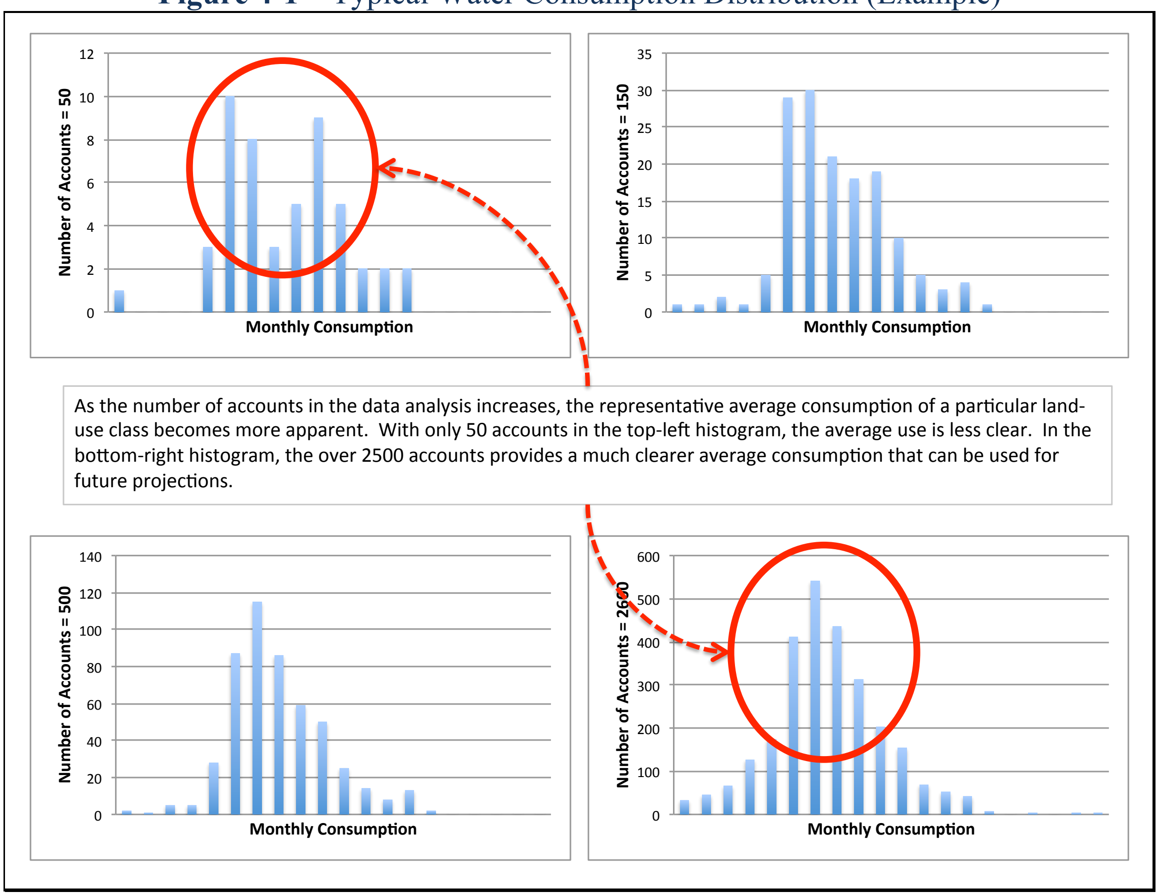
4.2.1 Land-use Based Demand Factors

A demand factor represents a generalized rate of annual water use by a customer. A demand factor is often differentiated by the customer type or land classification (e.g. a single family residential home versus a commercial building). Using demand factors that are uniquely distinguished for current and future customers allows for projections of future water demand to be based on current customer use and trends, as well as being representative of future homes and buildings that must adhere to new, more stringent, water efficiency standards.

Development of usable existing and future demand factors is based on the availability of existing customer water meter data and other readily available factors. Often, this customer meter data has only recently become available and easily manageable for these purposes (water meters were legally mandated in the early 90s). The City is fortunate to be completely metered, providing a useful data source for demand factor development.

As more fully discussed in the next subsection, the large number of individual meters with fairly extensive historic data provided the opportunity to assess enough specific customer types to provide a high level of confidence in the resulting demand factors. As represented in **Figure 4-1**, having a larger number of data points for a particular customer type improves the resulting representative monthly demand. This improvement is due to the diminished effect of outliers on the resulting average and median use – allowing better use patterns to emerge that provide a sound basis for determining demand factors.

Figure 4-1 – Typical Water Consumption Distribution (Example)



4.2.1.1 City's Legacy Demand Factors

During preparation of the City's 2010 UWMP, it was apparent that the City already preceded most other urban suppliers in its use of land-use based demand factors. Up to that point, the City's demand factors, however, were derived from customer use data from the 1990's, before the development of statewide efficient plumbing codes. Moreover, at that time, the City was less than 20 percent of its current size. Thus, the old factors were based on limited meter data, general representations of land use through the use of engineering estimates, and industry standard flow rates. Though better than many methods and data sources, these early demand factors had been losing accuracy with the City's rapid expansion as they tended to overestimate the annual demand of the majority of newer City customers. Due to new plumbing codes and changes in development types, which generally included larger houses on smaller lots, both indoor and outdoor average demands had been dropping. With over 80 percent of the development in the City occurring since 1993, when efficient plumbing codes were first established, the majority of the houses in the City were using less water than anticipated using the 1990's data. These older demand calculations were used for projecting buildout demand in the City's 2008 General Plan. While significantly more accurate than a simple use-per-person basis using population projections, the limited use of the more recent (at the time) meter data meant projections contained many assumptions that exaggerated actual water use by the City's customers.

4.2.1.2 Analysis using 2010 Residential Data

In early 2011, the City undertook a refined analysis of its residential customer use data to develop more appropriate demand factors for use in the 2010 UWMP update (which was being drafted in early 2011). Using a more extensive data set as well as finer discretion between types of residential customers (e.g. older versus new homes, smaller versus larger lots), the City generally found residential demand factors were lower than previous values used by the City. This new study (hereafter the "2011 Meter Study") also found a variance in demand factors based upon the age of structures, the development style (e.g. lot and house size), as well as definitive downward trending of indoor water use most likely attributed to new plumbing code regulations and the availability of water efficient fixtures and appliances.

4.2.1.3 Updated Analysis using 2013 Customer Data

To inform the 2015 UWMP and this WMP, additional residential data was reviewed and assessed. In addition, non-residential meter data was more fully analyzed (hereafter the "2015 Meter Study"). With drought conditions affecting customer water use in 2014 and 2015, water meter data from 2013 was obtained as it best represented "normal" water use for purposes of improving upon the 2011 Meter Study results. Though a comprehensive GIS database was still unavailable, complete access to the 2013 billing database provided ample data for a wide array of customer types. The 2015 Meter Study focused on refining or verifying the residential demand factors derived in the 2011 Meter Study with the availability of more data points for residential users, and developed more accurate numbers for the commercial, industrial, and public land uses.

4.2.1.4 Representative Demand Factors for Current Customers Use

Using the results from the 2011 Meter Study and those additions refined by the 2015 Meter Study, the following demand factors by land-use classification form the basis for use in demand forecasting.

Residential Country Estates

Country Estates are defined as very low density residential lots at approximately 1.0-2.9 dwelling units per acre (DU/Acre), generally inclusive of large, upscale homes. The demand factor from the 2008 General Plan assumed 1.22 acre-feet (AF) per DU per year. This prior demand factor was inclusive of a 15% loss factor, which would make the pre-loss demand factor about 1.06 acre-feet per dwelling unit per year (AF/DU/Yr). The 2011 Meter Study analyzed about 130 homes in the Catta Verdera development (representing about 15% of the total dwelling units in this category). To account for vacant homes due to the economy, all minimal use customers were excluded from the sample. The 2011 Meter Study determined a demand factor of 0.85 AF/DU/Yr. The 2015 Meter Study revisited this land classification for over 80 homes, resulting in a minimal increase to 0.86 AF/DU/Yr.

Low Density Residential

The Low Density Residential (LDR) category includes houses with densities ranging from 3.0-5.9 DU/Acre. The demand factor from the 2008 General Plan assumed 0.61 AF/DU/Yr, inclusive of a 15% loss factor – resulting in a representative customer demand factor of 0.53 AF/DU/Yr.

This unit type represents the majority of the City's residences, with a large variability in the ages of the structures. The older homes are located on the numbered and lettered streets surrounding the original downtown. By inspection of satellite imagery, these homes typically had minimal landscaping compared to the newer construction that began in earnest in the 1990's. These more recent residences were categorized as post-1993 homes and reflect efficient plumbing standards and tract-style developments where groups of homes are typically built almost simultaneously. The post-1993 homes typically have full property landscaping, but the residence itself commonly occupies more of the lot as compared to older homes in this class. The difference in these categories was confirmed during the 2011 Meter Study, identifying the post-1993 construction having higher peak summer demands while older homes had higher winter-only flows (reflecting indoor use).

The data sample for the 2011 Meter Study represented about 460 of the older homes and 550 of the post-1993 homes. These categories produced two different demand factors which were weighted to generate an average for this existing land class. This sample is estimated to represent just over 10% of the total number of homes in this land class. The results from the 2011 Meter Study indicated a demand factor of 0.46 AF/DU/Yr.

The 2015 Meter Study included data for over 600 homes from various locations throughout the City. The 2015 Meter Study showed a variance of less than 1% from the results of the 2011 Meter Study, but greater variance by neighborhood. The average demand factor was maintained at 0.46 AF/DU/YR. Because of the neighborhood variance, a future meter study that incorporates GIS technology to easily differentiate variables would be helpful to further define subcategories at this housing density and help refine future demand estimates.

Medium Density Residential

The Medium Density Residential (MDR) category includes houses with densities ranging from 6.0-12.9 DU/Acre. The demand factor from the 2008 General Plan assumed 0.52 AF/DU/Yr, which was inclusive of a 15% loss factor – resulting in a factor of 0.45 AF/DU/Yr.

This unit type of property represents duplexes and other larger attached, or small lot detached housing – as is often associated with new development proposals. This unit class is found primarily on the west side of the City, but is expected to be a large part of future development in the City's designated growth areas. Medium density housing is a newer portion of modern development and, as a result, the majority of these unit types are new and not subject to great variability in the ages of the structures. Due to the relatively small number of these structures the sample size was limited to 55 units for the 2011 Meter Study. The results from the 2011 Meter study indicated a demand factor of 0.29 AF/DU/Yr.

Residential Demand Analysis Example

The 2015 Meter Study analyzed data from 434 meters in this land use category and found no change from the findings of the prior study.

A few of the City's proposed developments also use this designation, but represent larger lots and non-age restricted housing (many of the units analyzed in the meter studies include houses with the Del Webb and other age-restricted communities). This caused the need to establish development-specific demand factors. As an example, Village 5's MDR identifies larger lots than existing MDR, but fell between major land use categories. A Village 5-specific demand factor was calculated using standard indoor demands, coupled with outdoor estimates for lots at the upper end of the MDR density range. The result was a Village 5-specific demand factor for MDR of 0.39 AF/DU/Yr.

High Density Residential

The High Density Residential (HDR) category includes houses with densities ranging from 13.0-25.0 DU/Acre. The demand factor from the 2008 General Plan assumed 0.29 AF/DU/Yr, inclusive of a 15% loss factor – resulting in a demand factor of 0.25 AF/DU/Yr. This type of property is typically associated with apartments and townhomes. This unit class is found primarily on the west side of the City but is also part of designated land classes in future development expected within growth areas. High Density housing is generally a newer portion of the City's development and as a result, the majority of these unit types are relatively new, built after the introduction of plumbing codes, and not subject to great variability in the ages of the structures. The 2011 Meter Study sample size was limited to about 150 units. The result of the 2011 Meter Study indicated a demand factor of 0.22 AF/DU/Yr.

The 2015 Meter Study used data from 200 meters in this land use category. The newer data resulted in a slight revision to a demand factor of 0.21 AF/DU/Yr.

Commercial, Office, Business, and Professional Land Uses

This land-use class can have significant variances when assessed individually, limiting the usefulness of individual meter analysis. However, grouping the set of commercial operations that may share a parcel area (e.g. share a parking lot) provides for averaging the water use of different types of commercial operations – resulting in a more functional demand factor for use in forecasting. Distinct demand classes saw significant decreases in projected demands. Most of the analysis for this land-use class was completed in the 2015 Meter Study. For comparative purposes, the 2008 General Plan used a demand factor of 2.8 AF/AC/Yr for this generalized land-use class.

For the 2015 Meter Study, businesses were grouped together for analysis resulting in a much more realistic projection of future demands for the following three sub-classifications:

Village Commercial/Retail Commercial Land Use Demand Factor

This subclass includes shopping centers, larger format retailers, hotels/motels, banks, and restaurants, meant to serve the City's residents. The 2015 Meter Study resulted in a demand factor of 0.99 AF/AC/Yr – significantly lower than the assumptions used in the 2008 General Plan.

Office/Commercial Land Use Demand Factors

This subclass includes fitness centers, financial institutions, restaurants, other business services, and other appropriate supporting businesses meant to serve as freeway accessible moderately intensive employment.

The 2015 Meter Study resulted in a demand factor of 0.99 AF/AC/Yr – significantly lower than the assumptions used in the 2008 General Plan.

Business and Professional Land Use Demand Factors

This subclass includes medical offices, clinics, and professional business office space.

The 2015 Meter Study resulted in a demand factor of 1.22 AF/AC/Yr – still lower than the assumptions used in the 2008 General Plan. This subclass is higher primarily due to the inclusion of medical facilities in the meter study.

Public Land Uses

This land use category is comprised of municipal land (City buildings and grounds), parks, and schools. The demand factor from the 2008 General Plan assumes 5.82 AF/AC/Yr, inclusive of a 15% loss factor – resulting in a pre-loss demand factor of 5.06 AF/AC/Yr. The 2015 Meter Study separated available customer use data and analyzed the following subclasses:

Schools

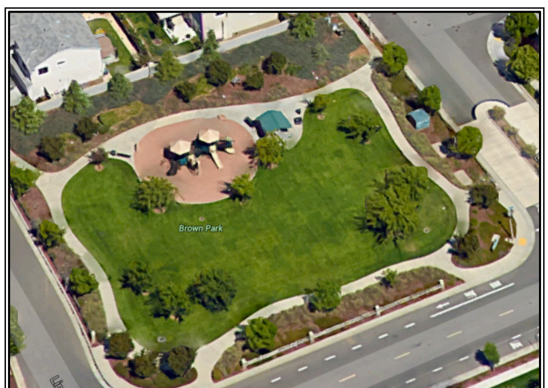
A school-specific demand factor was developed during the 2011 Meter Study – estimated at 2.57 AF/AC/Yr. But, due to the limited or non-existing billing information, the value was simply estimated by measuring lot size percentages in GIS and applying general demand factors. However, the 2015 Meter Study did analyze use data and confirmed the prior representative demand factor.

Public/Quasi-Public

This land use class is anticipated to include water demands from safety facilities such as fire stations, utilities, local government offices and facilities, community centers, and other similar uses. Due to the lack of billing information available for the 2011 Meter Study, the previous demand was estimated by measuring lot size percentages in GIS an applying general demand factors, with a resulting demand factor of 2.80 AF/AC/Yr. The 2015 Meter Study confirmed these demand factors.

Parks and Linear Parks

The 2011 Meter Study identified a demand factor of 3.55 AF/AC/Yr for typical neighborhood and community parks. However, many of the new developments also include "linear parks" that have differing proportions of non-irrigated areas (e.g. hardscape) than compared to neighborhood and community parks. The 2015 Meter Study determined these linear parks should have a demand factor of 3.73 AF/AC/Yr.[3]



Typical Neighborhood Park

[3] Linear Park Acreages were found to be limited to landscape areas more than typical parks that included other areas in total acreages including parking areas and other hardscapes.

Other Miscellaneous Uses

Recently proposed projects within the City have additional miscellaneous land uses including right of way landscaping, and various designations of open space (e.g. agricultural preserve, wildlife preserve, or common). These newer land-use classifications have not previously been assessed to understand specific demand factors. These uses have minimal impacts to the overall projected water use due to their limited water needs, and/or because they are temporary in nature. The following provides guidance used for demand forecasting.

Open Space

Open Space is often either planted with native landscaping or is left in its natural, undisturbed state. Either way, this designation does not require water over the long-term.

However, when native landscaping is planted, some water is necessary for plant-establishment. This demand may last for a few years after planting, after which the plants rely on natural precipitation. Establishment water, when necessary, uses a conservative demand factor of 3.73 AF/AC/Yr. Establishment irrigation is only anticipated to occur for less than 5 years.

Right-of-Ways

The 2011 Meter Study analyzed the demands for median landscaping and derived a demand factor that reflects the majority of this class is hardscaped (e.g. roadways), resulting in a minimal demand factor of 0.19 AF/AC/Yr for the entire right-of-way area (e.g. inclusive of the roadways, sidewalks, etc.).

Right-of-way Landscaping Example

High Water Use Industrial

High water using industrial customers, such as Gladding-McBean and Sierra Pacific Industries, use large quantities of potable City water, but also take up large areas within the City. These specific high-water users are reflected in demand forecasts based on their individual meter data records, so unit-based demand factors are not applicable.

4.2.1.5 Summary of Demand Factors

This section summarizes the demand factors developed from the 2011 Meter Study and 2015 Meter Study as applicable to forecasting the City's water demand.

These demand factors should not be considered static, as a variety of factors will continue to influence future land-use class-based demand factors. Demand factors should be analyzed about every 5 years. Given some of the lasting impacts of the recent drought on individual use and water use habits, many of these demand factors will likely be adjusted further downward.

Additionally, trend tracking of the City's demand factors over time will provide a useful tool in updating and refining future water system analysis.

These demand factors represent the most current and complete analysis available for the City and reflect factors used to forecast demands presented in the 2015 UWMP.

Residential demand factors are presented in **Table 4-3** and non-residential demand factors are in **Table 4-4**.

Table 4-3 – City of Lincoln Residential Annual Demand Factors

Residential Demand Category	Average Density (du/ac)	Indoor Factor	Outdoor Factor	Total Demand Factor (af/du)
Country Estate	2.0	0.19	0.67	0.86
Low Density	5.0	0.19	0.27	0.46
Medium Density (Village 5)	7.0	0.18	0.21	0.39
Medium Density	9.0	0.18	0.11	0.29
High Density	21.0	0.17	0.04	0.21

Table 4-4 – City of Lincoln Non-Residential Annual Demand Factors

Land Use	Demand Factor	Unit
Village Commercial	0.99	af/ac
Commercial	0.99	af/ac
Office/Commercial	0.99	af/ac
Business and Professional	1.22	af/ac
Elementary Schools	2.57	af/ac
Middle School	2.57	af/ac
High School	2.57	af/ac
Public/Quasi-Public	2.80	af/ac
Parks	3.55	af/ac
Linear Park	3.73	af/ac
Open Space (establishment only)	3.73	af/ac
Right of Ways	0.19	af/ac

4.2.1.6 Influencing Future Demand Factors

There are several factors that affect the development of future unit water demand that will be used by the City for future evaluations and updates to demand forecasts. These range from state mandates to changes in the types of housing products being offered, to simple changes in customer behavior. While the demand factors presented in **Table 4-3** and **Table 4-4** are likely conservative in that they do not reflect theoretical reductions from many evolving factors, they provide the City with a level of certainty for near and mid-term demand forecasts. Characteristics of the most important factors are described below.

Water Conservation Objectives

On November 10, 2009, Governor Schwarzenegger signed SBX7-7, which required each urban water supplier to reduce its per-capita water use by 2020, with a statewide goal of achieving a 20-percent reduction by 2020.[4] The City has established a 2020 Target GPCD in response to this requirement and its current use (see **Table 4-1**) nearly meets this target already.[5] In May 2016, Governor Brown issued an executive order (EO B-37-16) that, among other things, directed the State Water Resources Control Board (Board) to build upon the 20 percent reduction goal.[6] The Board is currently evaluating methods to achieve this directive, with new conservation targets potentially in place by 2020.

Indoor Infrastructure Requirements

In January 2010, the California Building Standards Commission adopted the statewide mandatory Green Building Standards Code (hereafter the "CAL Green Code") that requires the installation of water-efficient indoor infrastructure for all new projects beginning after January 1, 2011. The Cal Green Code was revised in 2013 with the revisions taking effect on January 1, 2014; however these revisions do not have substantial implications to the water use already contemplated by the 2010 Cal Green Code.[7] The CAL Green Code applies to the planning, design, operation, construction, use and occupancy of every newly constructed building or structure.

All new developments must satisfy the indoor water use standards directed by the CAL Green Code, which essentially require new buildings and structures to reduce overall potable water use by 20 percent. Expected future customers will satisfy the standards through the use of appliances and fixtures such as high-efficiency toilets, faucet aerators, on-demand water heaters, or other fixtures as well as Energy Star and California Energy Commission-approved appliances.

California Model Water Efficient Landscape Ordinance

The Water Conservation in Landscaping Act was enacted in 2006, requiring the Department of Water Resources to update the Model Water Efficient Landscape Ordinance (MWELO).[8] In 2009, the Office of Administrative Law (OAL) approved the updated MWELO, which required a

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[4] California Water Code § 10608.20.
[5] See the City's 2015 UWMP, Chapter 4, for further details.
[6] https://www.gov.ca.gov/news.php?id=19408
[7] "The 2010 CAL Green Code was evaluated for updates during the 2012 Triennial Code Adoption Cycle . HCD evaluated stakeholder input, changes in technology, implementation of sustainable building goals in California, and changes in statutory requirements. As such, the scope of the CAL Green Code was increased to include both low-rise and high-residential structures, additions and alterations." *Guide to the 2013 California Green Building Standards Code (Residential)*, California Department of Housing and Community Development, 2013.
[8] Gov. Code §§ 65591-65599.

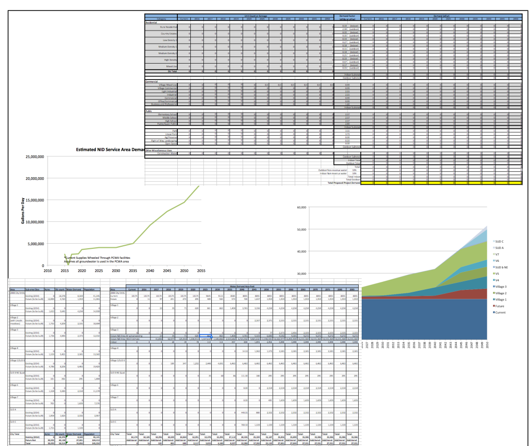
retail water supplier or a county to adopt the provisions of the MWELO by January 1, 2010, or enact its own provisions equal to or more restrictive than the MWELO provisions.[9]

In response to the Governor's executive order dated April 1, 2015, (EO B-29-15), DWR updated the MWELO again and the California Water Commission approved the revised MWELO on July 15, 2015. The changes include a reduction to 55 percent for the maximum amount of water that may be applied to a landscape for residential projects, which reduces the landscape area that can be planted with high water use plants, such as turf. The MWELO applies to new construction with a landscape area greater than 500 square feet (the prior MWELO applied to landscapes greater than 2,500 sf).[10] For residential projects, the coverage of high water use plants is reduced to 25 percent of the landscaped area (down from 33 percent).

It is difficult to predict the ultimate impact of the MWELO requirements on future water demand. While the requirement is for development of a landscape design plan that uses plants and features that are estimated to use no more than 55 percent of ETo, some recognition must be made for the inherent tendency to overwater even with irrigation controllers installed, piecemeal changes in landscape design, reductions in irrigation efficiency through product use, and limited resources for enforcement in the absence of dedicated irrigation meters.

4.2.2 Characteristics of Anticipated Growth

The City is in a unique position to couple the significant amount of land-use data with land-use based demand factors to develop a useful representation of expected demand over time. Land use information from the 2008 General Plan, various development Specific Plans or tentative map applications, and existing approved projects (yet to be built) provide a picture of anticipated rates of growth, types of expected growth and locations of that growth. This data supports forecasts of annual demand, but also becomes invaluable to integrate with the City's water infrastructure model to more practically anticipate delivery system improvements and potential limitations.


Master Planning Tool

To facilitate this effort, a comprehensive set of tables were constructed in a "living" Excel workbook (hereafter titled the "Master Planning Tool"). The Master Planning Tool includes an extensive number of individual tables developed to represent the various

[9] California Code of Regulations (CCR), Tit. 23, Div. 2, Ch. 27, Sec. 492.4. The MWELO provides the local agency discretion to calculate the landscape water budget assuming a portion of landscape demand is met by precipitation, which would further reduce the outdoor water budget.

[10] CCR Tit. 23, Div. 2, Ch. 27, Sec. 490.1.

land use data as understood by the City at any given point in time. The Master Planning Tool is meant to be a dynamic Excel workbook to allow the City to routinely update land use or water use information and re-evaluate forecast demand quantities and timing. Specifically, the Master Planning Tool represents the following land-use sources, listed by increasing level of certainty and/or detail regarding land-use plans:

2008 General Plan

The future projects accounted for in this subset of tables are derived from the 2050 General Plan adopted in 2008. The 2008 General Plan presents a number of Villages to be built in the City's Sphere of Influence (SOI) and provides a vision of housing densities and proportions of each density. These future areas with only the General Plan vision used to prepare a demand estimate represent the least developed City projects and furthest out time wise. Many of these projects are not anticipated to begin construction for more than 20 years. More information about the water model is discussed in **Chapter 9**, the Model Presentation and Assumptions Chapter.

Specific Plans

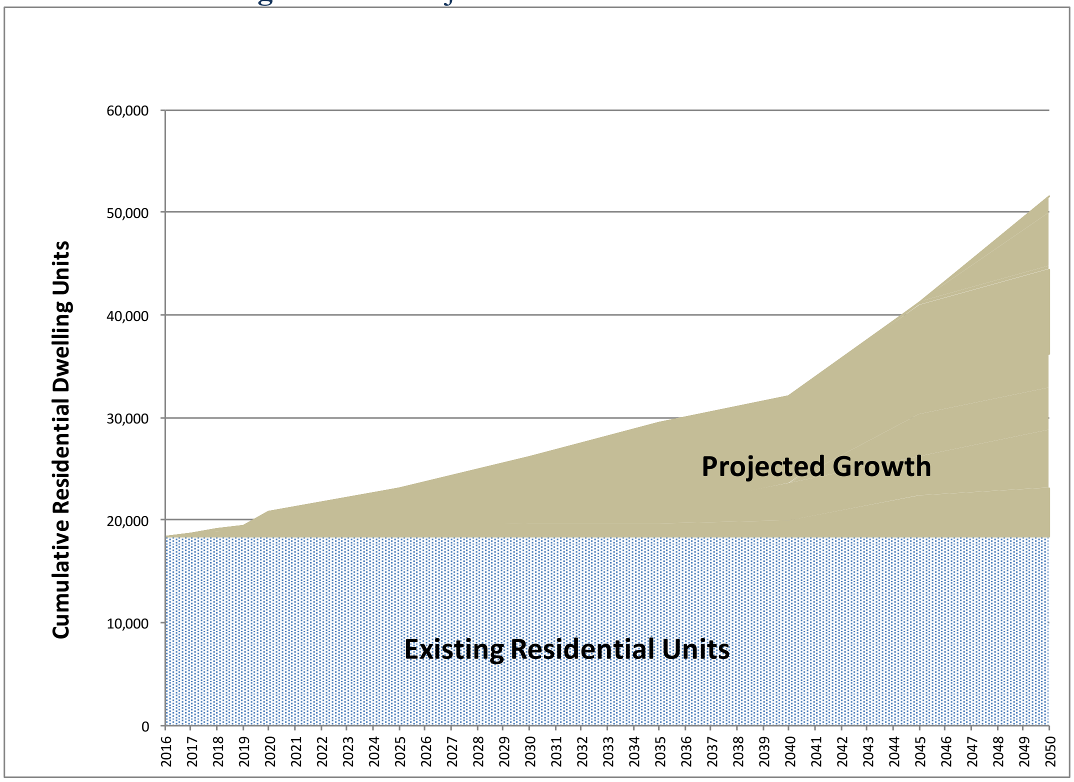
Several of the villages in the 2008 General Plan have prepared, or are preparing, specific plans that detail development plans. These projects have general housing counts for various housing types as well as acreages for non-residential demand types. These projects are generally anticipated to begin construction in the next decade and will buildout as housing demand allows.

Pending or Already Approved (but not fully built) Tentative Maps

These projects typically have an adopted specific plan with tentative maps and are sold to home builders or are already in the early phases of construction. These project types have the most detail available with specific lot counts, specific non-residential acreages, landscape designs, and specific project elements.

For each category, the Master Planning Tool includes individual tables that identify anticipated residential and non-residential land use counts (e.g. dwelling units or acres), and calculates demands at various time intervals, using the growth defined by each project's representative development timeline. The counts are adjusted so as to match a standard growth rate to buildout expected by the City. A summary table sums the forecasted water demands and housing counts by 5 year intervals. Because each development-specific table within the Master Planning Tool has a unique set of residential and non-residential land-use classes, a summary of all the residential and non-residential unit counts over time is not practical. Rather, as demonstrated by **Figure 4-2**, the growth anticipated by the City mimics roughly a 3 percent annual growth in residential units. The growth in residential units associated with each development was adjusted in a manner that resulted in approximating this rate – with limit regard to which type of residential class was being adjusted (e.g. the adjustments were made to all residential classifications from Country Estates to High Density).

Figure 4-2 – Projected Residential Unit Growth



4.2.3 Distribution System Losses

The demand factors presented earlier in this chapter represent the demand for water at each customer location. To fully represent the demand, distribution system losses must also be included. Often, these losses represent water that is lost due to system leaks, fire protection, construction water, unauthorized connections and inaccurate meters. Essentially, this is the water that is delivered to the City's main storage tanks or pumped by City wells that does not make it to the customer – either as a real loss or an apparent loss (e.g. such as may result when a customer meter under reports actual use). In most instances, the predominant source of distribution system losses is from leaks that inevitably exist throughout the many miles of pipes and service saddles.

As documented in the 2015 UWMP, the City calculated the distribution system loss for 2015 using methodology developed by the American Water Works Association (AWWA). The City calculated a loss equal to 11.8 percent of the water supplied into the distribution system. However due to the mandated conservation in 2015, this number is slightly higher than losses the

City has estimated in prior years (e.g. due to the lower overall use, but the system maintaining the same pressures, leaked volumes become a greater percentage of the total).

For purposes of estimating future demand from new connections, the distribution system loss is assumed to be 10 percent to reflect on-going City programs to address meter inaccuracies, find and fix identified system leaks, and normalize the mandated conservation requirements imposed in 2015.[11]

4.2.4 Demand Forecast Summary

Multiplying the projected land-use information detailed in the Master Planning Tool by the anticipated land-use based demand factors for the various projected development-specific land uses provides the City a functional forecast of annual water demand for many decades into the future. Notably, the further in the future the forecast, the less certain the projection. However, the City is most interested in the near and mid-term forecasts as they directly related to infrastructure planning (as discussed in the next section). **Table 4-5** summarizes the anticipated annual demand to build-out.

Note, however, that because the Master Planning Tool is very detailed to reflect development-specific land-use details, it does not create a summary by land-use class – only a summary of total demand. Thus, although the total demand projections in **Table 4-5** accurately reflect the Master Planning Tool, the breakdown by the listed land-use classes is an estimated representation. In other words, although the 2040 estimated demand of 20,336 acre-feet is from the Master Planning Tool, the representation of "single family" of 13,718 acre-feet may not exactly the single family demand if all of the unique single-family classes for each development-specific table were added together. The Master Planning Tool should be referred to for detail demand estimates.

As presented in the table, based upon the current configuration of growth and understanding of future land-use plans, the City anticipates needing about 36,000 acre-feet at build-out. For purposes of distribution infrastructure planning, this equates to approximately 32 million gallons per day on average (e.g. the ADD is 32 MGD).

[11] For purposes of estimating this quantity when viewed from the customer meter looking back to the "beginning" of the water supply distribution system, a slightly higher value is multiplied by the customer demands, then added to those demands to reflect a total projected demand.

Table 4-5 – Projected Annual Water Demand

Land-class		Forecast Demand (af/yr)					
		2020	2025	2030	2035	2040	Build-out
Multi-Family	Existing	562	538	515	492	468	468
	Future	82	242	421	642	853	1939
	Subtotal	644	780	936	1,133	1,321	2,407
Single Family	Existing	7,584	7,130	6,677	6,223	5,770	5,770
	Future	1,159	2,291	3,817	5,575	7,948	18077
	Subtotal	8,743	9,421	10,493	11,799	13,718	23,847
Commercial	Existing	245	245	245	245	245	245
	Future	129	271	491	568	905	2059
	Subtotal	373	515	736	813	1,150	2,304
Industrial	Existing	15	15	15	15	15	15
	Future	2	2	2	2	382	868
	Subtotal	17	17	17	17	397	883
Public	Existing	59	59	59	59	59	59
	Future	60	79	159	159	176	401
	Subtotal	119	138	218	218	235	460
Parks/ Landscape	Existing	694	694	694	694	694	694
	Future	472	566	673	729	789	1795
	Subtotal	1,166	1,260	1,367	1,423	1,483	2,489
	Subtotal	11,063	12,132	13,768	15,404	18,305	32,391
Unaccounted water (at 10%)		1,228	1,347	1,528	1,710	2,032	3,595
	Total	12,291	13,478	15,296	17,113	20,336	35,986

4.3 Relationship Between Demand Forecasts and Infrastructure Planning

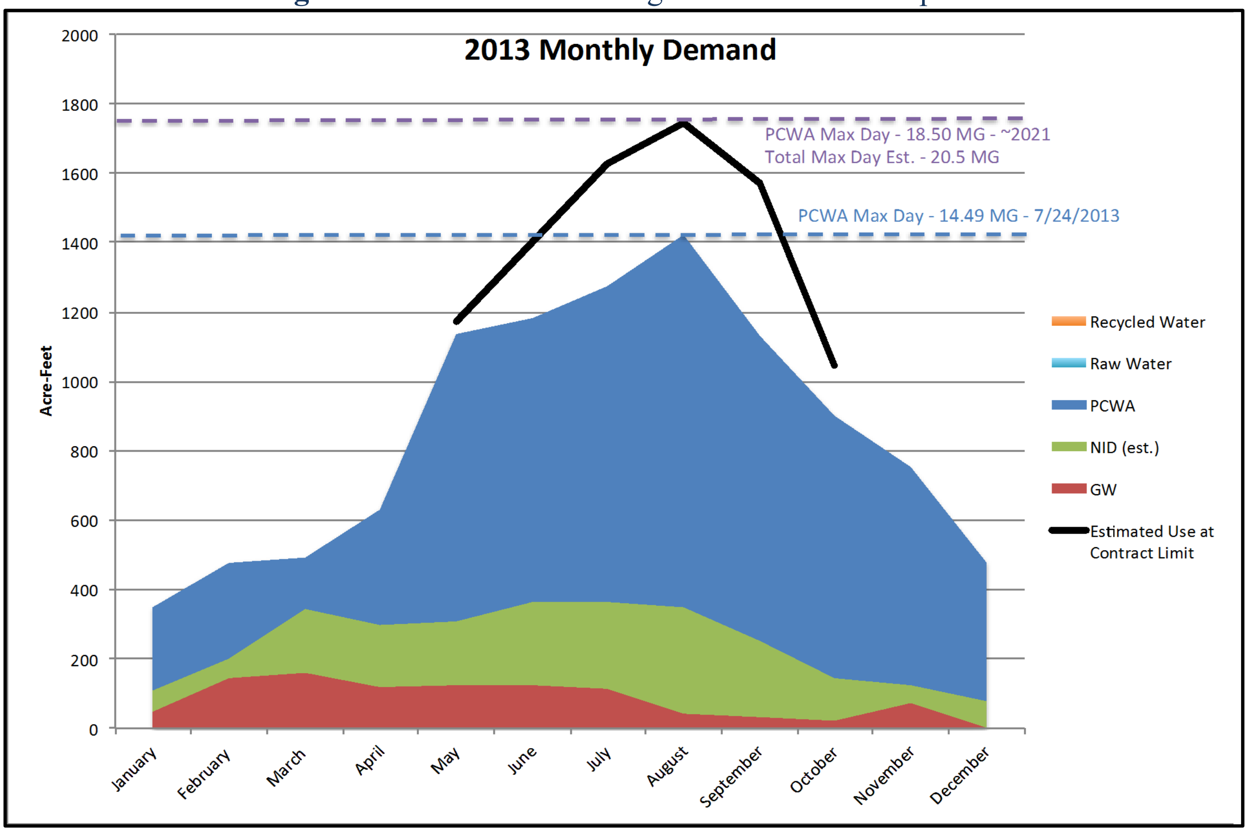
The forecast annual demand detailed in the prior section is the foundation for determining when, where, and how distribution system infrastructure must be improved to meet the expected growing water needs of the City. The projected annual demand, however, must be modified in order to understand the potential infrastructure needs, such as pipe sizes, pumping capacities, well production rates, and treatment plant capacities. The annual demand needs to be translated to anticipated peak demands during the expected maximum days and peak hours of customer needs. Ultimately, it is these apex values that guide source water capacity requirements and infrastructure sizing.

4.3.1 Annual Demands

As described in the prior section, demands are expected to grow annually until projected buildout conditions are reached around 2060.

If the typical annual demand or a single family home is evaluated on a monthly demand basis, it becomes evident that winter water use is lower than summer water use. This observation is intuitive because indoor water use is fairly constant year round but irrigation generally occurs only during the dry, summer months. This pattern, normalized using data from many water meters, generates a curve that is flat in the winter, gradually ascends in the spring, peaks in the summer and again descends in the fall. The flat winter period generally represents the residential indoor demand, which remains nearly consistent throughout the entire year while the peak period represents the irrigation demands that generally start around March or April, peak in July and August, then taper off by September and October. **Figure 4-3** represents the peaking phenomenon. Besides reflecting the varied use by the City of its different supply sources, **Figure 4-3** demonstrates the significant difference between average monthly indoor demands seen in January, February and December, and the peak significant increase in monthly demand to meet added irrigation demands over the summer. The Average Day Demand (ADD) reflects the average of these lower winter demands and higher summer demands.

Figure 4-3 – Seasonal Peaking of Lincoln Consumption



4.3.2 Estimating Maximum Daily Demand

The ADD provides a useful value for purposes of securing water supplies (e.g. annual use of surface supplies, groundwater resources, and recycled water). But, for purposes of infrastructure sizing and design, an estimate of the potential maximum demand for any given day during the year is needed (commonly referred to as "Max Day" demand, or "MDD"). Most customer water meter data is only recorded monthly, so understanding the MDD requires evaluation of meters that record water flowing into the distribution system (from production wells and from PCWA's metering station) in combination with customer meter data. The Max Day will typically occur during the highest water use month during the hottest time of the year (e.g. July or August for the City). Therefore, data from system meters as well as customer meters for July and August were analyzed to determine the average day demand during the peak month. Further assessment of the daily data records for system inflow meters allows a comparison of average day during the peak month to peak day. For the City, the Max Day was about 10 percent greater than the average day during the peak month.

Historically, the City has used a value of 2.5 times its ADD to determine its Max Day demand. Based upon evaluation of system inflow meters and customer demands during the peak month, it appears that the City's Max Day multiplier may now be overstating the Max Day demand. This is likely due to continued improvements in irrigation management and changes in landscape plantings that require less water overall – lowering the peak demand. For the future homes, the new MWELO (discussed previously) further limits landscape plant types, likely further influencing the relation between ADD and Max Day.

For purposes of infrastructure planning, the City is adopting a Max Day demand of 67 MGD. This value reflects a multiplier between 2.0 to 2.2 – a range of between 64 and 70 MGD. It is important to note, however, that this Max Day reflects the potential build-out condition when the City anticipates serving about 36,000 acre-feet annually. Since that is projected to occur several decades from now, the Max Day estimate will continue to be refined as the water planning efforts are regularly updated.

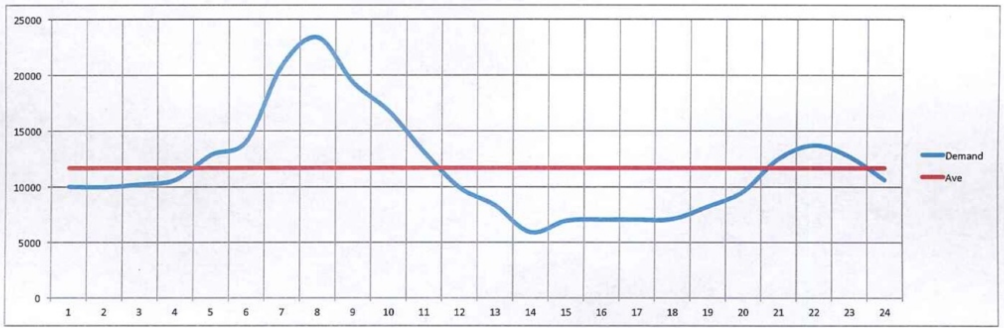
4.3.3 Estimating Peak Hour Demand

Similar to translating ADD to generate a Max Day estimate, daily demands can be used to understand peak hour demands. Unlike the bell curve that represents the monthly variance of annual demand, hourly use is more sinusoidal with two distinct peaks and valleys. The typical hourly curve is different by user class, but given the preponderance of residential use in the City, a curve using system inflow data will likely represent typical residential daily use patterns. Using the inflow and well production meters beginning at midnight demonstrates a curve that starts about average usage, peaks in the morning, dips mid-day to below average, then peaks again in the evening.

Figure 4-4 – Representative Flow Dynamics Used to Define Peak Hour Demand

2013 Scada Results Max Day July

Flows	Demand	Ave	Ratio
1	10000	11692.2917	0.855
2	9950	11692.2917	0.851
3	10200	11692.2917	0.872
4	10600	11692.2917	0.907
5	12850	11692.2917	1.099
6	14090	11692.2917	1.205
7	20870	11692.2917	1.785
8	23350	11692.2917	1.997
9	19300	11692.2917	1.651
10	16775	11692.2917	1.435
11	13110	11692.2917	1.121
12	9910	11692.2917	0.848
13	8310	11692.2917	0.711
14	5900	11692.2917	0.505
15	6950	11692.2917	0.594
16	7050	11692.2917	0.603
17	7050	11692.2917	0.603
18	7100	11692.2917	0.607
19	8200	11692.2917	0.701
20	9550	11692.2917	0.817
21	12500	11692.2917	1.069
22	13700	11692.2917	1.172
23	12700	11692.2917	1.086
24	10600	11692.2917	0.907



The shape of this curve is explainable with a typical nuclear family routine in a day. The curve starts sloping upwards in the early morning as people shower, irrigation systems are often run and other morning activities are occurring. Mid-day use is low as most people are at work, and irrigation typically is not occurring due to being inefficient (and strongly discouraged). The evening peak represents residents returning home doing laundry, dishes, and bathing. In reality a number of factors impact water use and the timing thereof and the delay in tank releases and wells operations means there may be some shifting of the peaks than what the meters show (since these are not reflecting actual customer meters).

Commercial and industrial demands would typically be more constant and either continuous or limited to standard business hours.

The curve shape from the City is expected because the majority of water use is residential and driven by typical residential use patterns. A number of studies have found similar curves in residential driven service areas.[12] The City's policies, such as limits on watering times or on days of the week, can affect the resulting curve without changing the total daily demand – potentially flattening or increasing the hourly variance from average.

Similar to how an average line can be drawn across the representative monthly bell curve to understand the peaking factor between ADD and Max Day, a similar peaking factor can be derived for understanding peak hour demands. This peak hour factor is an important input to infrastructure design.

4.3.4 Historic Trends in City Planning Demands

Shortly after completion of the 2008 General Plan, the City assessed its projected demands and developed anticipated Max Day and Peak Hour requirements based on data available at that time.

[12] Residential End Uses of Water, AWWA 1999

A Max Day demand of 118 MGD was determined. This determination would drive significant investments in infrastructure and supply contracts – including potentially calling for larger pipes (up-sizing) or building many miles of new pipe parallel to existing infrastructure to accommodate the high peaks.

As presented in the previous sections, the new projection of annual demand and resulting Max Day needs has shrunk significantly. This is mostly due to the improved data used to establish unit demand factors, coupled with improved land-use information and on-going conservation standards.

The new Max Day design value established by this WMP effort is 67 MGD – almost half the value projected as part of the 2008 General Plan efforts. This reduction will result in significant savings in terms of water supply contracts, treatment plant facilities, and conveyance infrastructure.

The significance of this drop highlights the importance of ongoing demand trend tracking. Forecasting future demand is only as good as the quality of the data used, which is highly reliant on the City's on-going data management and analysis protocols. It is critical that the City continue to periodically re-assess demand factors, land-use understandings, and peaking factor relationships to assure infrastructure requirements are appropriately being planned and installed.

4.4 Recommendations

As part of its on-going data management and analysis protocols, this Comprehensive Water Master Plan recommends that the City:

- Complete a comprehensive customer meter study every 5 years to evaluate any necessary refinements to land-use based demand factors.
- Track addresses of residential and commercial water use audits and rebate programs and analyze before and after conditions to assess the benefits of audits (including non-audited customers can help evaluate the benefits of the audit compared to naturally occurring changes in water use).
- Increase the information and functionality of the existing City SCADA system to obtain more data points to further improve pressure and flow management.
- Calibrate system meters and replace undersized system meters.
- Install additional meters on main transmission lines in key areas of the system to enable improved understanding of customer water use dynamics.

- Expand support for PCWA and NID raw water supplies to offset potable demands. Use of raw water will reduce the demands on the City's potable water infrastructure and reduce Max Day and peak hour demands.
- Expand use of recycled water to also reduce the demand on the City's potable water infrastructure.
- Investigate potential water use policies that can help manage peak hour and Max Day demands in a manner that can decrease pipeline sizing and other infrastructure expansion.