

CHAPTER 5

System Performance Criteria

The purpose of this chapter is to define the recommended performance and operational criteria for the City's water distribution system. These criteria include required fire flow, pump station capacity, system storage capacity (including operational, fire flow, and emergency storage components), minimum and maximum system pressures, and maximum pipeline velocity and head loss.

Table 5-1 summarizes the recommended criteria, and the following sections of this chapter present the recommended performance and operational criteria for sizing the City's water system:

- General Water System Guidelines
- Water System Performance
- Facility Sizing Criteria

5.1 GENERAL WATER SYSTEM GUIDELINES

Before discussing specific water system evaluation criteria, it is helpful to provide some general guidelines that a water system should follow. This section identifies requirements for a reliable water system that delivers high quality water.

5.1.1 Water System Reliability

Attention to enhancing the reliability of the system under all conditions is an important part of maintaining high quality water service. Water system reliability is achieved through a number of system features including: (1) appropriately sized storage facilities; (2) redundant or "firm" pumping capacity, transmission/distribution, and supply facilities where required; and (3) alternative power supplies. Reliability and water quality are also improved by designing looped water distribution pipelines and avoiding dead-end distribution pipelines whenever possible. Looping pipeline configurations reduces the potential for stagnant water and the associated problems of poor taste and low chlorine residuals. In addition, proper valve placement is also necessary to maintain reliable and flexible system operation under both normal and emergency operating conditions.

5.1.2 Water Quality Standards

Water quality standards largely pertain to protecting public health and consistently delivering a satisfactory product to the customer. The United States Environmental Protection Agency (EPA) and the SWRCB Division of Drinking Water (DDW) are the agencies responsible for establishing water quality standards. The EPA and the DDW prescribe regulations that limit the amount of certain contaminants in the water provided by a public water system. The City, as a water purveyor, is responsible for ensuring that the applicable water quality standards and regulations are met at all times.

Table 5-1. Summary of Recommended Water System Performance and Operational Criteria

Component	Criteria	Remarks / Issues	
Fire Flow Requirements			
Country Estates	1,500 gpm	Fire flows are for planning purposes and are based on the 2022 California Fire Code (CFC) and the City of Lincoln Design Standards. Actual requirements are established by the City of Lincoln Fire Department. The Fire Department will conform to the 2022 CFC's recommendations for fire flow durations.	
Low-Density Residential	1,500 gpm		
Medium Density Residential	3,000 gpm		
High Density/Multi-Family Residential	3,000 gpm		
Commercial	3,000 gpm		
Schools	4,000 gpm		
Other ^(a)	4,000 gpm		
Firm Capacity			
Firm Placer County Water Agency (PCWA) Capacity	Defined as City's maximum delivery entitlement of 18.9 mgd as identified in the City's agreement with PCWA.		
Firm Booster Pump Station Capacity	Defined as total booster pump station capacity with the largest pump offline at each station.	The City's future water system is expected to include installation of new at-grade pump stations at future storage tanks.	
Firm Groundwater Well Capacity	Defined as 50 percent of maximum day demand for buildout system.	The City will require new wells to have aquifer storage and recovery (ASR) capability.	
Supply Capacity			
Water Supply Capacity	Provide firm supply capacity equal to maximum day demand.	Met through a combination of purchased water and groundwater with wells operating at firm capacity.	
Pumping Capacity Sizing			
Pumping Capacity	<p>- Zones with Gravity Storage must provide firm pumping capacity or gravity supply capacity that is sufficient to meet maximum day demand. Fire flows should be provided from storage.</p> <p>- Zones without Gravity Storage must provide firm pumping capacity equal to the larger of either (1) the maximum day demand plus fire flow, or (2) the peak hour demand.</p>		
Backup Power	Equal to the firm capacity of the pumping facility.	Plug-in adaptor at pumping location with available portable generator.	
Storage Capacity Sizing			
Operational	Equal to 25 percent of maximum day demand		
Fire	Equal to the largest fire flow requirement in pressure zone multiplied by the CFC's recommended duration.	Varies depending on land use and associated fire flow requirement in a given pressure zone.	
Emergency	Equal to 60 percent of maximum day demand.		
Emergency Groundwater Credit (EGWC)	Equal to the 80 percent of maximum day demand.	The 375 Pressure Zone is the only pressure zone that receives groundwater supply. The emergency storage for the 375 Pressure Zone is assumed to be met by EGWC, and its associated tanks will provide emergency storage to the upper pressure zones.	
Storage Facility Capacity	Operational + Fire + Emergency - EGWC	Storage capacity should be evaluated by pressure zone.	
Distribution and Transmission Pipeline Sizing			
<i>Normal Operating Conditions</i>			
Maximum Pressure [psi]	120 ^(b)	Criteria based on requirements for new development. Existing distribution mains will be evaluated on a case-by-case basis.	
Minimum Pressure (Maximum Day Demand) [psi]	50		
Minimum Pressure (Peak Hour Demand) [psi]	40		
Maximum Velocity [ft/sec]	7		
Maximum Head loss (Maximum Day and Peak Hour Demand) [ft/1000 ft]	3		
<i>Fire Flow Conditions</i>			
Minimum Pressure [psi]	20		
Maximum Velocity [ft/sec]	10		
<p>(a) Other includes industrial areas and other individual high value buildings.</p> <p>(b) Per California Plumbing Code, an individual PRV must be installed on the service line if service pressure is greater than 80 psi.</p>			

5.2 WATER SYSTEM PERFORMANCE CRITERIA

This section describes the recommended water system performance criteria for system supply capacity, fire flows, and distribution system pressures.

5.2.1 Water System Supply Capacity

Under normal (i.e., non-emergency) demand conditions, the City must have a firm supply capacity capable of meeting maximum day demand under existing and future conditions. Adopted peaking factors for maximum day and peak hour demands are discussed in Chapter 3.

The following definitions of firm capacity will be used when considering the City's water supply:

- **Firm PCWA Capacity:** Firm water supply from PCWA will be assumed to be the City's maximum delivery entitlement of 18.9 mgd as identified in the City's agreement with PCWA (Appendix A).
- **Firm Groundwater Capacity:** Firm groundwater supply will be assumed to be the City's ultimate plan of developing enough groundwater to meet 50 percent of maximum day demand. The City will require new wells to have ASR capability.

It should be noted that storage facilities are intended to help balance supplies and demands during peak use and emergency conditions but are not considered a supply source to meet maximum day demand requirements.

5.2.2 Fire Flow Requirements

The City of Lincoln Fire Department (Fire Department) is focused on the availability of adequate water supply during fire activity within its service area. The City is responsible for water supply and distribution, while the Fire Department establishes minimum water flows required for firefighting purposes.

The Fire Department conforms to the 2025 California Fire Code (CFC) to establish the minimum fire flows and durations for specific buildings. The CFC also establishes the minimum residual pressure of 20 pounds per square inch (psi) required within a water system during a fire flow condition.

The City's water system should concurrently meet maximum day demands during a fire flow event and maintain at least 20 psi residual pressure for all customer service locations in the distribution system. Fire flows and the expected duration are also used to establish storage requirements.

The Fire Department is responsible for setting and enforcing fire flow requirements as future developments are approved. However, for planning purposes, the minimum recommended fire flow requirements are generalized based on land use type, as shown in Table 5-2, since actual future building types and/or design details are not yet known. The Lincoln Municipal Code (Title 15 – Buildings and Construction, Section 15.04.170) specifies additional requirements for automatic sprinkler systems to be installed for all new construction including residential structures and buildings that undergo a substantial improvement and/or change of occupancy classification. Therefore, the minimum recommended fire flow criteria that have been established assume new buildings are equipped with automatic sprinkler systems; buildings without sprinklers will require higher fire flow requirements.

Table 5-2. City of Lincoln Recommended Fire Flow Planning Criteria^(a,b)

Land Use Category	Fire Flow, gpm
Country Estates (1-2.9 du/ac)	1,500
Low-Density Residential (3-5.9 du/ac)	1,500
Medium Density Residential (6-12.9 du/ac)	3,000
High Density/Multi-Family Residential (13-20 du/ac)	3,000
Commercial	3,000
Schools	4,000
Other ^(c)	4,000

(a) Fire flow requirements assume new buildings are fully equipped with automatic sprinkler systems per the Lincoln Municipal Code (Title 15 – Buildings and Construction, Section 15.04.170).
 (b) The City of Lincoln Fire Department will conform to the 2022 CFC’s recommendations for fire flow durations.
 (c) Other includes industrial areas and other individual high value buildings.
 gpm = gallons per minute

5.2.3 Distribution System Pressure

Adequate system pressure is a basic indicator of acceptable water distribution system performance. The recommended performance standards for system pressures are summarized in Table 5-1.

These performance standards are applied to all areas that fall within the normal customer service elevation ranges for each pressure zone. Customers outside of the normal service elevation ranges may require an individual pressure regulator or pump.

5.3 FACILITY SIZING CRITERIA

This section describes the recommended criteria governing the size of water facilities within the City’s service area, including pump stations, backup power, storage facilities, and pipelines.

5.3.1 Pump Station Capacity and Backup Power

The City’s only BPS is the Catta Verdera BPS which only operates during times of peak demand to provide supplemental supply. The City may potentially install new at-grade pump stations at new storage tanks to meet future demands. Sufficient water system pumping capacity should be provided to meet demands of the pressure zone under the conditions listed below. Pump stations in a pressure zone must be sized to serve other pressure zone(s) dependent upon them for supply.

- **Pressure Zones with Storage** must provide firm pumping capacity or gravity supply capacity equal to the maximum day demand. Fire flows should be provided from storage.
- **Pressure Zones without Storage** must provide firm pumping capacity equal to the larger of either (1) the maximum day demand plus fire flow, or (2) the peak hour demand.

Firm pump station capacity assumes total pump station capacity with the largest pump out of service at each pump station. These conservative assumptions ensure the reliability and flexibility of the system to provide sufficient pumping capacity during peak demand conditions.

5.3.1.1 Critical Supply and Pumping Facilities

Critical pumping facilities are defined as those facilities that provide service to a pressure zone(s) without sufficient emergency storage (see Section 5.3.2.3) and that meet one of the following criteria:

- The largest pumping facility that provides water to a particular pressure zone and/or water service area
- A pumping facility that provides the sole source of water to single or multiple water pressure zones
- A pumping facility that provides water from key groundwater supply wells (determined based on capacity, water quality and location)
- All tank pump stations

All critical pumping facilities should be equipped with an on-site, back-up power generator. At less critical facilities, a plug-in adapter and transfer switch can be used to allow interconnection to a generator appropriately permitted (i.e., mobile or stationary) with the State, which will be brought to the site by City staff during a prolonged power outage. In addition, sites without permanent generators should be configured to have hook ups for portable generators.

5.3.2 Storage Facility Capacity Criteria

The total water storage capacity required for each pressure zone is based on the following three major components:

- Operational Storage
- Fire Flow Storage
- Emergency Storage

A discussion of these three storage components, along with a discussion of “credits” for groundwater supply available within each zone is discussed below. Also described are potential operational strategies for the City’s storage facilities based on seasonal water demand patterns (i.e., winter vs. summer) to help optimize system operations by facilitating tank turnover to minimize water quality issues (e.g., stale water, loss of disinfectant residual).

5.3.2.1 Operational Storage

Operational storage is defined as the amount of stored water needed to meet peak demands in excess of normal supply delivery. Since water supplies are generally designed to meet maximum day demands, operational storage is typically used to supply peak demands (e.g., the difference between peak hour and maximum day demand). Supplies replenish operational storage during periods of lower demand.

In accordance with American Water Works Association (AWWA) guidelines,¹ it is recommended the City plans for an operational storage volume equivalent to 25 percent of the maximum day demand.²

5.3.2.2 Fire Flow Storage

Fire storage is the volume of water reserved for fire suppression. As discussed in Section 5.2.1, fire flow requirements are based on generalized land uses. Required fire flow for each pressure zone is calculated using the land uses within the zone and the largest associated fire flow requirement shown in Table 5-2. The fire storage volume requirement for each zone is determined by multiplying the required fire flow rate by the 2022 CFC's required duration time.

5.3.2.3 Emergency Storage

Emergency storage helps meet demands during an unforeseen or unplanned event that may degrade the quality or quantity of potable water supplies available to serve customers. There are three types of emergency events that a water utility typically prepares for:

- **Minor emergency.** A fairly routine, normal, or localized event that affects a few customers, such as a pipeline break, malfunctioning valve, hydrant break, or a brief power loss. Utilities plan for minor emergencies and typically have staff and materials available to address them.
- **Major emergency.** A disaster that affects an entire, or large, portion of a water system, lowers the quantity and quality of the water, or places the health and safety of the community at risk. Examples include water treatment plant failures, raw water contamination, and/or major power grid outages. Water utilities infrequently experience major emergencies.³
- **Natural disaster.** A disaster caused by natural forces or events that create water utility emergencies. Examples include earthquakes, forest or brush fires, hurricanes, tornados or high winds, floods, and other severe weather conditions such as freezing or drought that damage or cause water system facilities to not be able to operate.

Determination of the required volume of emergency storage is a system-specific policy decision based on the assessment of the risk of failures and the desired degree of system reliability. The amount of required emergency storage is a function of several factors including the diversity of the supply sources, redundancy and reliability of the production facilities, and the anticipated length of the emergency outage. In developing an emergency storage requirement for the City, typical industry standards were used.

¹ AWWA Manual M32, Distribution Network Analysis for Water Utilities (AWWA, 2012) states that for large systems, the equalizing storage requirement is typically 15 to 20 percent of the total maximum day demand over a 24-hour period, but equalizing storage could exceed 30 percent for small service areas or arid climates (page 116). The AWWA Water Distribution Handbook (AWWA, 2000) (Section 3.2.2.2 Storage) states that the volume of operational storage required is a function of the diurnal demand fluctuation in a community and is commonly estimated at 25 percent of the total maximum day demand.

² Tully & Young. April 2017. *City of Lincoln 2017 Water Master Plan*. Section 9.5.2 Storage.

³ In 2024 and 2025, supply from PCWA was impacted by damage to PG&E Spaulding Powerhouses No. 1 and No. 2. The impacts forced PCWA customers to reduce the supply they received. For the City, this meant they needed to rely on groundwater pumping to meet demands.

The AWWA states that no formula exists for determining the amount of emergency storage required, and that the decision will be made by the utility based on a judgement about the perceived vulnerability of the system. The City requires an emergency storage volume equivalent to 60 percent of maximum day demand.

5.3.2.4 Emergency Groundwater Storage Credit

Based on the available City groundwater wells, an emergency groundwater credit (EGWC) can account for a portion of the recommended emergency storage. The following must be true to use the groundwater supply to offset the need to provide surface storage:

- Groundwater supply is of potable water quality and can be reliably accessed (i.e., wells are equipped with an on-site emergency generator or a plug-in adapter and transfer switch).
- Groundwater supply is not already being relied upon to meet the City's average day demand requirements.
- Sufficient water distribution facilities are available to distribute this water to demand areas.

It will be assumed that only the firm groundwater supply will be available for an emergency groundwater storage credit to offset the City's emergency storage requirement (i.e., 80 percent of maximum day demand); however, the EGWC cannot exceed the emergency storage requirement. EGWC is only applicable to pressure zones with available groundwater supply (i.e., the 375 Zone).

5.3.2.5 Total Storage Capacity Recommended

The recommended City potable water storage capacity should be determined using the following formula, with each component defined below:

Total Recommended Storage Capacity = Operational + Fire Flow + Emergency – Emergency Groundwater Storage Credit

- **Operational:** Volume of water necessary to meet diurnal peaks observed throughout the day, assumed to be equivalent to 25 percent of the maximum day demand.
- **Fire Flow:** Volume of water necessary to supply a single large fire flow event in each pressure zone.
- **Emergency:** Volume of water necessary to provide 60 percent of a maximum day demand.
- **Emergency Groundwater Storage Credit:** Equal to the firm groundwater supply that can be reliably accessed, assumed to be 80 percent of maximum day demand.

The amount of total system storage and system peaking capacity required to meet these criteria will change over time as the City's potable water demands increase.

5.3.2.6 Storage Operational Strategies

The operations of the City's storage tanks can be varied seasonally to optimize tank operations and facilitate tank turnover to maintain water quality throughout the system. If water demands are evaluated seasonally (e.g., winter vs. summer), the required operational storage volumes for the winter months would be less than the required storage volumes for the summer months as the water demands are lower. Therefore, storage levels in the tanks could be maintained at lower levels in the winter months to facilitate better tank turnover or selected tanks could be removed from service during the low demand conditions, provided that fire-fighting ability is not compromised.

5.3.3 Valve Capacity Criteria (For Zones Supplied by Pressure Reducing Stations)

The 475 Zone, 610 Zone, and 650 Zone are currently the City's only pressure regulated areas. Since these pressure zones do not have a BPS or a storage tank, the total valve capacity of the PRS should be equal to the peak hour demand plus fire flow condition.

Future areas that are determined to have static pressures greater than 120 psi are recommended to be served via PRSs. For these future areas, the PRSs will also need to have sufficient total capacity to be able to meet the peak hour demand plus fire flow condition.

It is generally recommended that maximum pressures at customer service locations not exceed 80 psi. Should pressures exceed 80 psi at customer service locations, individual pressure regulating valves should be installed in accordance with California Plumbing Code requirements (Section 608.2 Excessive Water Pressure) to avoid potential damage to customer fixtures (e.g., water heaters, hoses, etc.).

5.3.4 Water Transmission and Distribution Pipeline Criteria

The following criteria will be used as guidelines for sizing new transmission and distribution pipelines. However, the existing water system will be primarily evaluated using system pressure as the criterion. Pipeline velocity and head loss are secondary criteria that help prioritize water system improvements, along with pipeline age, material type, and location in the system. If the pressure criterion is satisfied, an existing pipeline with high velocities is not necessarily problematic. The following list summarizes the general definitions and City standards for transmission and distribution pipelines:

- Transmission pipelines are defined as having a diameter greater than or equal to 18-inch.
- Distribution pipelines are defined as having a diameter less than 18-inch.
- All new pipelines are required to have a minimum diameter of 6-inch in residential areas and 8-inch in non-residential areas unless otherwise required or allowed by the City.
- New transmission and distribution pipelines to serve the future planning areas within the City's water service area should be located within designated utility corridors wherever possible. These designated utility corridors should be within public rights-of-way to minimize or eliminate the need for utility easements within private property.

Velocity and head loss criteria are used as indicators to locate and prioritize where water system improvement may be needed. The recommended criteria for water transmission and distribution system pipelines are summarized in Table 5-1.

CHAPTER 6

Hydraulic Model Update and Calibration

This chapter describes the update and calibration of the City’s existing water distribution system hydraulic model to reflect existing conditions. The City’s water system GIS was used to confirm the configuration of water system facilities in the existing model. The hydraulic model was calibrated to a high degree of accuracy, per general guidelines established by the American Water Works Association Manual of Practice 32 (AWWA M32), and to a level that is acceptable for use for planning purposes or detailed design/operational studies. The resulting updated hydraulic model was subsequently used to evaluate the adequacy of the City’s existing and future water systems to meet existing and future needs (see Chapters 7 and 8, respectively).

The hydraulic model updates and calibration efforts are described in the following sections of this chapter:

- Hydraulic Model Background
- Hydraulic Model Update Methodology
- Hydraulic Model Update
- Hydraulic Model Extended Period Simulation (EPS) Calibration

6.1 HYDRAULIC MODEL BACKGROUND

The City’s original hydraulic model was developed in the early 2000s using H₂ONET software. For the 2017 WMP, the hydraulic model was converted and updated using Innovyze InfoWater software. In 2018, the City requested West Yost to perform a peer review of the hydraulic model which resulted in West Yost re- building the City’s water system hydraulic model using the City’s updated GIS water system. In 2023, West Yost updated and calibrated the model using 2021 water consumption data and converted the InfoWater model to InfoWater Pro. As part of the on-going hydraulic modeling support West Yost provides to the City, the hydraulic model is consistently updated with new development projects. For this WMPU, West Yost converted the hydraulic model from InfoWater Pro to Aquanuity AquaTwin Water software.

6.2 HYDRAULIC MODEL UPDATE METHODOLOGY

West Yost completed the following tasks to update the City’s hydraulic model:

- Converted the updated InfoWater Pro model to Aquanuity’s AquaTwin Water software;
- Used the existing City water distribution GIS to verify that the existing hydraulic model system configuration (pipeline sizes, alignments, connections, and other facility sizes and locations) is representative of the current water system;
- Incorporated small diameter PRVs at all existing PRSs (refer to Table 2-6 for valve diameters and PRS locations) that were not originally in the InfoWater Pro hydraulic model;
- Allocated 2023 water consumption using spatially located meter data to assign demands where they occur in the system;
- Assigned elevations to new nodes using the Placer County’s digital elevation model (DEM) and/or Central Valley Floodplain Evaluation and Delineation (CVFED)’s DEM; and
- Dynamically calibrated the City’s water system hydraulic model to simulate pressures, levels and flows observed in the field and recorded by the City’s SCADA system.

To accomplish these tasks, West Yost worked closely with City staff to obtain and review the following available data:

- As-built information, where needed, for storage tanks, control valves, wells, and pump stations;
- System operation plans;
- Metered account water consumption data;
- Historical SCADA system data; and
- Pressure data gathered using hydrant pressure recorders (HPRs).

The updated hydraulic model was calibrated under maximum day demand conditions using an updated diurnal demand pattern for a 24-hour EPS. The calibration utilized SCADA and field collected data from July 11, 2024, which was the peak demand day concurrent with the HPR data collection.

6.3 HYDRAULIC MODEL UPDATE

The following sections describe the findings of West Yost’s model review, and the specific updates made to the water distribution system hydraulic model.

6.3.1 Model Pipeline Configuration Update

West Yost compared the latest hydraulic model with the GIS geodatabase file provided by City staff to verify and, if needed, update the pipeline diameters and configurations of the existing model to be consistent with the GIS geodatabase. Additionally, the City consistently has the hydraulic model updated with new development projects that are in construction or scheduled to be completed soon as part of on-going hydraulic modeling support. Therefore, no pipelines or major facilities were required to be added or updated.

6.3.2 Pipeline Roughness Characteristics

Hazen-Williams coefficients, C-factors, are used in the Hazen-Williams equation to calculate friction loss in ducts and pipes. C-factors indicate the roughness (or smoothness) of the interior of a pipeline. The lower the C-factor, the rougher the pipeline interior and the higher the friction loss in the pipeline. Typically, C-factors are assigned to pipelines based on the characteristics of the pipeline (e.g., age, material type, and size). The City’s GIS geodatabase contains information on install year, material type, and pipe age. During West Yost’s 2018 re-building of the City’s hydraulic model, C-factors were assigned on the basis of material type and age and results verified through SCADA calibration. For the purposes of this update, C-factors were not reassigned.

6.3.3 Water Demand Allocation

The City’s GIS geodatabase contains a feature class for spatially located water meters. City staff provided a spreadsheet containing meter IDs, register numbers, and water consumption for 2023 to use for the hydraulic model as it represents the latest complete year of water consumption. The water use data for 2023 was linked to the water meter feature class by register number. All of the 2023 metered water consumption was able to be linked to the spatially located water meters.

The 2023 consumption data was allocated by spatially assigning meters to the nearest pipeline. The demand allocation results were reviewed to confirm that the demands were allocated appropriately (i.e., demands not placed on large transmission pipelines or to the wrong pressure zone).

6.3.4 Elevation Extraction

The node features in the hydraulic model require that elevations be assigned to calculate pressures in the system. It is important to use the most accurate elevation data available when assigning elevations to the hydraulic model. All existing nodes in the hydraulic model already had an assigned elevation which were not updated. Elevations were manually assigned using either CVFED's DEM or Placer County's DEM. Elevations assigned in the hydraulic model range from a low of 116 feet above sea level in the furthest west of the distribution system, near the Lincoln Regional Airport, to a high of 584 feet above sea level along Bella Circle on the east side.

6.3.5 Water System Facilities

After the pipelines and nodes were confirmed in the hydraulic model, major system facilities (i.e., groundwater wells, storage tanks, Catta Verdera BPS, and PRVs) were reviewed in the model to confirm correct configuration. Tank elevations (i.e., base, inlet, and overflow) were verified based on available information. Existing pump curves for the Catta Verdera BPS and wells in the hydraulic model were not updated. The City's existing PRVs in the field include multiple PRVs, however, the hydraulic model only included a single PRV to represent each PRS. The associated PRVs for each PRS were updated in the hydraulic model and settings for each PRV were updated as needed.

6.3.6 Hourly Pattern Development

City staff provided SCADA system data in 30-minute intervals from July 8, 2024 to July 15, 2024, which corresponds with the HPR monitoring period. The SCADA information included flows, tank levels, and pressures for most of the City's water system facilities (i.e., tanks, wells, PRVs, and Catta Verdera BPS) that were in operation during the monitoring period. Since SCADA flow data for the PRVs are not monitored, the pressure zones were grouped into three zone groups (i.e., Lower Zones [375, 475, 575], 750 and 610 Zones, and 775 and 650 Zones) based on how the zones are connected and available SCADA data to develop the hourly diurnal patterns.

The Lower Zones are supplied predominantly by the two PCWA regulated connection points (one located at the metering station supplying Conspiracy Point Tank and one located at the metering station at Verdera Tank No. 3 supplying Verdera Tank No. 3) and are supplemented with water from existing groundwater wells. The 750 and 610 Zones are supplied by the PCWA unregulated connection at the metering station at Verdera Tank No. 3 (i.e., the Verdera Tank No. 3 bypass). The 775 and 650 Zones are supplied by the unregulated connection at the metering station at Conspiracy Point Tank (i.e., the Conspiracy Point Tank bypass). Refer to Chapter 2 for specific detail on supply facilities that supply each individual pressure zone.

To conduct the extended period calibration, West Yost compiled PCWA metering station flows, tank levels, well production, and pump flows to develop diurnals for each of the three zone groups. The diurnal pattern from July 11, 2024 was selected for calibration because the peak demand occurred on that day during the HPR monitoring period. Figure 6-1 shows the diurnals for each of the zone groups. These diurnals were similar in shape to the curves developed for the 2023 calibration.

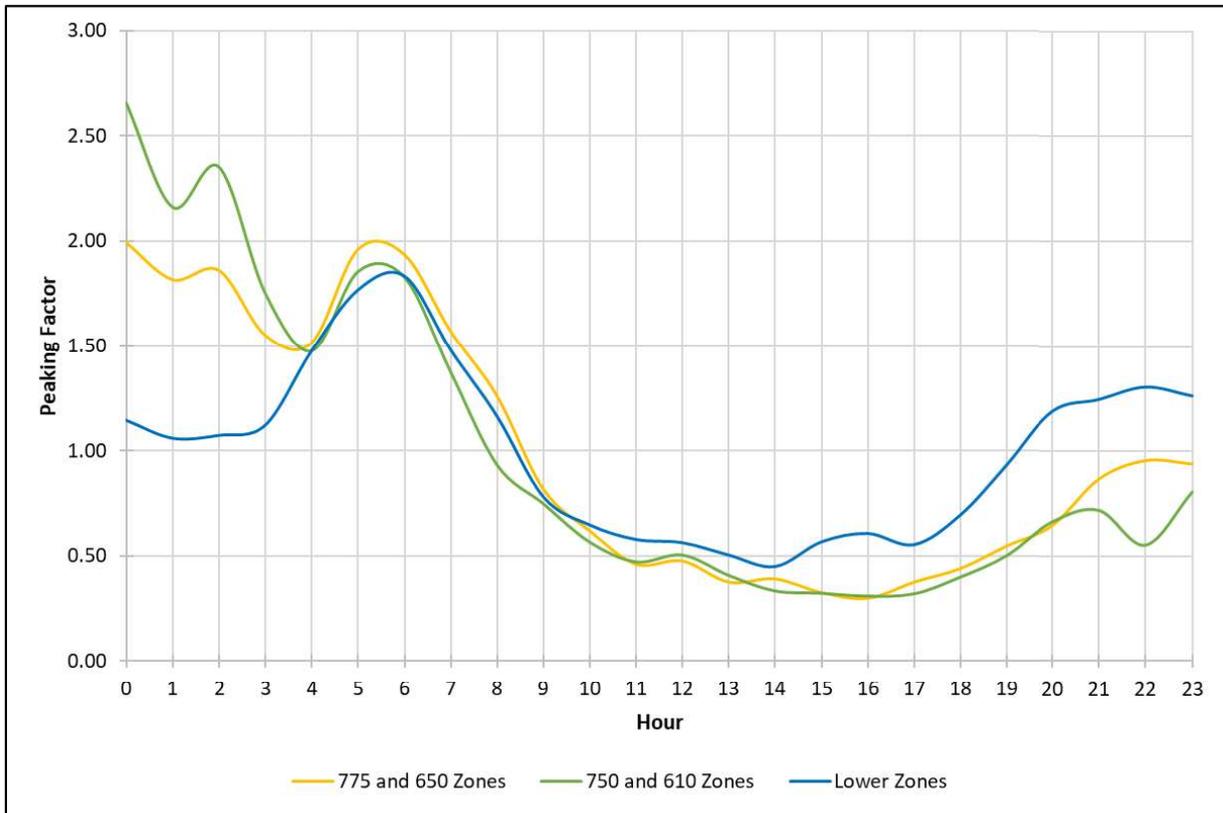


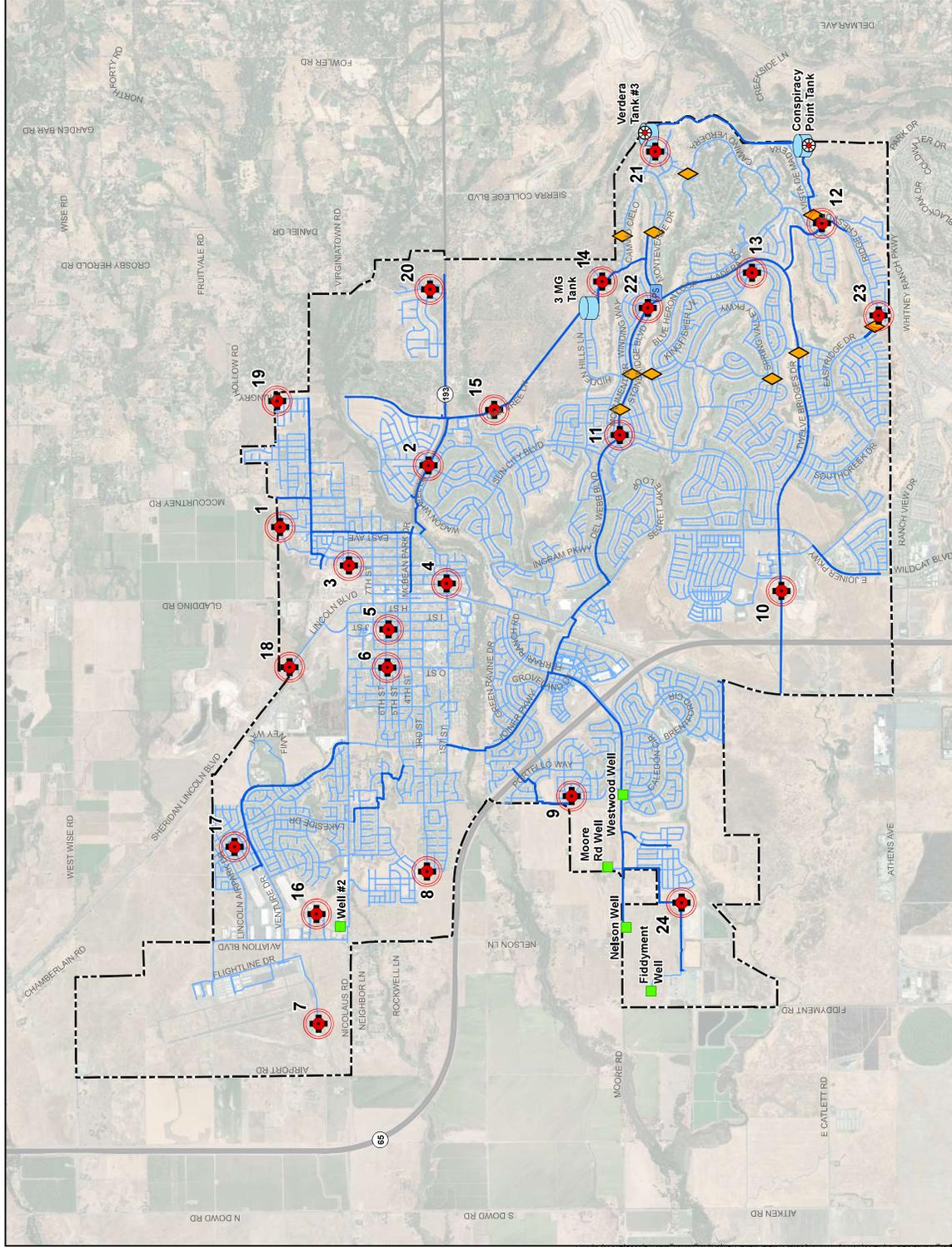
Figure 6-1. Calibration Day Diurnal Patterns (July 11, 2024)

6.4 HYDRAULIC MODEL EPS CALIBRATION

Calibrating a hydraulic model to replicate field operating conditions requires thorough knowledge of how the water system performs over a range of operating conditions. To ensure that the hydraulic model was correctly configured and capable of producing results that are consistent with those observed in the field, a detailed EPS calibration process for summer conditions was conducted.

The hydraulic model EPS calibration was developed using SCADA data for the maximum demand day of July 11, 2024 during the HPR monitoring period of July 8, 2024 to July 15, 2024. For the EPS calibration, 24 HPRs were deployed to collect supplemental pressure data that was subsequently used to compare model predicted results at various locations throughout the system, including high and low elevation locations, locations that are hydraulically distant from supply points, and locations chosen by the City. Twenty HPRs were provided by West Yost and four HPRs were provided by the City. The locations where the HPRs were set up in the system are shown on Figure 6-2.

The hourly diurnal patterns developed for each zone group were applied to the demand nodes in the model. The model was set up to replicate the system operations by applying controls to facilities based on specific conditions (i.e., well pumps on or off based on tank level). Model predicted results (i.e., facility flows and pressures, tank levels, and HPR pressures) were plotted and compared to the SCADA system and field collected HPR data for July 11, 2024 to verify whether the City’s hydraulic model accurately predicts field conditions.



Notes:

1. Facilities and hydrants shown based on GIS data provided by the City in April 2024.
2. HPRs 1 to 10 and 12 to 15 are locations previously used for the 2019 model calibration.
3. HPR 11 is a new location added by West Yost and HPRs 16 to 24 are new locations added by the City

HPR Locations
 Overview Map
 Figure 6-2

Prepared for:
 City of Lincoln
 Water Master Plan Update

Prepared by:
 WEST YOST



Model predicted flows and levels were matched as closely as possible and aimed to be within 10 percent of field recorded data. Pressure trends were checked to see whether results were within ± 5 psi of field trends. Minor adjustments to the model were made (i.e., pump settings and PRV pressure settings), if needed, to better match field data when results from the hydraulic model did not trend well with the field data. Results from the calibration are discussed in the following sections.

6.4.1 Hydraulic Model EPS Calibration Results

The 2023 demands allocated in the model discussed in Section 6.3.3 were scaled to match demands for the calibration day of July 11, 2024. The calibration diurnals were applied to the scaled demands for the associated zone group.

Graphs of the comparisons between model simulated results and SCADA values for the calibration date of July 11, 2024 are provided in Appendix D. For the model EPS calibration scenario, HPR results are also shown and are provided in Appendix E. Figures are grouped to show results for facilities in the Lower Zones, 750 and 610 Zones, and 775 and 650 Zones.

Hours where the field recorded data deviates slightly from the model predicted results may be due to the zone group diurnal not completely capturing the nuances of water use trends in each pressure zone within the zone group.

6.4.1.1 Lower Zones EPS Calibration Results

Figures D-1 through D-15 of Appendix D show results for the EPS calibration of the facilities in the Lower Zones with available SCADA data (i.e., PCWA regulated connections, three tanks, five groundwater wells, and three PRVs). It should be noted only the Westwood and Nelson Wells were operating on calibration day. Model simulated flows, tank levels, and system pressures trend very closely with field recorded data and are within 10 percent and 5 psi, respectively.

Figures E-1 to E-21 from Appendix E show the HPR pressure comparison between the model simulated results and the recorded field pressures in the Lower Zones. The pressure trends collected by the HPRs installed in the Lower Zones generally match similarly with the pressure results from the model simulation and are within approximately 5 psi. However, the model simulated pressures for HPR 7 (Figure E-7), HPR 16 (Figure E-14), and HPR 24 (Figure E-21) are off by more than 5 psi than the field recorded pressures. Since the majority of model results for the remaining HPRs fall within 5 psi, it is assumed that HPRs 7 and 16 may not have been properly calibrated and therefore collected data incorrectly. However, this does not affect the reliability of the overall model, as the majority of results remain within the acceptable range.

6.4.1.2 750 and 610 Zones EPS Calibration Results

Figures D-16 through D-18 of Appendix D show results for the EPS calibration of the facilities within the 750 and 610 Zones (i.e., Verdera Tank No.3 bypass, Catta Verdera BPS, and Village 18 PRV). The model simulated results trend very closely with the field recorded flows and pressures and are within 10 percent and 5 psi, respectively.

Figures E-22 and E-23 from Appendix E show the HPR pressure comparison between the model simulated results and the recorded field pressures in the 750 and 610 Zones. As shown on Figure E-22, unfortunately, HPR 21 in the 750 Zone did not record pressures. The pressure trends collected by HPR 14 in the 610 Zone shown on Figure E-23 trend similarly with the pressure results from the model simulation and are within 5 psi.

6.4.1.3 775 and 650 Zones EPS Calibration Results

Figures D-19 through D-21 of Appendix D show results for the EPS calibration of the facilities within the 775 and 650 Zones (i.e., Conspiracy Point Tank bypass, Village 13 PRS, and Village 17 PRS). The model simulated results trend very closely with the field recorded flows and pressures and are within 10 percent and 5 psi, respectively.

Figures E-24 from Appendix E shows the HPR pressure comparison between the model simulated results and the recorded field pressures for HPR 12 in the 775 Zone. The pressures collected by the HPR trends very similarly with the pressure results from the model simulation and are within 5 psi.

6.4.2 Hydraulic Model EPS Calibration Findings and Conclusions

Majority of the hydraulic model EPS calibration results were within the acceptable ranges (i.e., within 10 percent for flows and tank levels and within 5 psi for pressures). Therefore, it can be concluded that the hydraulic model provides a reasonable representation of the City's water distribution system and can be used for planning evaluations and design/operational analysis for a variety of flow conditions.

Additionally, City staff should continue to update and verify facilities data and pipeline system configurations in the hydraulic model as facilities are constructed or replaced to maintain a hydraulic model that will continue to accurately represent the City's water distribution system.