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City of Oxnard

Public Works Integrated Master Plan

WATER

PROJECT MEMORANDUM 2.3
INFRASTRUCTURE MODELING AND ALTERNATIVES

FINAL DRAFT
December 2015

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City of Oxnard

Public Works Integrated Master Plan

WATER SYSTEM

PROJECT MEMORANDUM 2.3
INFRASTRUCTURE MODELING AND ALTERNATIVES

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INFRASTRUCTURE MODELING AND ALTERNATIVES

1.0 INTRODUCTION

This Project Memorandum (PM) will examine the needs of the City of Oxnard's (City's) existing water distribution system based on the system's capacity, rehabilitation and replacement (R&R) and design conditions. As noted in PM 2.1, *Water System - Background Summary*, the City's distribution system is made up of a network of 614 miles of pipe along with six (6) blending stations that blend water from three (3) different sources. An overview of the domestic water system is shown on Figure 1.

The needs and recommended improvements were developed in conjunction with the City's updated water system model, PotableWater_2015. This PM provides an overview of the model as well as the calibration results and adjustments.

1.1 PMs Used for Reference

The recommendations outlined in this PM are made in concert with recommendations and analyses from other related PMs:

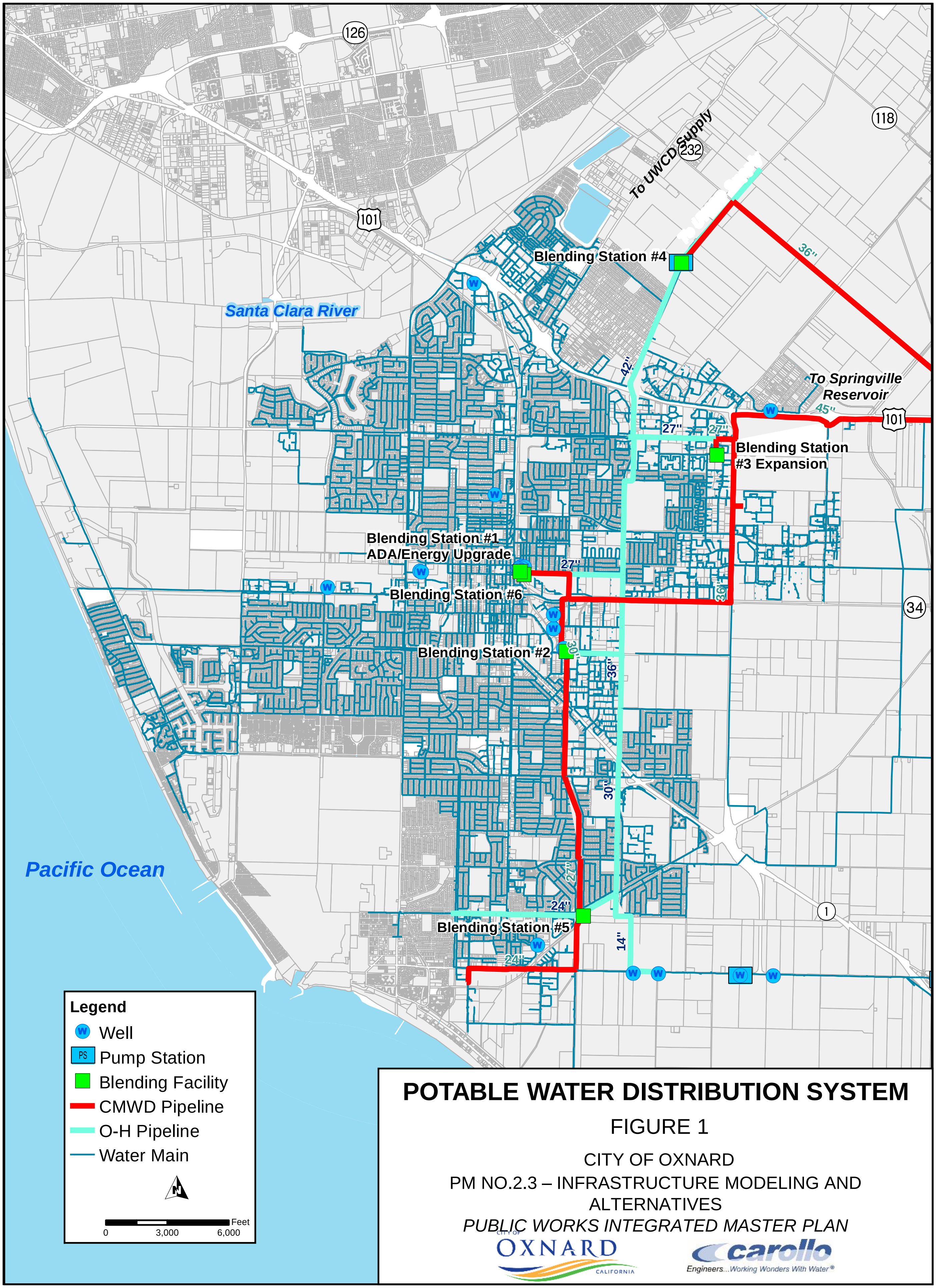
- PM 1.5 – Overall - Basis of Costs.
- PM 2.1 – Water System - Background Summary.
- PM 2.2 – Water System - Water Demand Projections.
- PM 2.4 – Water System - Condition Assessment.
- PM 2.5 – Water System - Supply and Treatment Alternatives.
- PM 2.7 – Water System - Cathodic Protection Assessment – Phases 1 and 2.

1.2 Other Reports Used for Reference

- Oxnard GIS Data.

2.0 PLANNING AND EVALUATION CRITERIA

This PM presents the planning criteria and methodologies used to evaluate the existing water distribution system and associated facilities and to identify existing system deficiencies and size future improvements and expansions.



POTABLE WATER DISTRIBUTION SYSTEM

FIGURE 1

CITY OF OXNARD

PM NO.2.3 – INFRASTRUCTURE MODELING AND ALTERNATIVES

PUBLIC WORKS INTEGRATED MASTER PLAN

CITY OF OXNARD CALIFORNIA

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2.1 Water System Evaluation Criteria

The City's water system is evaluated under a range of normal and emergency operating conditions and demand scenarios. The normal operating conditions are:

- Average Day Demand (ADD): The average demand over a 24-hour period for the average day of the year.
- Peak Hour Demand (PHD): The peak hourly demand (typically on the maximum demand day) of the entire year.
- Maximum Day Demand (MDD): The maximum daily demand over an entire year.
- Minimum Hour Demand (MinHD): The minimum hourly demand of the entire year.
- MDD plus Fire Flow (MDD+FF): Fire flow is governed by the land use type a fire hydrant is located at.

Distribution system evaluation criteria are required to determine the performance of the City's water system under the range of operating conditions as discussed above and to identify system deficiencies and improvement projects. Under each operating condition, the capacities and performance of the water system are compared with the evaluation criteria to determine which pipelines or water facilities need to be upgraded or replaced. The evaluation criteria for water system evaluations in this Public Works Integrated Master Plan (PWIMP) consist of the following categories:

- System Pressure.
- Pipeline Velocity.
- Storage Volume.
- Pump Station (PS) Capacity.
- Pressure Reducing Station (PRS) Capacity.

The specific evaluation criteria used for the evaluation of the City's potable water system are summarized in Table 1.

2.2 System Pressure

Minimum system pressures are evaluated under both PHD and MDD plus fire flows conditions. Maximum system pressures are evaluated under ADD. The typical minimum pressure criterion for PHD demand conditions is 40 pounds per square inch (psi), while the minimum pressure criterion under MDD with fire flow conditions is 20 psi. However the City is targeting a minimum pressure of 50 psi, which is used as the minimum acceptable system pressure. The pressure analysis is limited to demand nodes, because only locations with service conditions need to meet such pressure requirements. Lower pressures are only acceptable for junctions at water system facilities and on transmission mains. However, no pressure shall be less than 5 psi to avoid potential water quality issues.

Table 1 Distribution System Evaluation Criteria Public Works Integrated Master Plan City of Oxnard		
Description	**Value**	**Units**
Maximum Pressure		
Without Service Lateral Pressure Regulator	80	psi
Triggering Potential Improvements (maximum pressures evaluated under ADD conditions)	200	psi
Minimum Pressure		
Peak Hour Demand (PHD)	50	psi
Maximum Day Demand (MDD) + Fire Flow	20	psi
Pipeline Criteria		
Maximum Velocity at PHD	7	fps
Maximum Velocity at MDD + Fire Flow	10	fps
Design Velocity for New Pipelines	7	fps
Hazen-Williams C-factor	130	n/a
Minimum Size for Pipeline Replacement	8	inches
Fire Fighting Requirements		
Open Space (OS)	1,000	gpm for 2 hours
Single Family Residential (SFR)	1,500	gpm for 2 hours
Multiple Family Residential (MFR)	2,500	gpm for 2 hours
Commercial (COM)	3,000	gpm for 4 hours
Mixed Use (MIX)	3,000	gpm for 4 hours
Industrial (IND)	4,500	gpm for 4 hours
Agricultural (AG)	4,500	gpm for 4 hours
Storage Volume		
Operational	25% of MDD	MG
Fire Fighting	Highest fire flow requirement of pressure zone	
Emergency	100% of MDD(1)	
Notes: (1) It is assumed that the emergency storage is stored as ground water.		

Maximum system pressures are evaluated under the ADD conditions. The maximum pressure criterion for normal ADD conditions is 80 psi for service connections without individual pressure-reducing valves. In areas where the maximum pressure exceeds 80 psi, individual pressure-reducing valves are required on service connections; however, the system pressure shall generally not exceed 150 psi. A maximum pressure of 200 psi was used to trigger the need for pipeline improvements, assuming that the typical pipelines installed are limited to 200 psi. The actual pipe class of pipelines identified for high pressure improvement shall be verified with as built drawings and/or field inspection prior to design as this is beyond the scope of this PWIMP.

2.3 Pipeline Velocities

Pipeline velocities are evaluated using three different maximum velocity criteria for selected flow conditions under both existing and future demand scenarios. For transmission and distribution pipelines, a maximum velocity of 7 feet per second (fps) was used for ADD and PHD conditions, respectively. Fire hydrant laterals are excluded from these criteria, as higher velocities are acceptable. Under fire conditions, velocities of up to 10 fps were allowed. Ideally, all transmission and distribution pipelines should have maximum velocities less than 7 fps in order to minimize headloss; however, higher velocities in existing pipelines is not, by itself, sufficient justification for pipeline replacement.

2.4 Storage Requirements

The total storage required for a water system is evaluated in three components:

- Storage for operational use.
- Storage for firefighting.
- Storage for emergencies.

These three components are determined for each pressure zone to evaluate the ability of the water system to meet the storage criteria on both a zone-by-zone basis, as well as a system-wide basis. These three storage requirements are discussed in more detail below.

2.4.1 Operational Storage

Operational storage is defined as the quantity of water that is supplied to meet daily fluctuations in demand beyond the quantity of water that is produced on a daily basis. It is necessary to coordinate the production rates of water sources and the available storage capacity in a water system to provide a continuous flow of treated water supply to the system. Water systems are often designed to supply the average flow on the day of maximum demand. Water storage is then used to supply water for peak hour flows that may occur throughout the day. This operational storage is continuously replenished throughout the day to maintain water quality.

American Water Works Association (AWWA) recommends an operational supply volume ranging from one-quarter to one-third of the demand experienced during one maximum day. It is recommended that pressure zones in the City's water system have operational storage of 25 percent of the MDD supplied by that reservoir.

2.4.2 Fire Flow Storage

The governing fire department shall provide the City with the fire flow rate and duration to determine if fire storage is required for a pressure zone. The values provided in Table 1 are simply provided as a reference and are based on typical values for water utilities. Fire flow storage is determined based on the single greatest fire flow requirement (flow and duration) within each pressure zone group.

2.4.3 Emergency Storage

Storage is also required to meet system demands during emergencies. Emergencies cover a wide range of rare but probable events, such as water contamination, failure at a water treatment plant, power outages, transmission pipeline ruptures, several simultaneous fires, and earthquakes. The volume of water that is needed during an emergency is usually based on the estimated amount of time expected to elapse before the disruptions caused by the emergency are corrected. The occurrence and magnitude of emergencies is difficult to predict and therefore, typical emergency storage recommendations are set to 100 percent of MDD per pressure zone. However, because Oxnard doesn't currently operate their system using storage reservoirs, it is assumed that they can supply their entire emergency storage from the groundwater aquifer.

2.5 Repair and Rehabilitation

The City's geographic information system (GIS) data was used to conduct a cursory level pipeline replacement analysis and to prepare planning level cost estimates for the CIP. The repair and rehabilitation (R&R) pipeline analysis is based on the approximate anticipated life span for pipelines of each material in the City's system, which are listed in Table 2.

As shown in Table 2, pipeline life spans are estimated to range from roughly 50 to 115 years depending on pipeline material. Polyethylene pipes are assumed to have the shortest lifespan with 50 years, while lined cast iron pipes (CIP) are assumed to have the longest lifespan with 115 years.

Table 2	Useful Life of Water Mains Public Works Integrated Master Plan City of Oxnard
Material	**Anticipated Life Span (years)**
Unlined Cast Iron (CIU)	70
Lined Cast Iron Pipe (CIP)	115
Lined Ductile Iron (DIP)	100
Steel (SCP)	70
Asbestos Cement (ACP)	65
Concrete (CONC)	95
AWWA C900 PVC (C900)	75
Polyvinyl Chloride Plastic (PVC)	85
Vitrified Clay Pipe (VCP)	100
Polyethylene (PE)	50
Manholes (MAN)	70

Notes:
(1) A more detailed assessment of Useful Life expectancy is presented in Table 7 of PM 2.4, *Water System - Condition Assessment*.

3.0 MODEL UPDATE / CALIBRATION

A hydraulic computer model of the water distribution system is an important tool for many analyses of a water system. Models are used as a part of water master plans to identify deficiencies in water systems, and to size capital improvements. The widespread use of personal computers and availability of hydraulic modeling software has made network analysis modeling efficient and practical for virtually any water system.

The City's existing hydraulic model was developed in WaterCad®; however, at the start of this project, it was agreed that the model would be updated in the WaterGEMS® modeling software platform.

The procedures used to update and calibrate the City's hydraulic model for this PWIMP are outlined herein, including how the projected water demands developed in PM 2.2, *Water System - Water Demand Projections* were allocated in the updated model.

3.1 Data Sources

A description of data sources used in the model update and calibration process is provided below:

- **Existing Water Model.** The City provided Carollo with a copy of the most recent water system hydraulic model. The City's water model was originally constructed in 2003 using the WaterCad® water modeling software application.

- **City As-Built Drawings.** Record drawings for major water system facilities were used to update the hydraulic model, where needed and available.
- **Water GIS Layers.** GIS layers of the water distribution system were provided by the City. The layers provide the location, unique ID, length, and pipe diameter for all water mains within the City.
- **Water Consumption Data.** Water billing records from 2014 were provided by the City and were the primary source for existing demand allocation in the hydraulic model.

3.2 Model Update

Developing a good hydraulic model begins by updating the model with the best available information into the database and calibrating the model to match existing conditions in the field. Once the model has been calibrated, it becomes an invaluable tool to solve planning and operational problems. It can simulate the existing and future water systems, identify system deficiencies, analyze impacts from increased demands, and determine the appropriateness of proposed improvements for the system.

3.2.1 Diurnal Demand Patterns

As a part of the calibration process, the City provided hourly data from Supervisory Control and Data Acquisition (SCADA) for all of the City's supply sources and reservoirs. This data was used to establish a daily diurnal demand pattern by balancing the total inflow into the water distribution system with the demands. Figure 2 presents the resulting hourly demand factors, which are based on the March 31, 2015 SCADA data. As shown in this figure, the City's water demand peaks at around 7:00 PM with an hourly peaking factor of 1.3. This peaking factor and diurnal pattern were applied for the model calibration discussed in Section 3.3.

3.2.2 Demand Allocation

The City's previous water system hydraulic model, which was developed as part of the 2003 Water Master Plan (WMP), included previous existing and future demands. For this PWIMP, it was determined that the water demands in the hydraulic model should be reallocated to better reflect current demand distribution. Both an existing and a future scenario were created in the model to specify alternative demand conditions. The next sections summarize the process used to allocate the existing (2013) and future water demands within the model. Future water demand projections were taken from PM 2.2, *Water System - Water Demand Projections*.

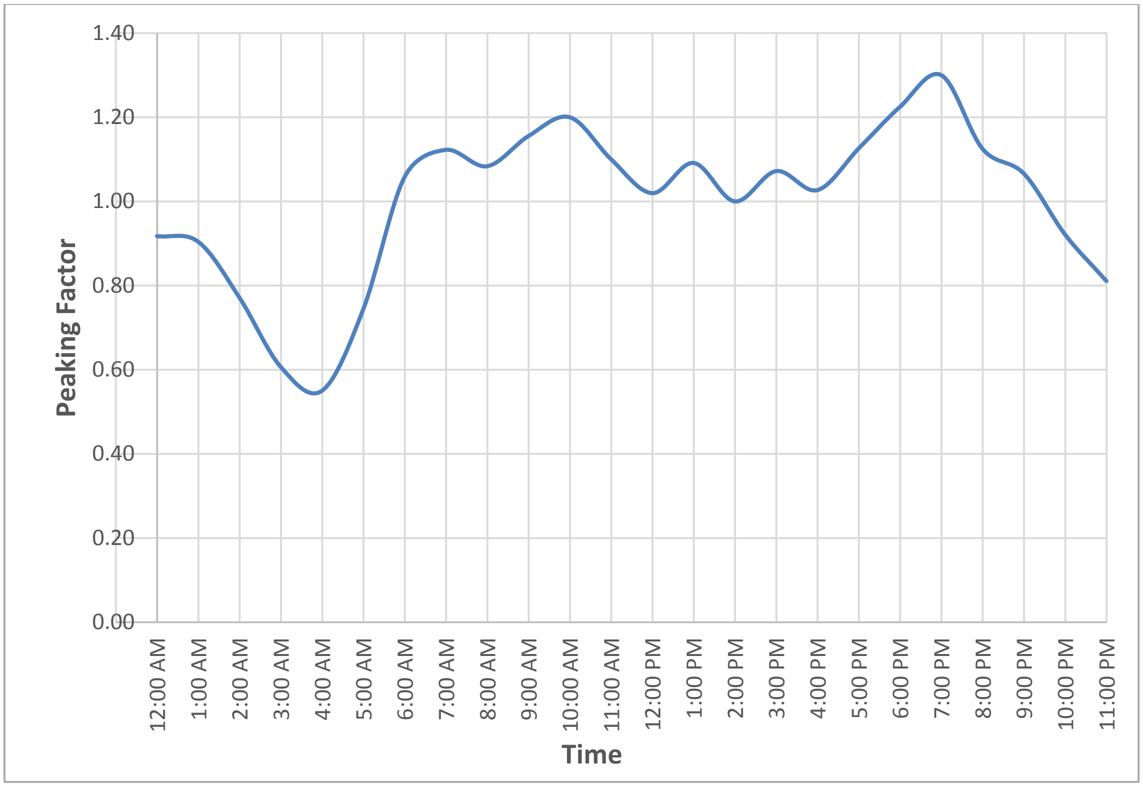


Figure 2 System-Wide Diurnal Pattern

3.2.2.1 Existing Demand Allocation

Several methods can be used for the allocation and estimation of water demands within the system, depending on the type of information that is available. Demands were allocated by the parcel-level method, which uses the City's water consumption database, by parcel, to allocate the demands to the nearest node in the distribution system hydraulic model.

Using the City's 2013 water billing records, the water demands for the water users were represented as point demands in the hydraulic model in order to accurately represent actual measured water consumption. Address points for each billing record were geocoded and then linked to the nearest node in the hydraulic model. The billing record demands were then linked to the model and assigned as demands under the demand collection table. As shown in PM 2.2, the 2013 demands were approximately 26,892 acre-feet per year (AFY) [or 23.4 million gallons per day (mgd)].

3.2.2.2 Future Demand Allocation

As discussed in PM 2.2, two sources were used for future demands: known near-term developments and population growth projections. Both the known developments as well as the future demand growth were allocated into the model. Each new known development required a new node and pipe segment to be added to the model. Each development's projected demand was added to its new corresponding node. The overall future demand growth was achieved by scaling the existing demand allocation by the increased growth determined in PM 2.2.

3.3 Model Calibration

This section summarizes overall methodology employed to calibrate the City's water system hydraulic model and provides a detailed description of each of the major components of the model calibration process.

3.3.1 Model Calibration Data Collection

To coordinate the data requirements for model calibration and field-testing, a model calibration plan was prepared which described what SCADA and field data needs were required to calibrate the updated hydraulic model. The calibration plan included site maps for specific test locations, pressure logger locations, and included a list of the SCADA data needs, including flow durations, time intervals, and units.

3.3.1.1 SCADA Data Gathering

Field-testing and data gathering for model calibration took place from March 24, 2015 through April 13, 2015. Carollo coordinated with City staff to obtain 5-minute data for all of the major SCADA points within the water distribution system, including reservoir levels, booster pump station flows and discharge pressures, and supply connection flows. This data was used to generate the diurnal patterns described in Section 3.2.1 and for the Extended Period Simulation (EPS) model calibration. Table 3 identifies the SCADA data sources that were available for model calibration.

3.3.1.1 Temporary Pressure Logger Install

In addition to the data obtained from the City's SCADA system for the major system facilities, Carollo also provided 10 temporary pressure loggers to City staff that were attached to hydrants within the City's distribution system. The data obtained from the temporary pressure loggers consisted of 1-minute pressure data for the duration of the EPS data gathering period. The locations of the 10 temporary pressure loggers are listed in Table 4.

3.3.2 Model Calibration Methodology and Results

The purpose of a water system hydraulic model is to estimate, or predict, how the water distribution system will respond under a given set of conditions. One way to test the accuracy of the hydraulic model is to create a set of known conditions in the water system and then compare the results observed in the field against the results of the hydraulic model simulation using the same conditions.

Table 3 EPS Calibration Data Gathering Parameters
Public Works Integrated Master Plan
City of Oxnard

Facility Name	Measurement	Unit
Reservoirs		
Springville	level flow	feet gpm
Blending Stations		
Blending Station # 1	pressure flow	psi gpm
Blending Station # 2	pressure flow	psi gpm
Blending Station # 3	pressure flow	psi gpm
Blending Station # 4	pressure flow	psi gpm
Blending Station # 5	pressure flow	psi gpm
Blending Station # 6	pressure flow	psi gpm
Pressure Monitoring Locations		
P&G	pressure	psi
PV & Perkins	pressure	psi
Arcturus & McWane	pressure	psi
5th & Harbor	pressure	psi
3rd & K	pressure	psi
Flow Monitoring Locations		
P&G	flow	gpm
PHWA	flow	gpm
Wells		
Well -20	flow	gpm
Well -22	flow	gpm
Well -23	flow	gpm
Well -28	flow	gpm
Well -29	flow	gpm
Well -30	flow	gpm
Well -31	flow	gpm
Well -32	flow	gpm
Well -33	flow	gpm
Well -34	flow	gpm

Table 4	Pressure Logger Locations Public Works Integrated Master Plan City of Oxnard			
Site	**Logger No.**	**Map**	**Hydrant**	**Location**
1	C1	O-11	H-59	2900 Davers River St X/St Moonlight Park Ave
2	C2	K-15	H-16	2177 Eastridge Dr (Vineyard Ave and Ventura Rd
3	C3	P-15	H-12	2110 Snow Ave X/St Rio Lindo St
4	C4	M-17	H-26	761 Ivywood Dr X/St N F St
5	C5	S-21	H-41	2340 Sturgis Rd X/St Lombard St
6	C6	E-23	H-6	5306 Sandpipper Way X/St Mandalay Beach Rd
7	C7	I-22	H-29	3604 Dunkirk Dr
8	C8	K-25	H-9	2020 Woodland St X/St Birch St
9	C9	N-31	H-9	4500 SC Street X/St Bucker Dr
10	C10	Q-30	H-15	1630 Nelson Pl X/St Dallas Dr

The calibration process for the City's water distribution system hydraulic model consisted of two parts: (1) a macro calibration and (2) an EPS calibration. This section summarizes the results of this calibration process.

3.3.2.1 Macro Calibration

Initially, the model was run under existing demand conditions and necessary adjustments were made to produce reasonable system pressures. Such adjustments include modifications of pipeline connectivity, operational controls, ground elevations, and facility characteristics.

The macro calibration process involves several steps to verify that the model produces reasonable results:

- **Transmission Main Connectivity.** Using the connectivity features of the modeling software, the connectivity of the transmission mains within the distribution system was verified. Problems found using the connectivity locators are reviewed to determine whether adjustments were needed to the connectivity of the model. Output reports of pipe flow characteristics, such as headloss (feet per thousand feet [ft/kft]) and velocity (feet per second [fps]) were also used to locate problem areas where additional adjustments may be necessary.
- **System Pressures.** The macro calibration compared the model output to the typical pressures observed within the distribution system in psi. This process was used to locate major errors in model creation, elevations, or connectivity, as well as changes that reflect how operational controls of the system should be implemented in the model.

- **Facility Characteristics/Operational Controls.** Hydraulic model results were compared to data provided by the City to verify that facility attributes entered into the model, such as the physical characteristics of the tanks and pumps, produced results comparable to what the City experiences. Carollo worked extensively with City operations staff to understand the operational characteristics of each facility so that they were simulated appropriately in the model. This data is summarized in Table 5.

Table 5 Facility Controls
Public Works Integrated Master Plan
City of Oxnard

Blending Station	Capacity/Setting	Unit
Blending Station Capacity		
Blending Station # 1/6	34,700	gpm
Blending Station # 2	25,000	gpm
Blending Station # 3	25,000	gpm
Blending Station # 4	17,000	gpm
Blending Station # 5	11,100	gpm
Well Flow Capacity		
Blending Station # 1/6	12,000	gpm
Blending Station # 2	0	gpm
Blending Station # 3	8,000	gpm
Blending Station # 4	0	gpm
Blending Station # 5	0	gpm
UWCD Flow Capacity		
Blending Station # 1/6	20,400	gpm
Blending Station # 2	19,300	gpm
Blending Station # 3	20,500	gpm
Blending Station # 4	20,900	gpm
Blending Station # 5	5,500	gpm
CMWD Flow Capacity		
Blending Station # 1/6	20,400	gpm
Blending Station # 2	13,000	gpm
Blending Station # 3	20,100	gpm
Blending Station # 4	19,300	gpm
Blending Station # 5	5,500	gpm
Station Pressure Setting		
Blending Station # 1/6	67	psi
Blending Station # 2	0	psi
Blending Station # 3	60	psi
Blending Station # 4	50	psi
Blending Station # 5	75	psi

3.3.3 Extended Period Simulation Calibration

The extended period calibration is intended to calibrate the EPS capabilities of the hydraulic model by closely matching the model pressures and flows to field conditions over a 24-hour period of similar demand and system boundary conditions. Pressure data, reservoir level data, and source water and booster pump flows were recorded to create diurnal patterns and obtain EPS calibration data. The primary varied parameters for this calibration were operational controls and pipeline roughness coefficients, although other parameters were also adjusted as calibration results were generated. Carollo worked closely with City operations staff to model each facility with appropriate controls.

From the 16-day calibration data gathering period, Tuesday, March 31, 2015, was selected to be used for the 24-hour EPS calibration day. This day was chosen because it produced the most typical system diurnal with no unusual flow spikes or dips.

The estimated daily demand for this day was about 11,139 gallons per minute (gpm) (or 16.0 mgd). This is approximately 57-percent lower than the projected ADD in 2015 of 27.9 mgd. For the EPS calibration, the 2015 ADD model demands were scaled down by a factor of 0.57 to match this estimated demand condition during the calibration day.

The EPS calibration compared model simulated blending station flows, and discharge pressures, as well as pressure monitor devices throughout the system to the field measured data. In addition, model simulated pressures at the pressure logger locations were compared to the actual field pressures recorded during the calibration day.

A few samples of the EPS calibration are shown on Figure 3 through Figure 5.

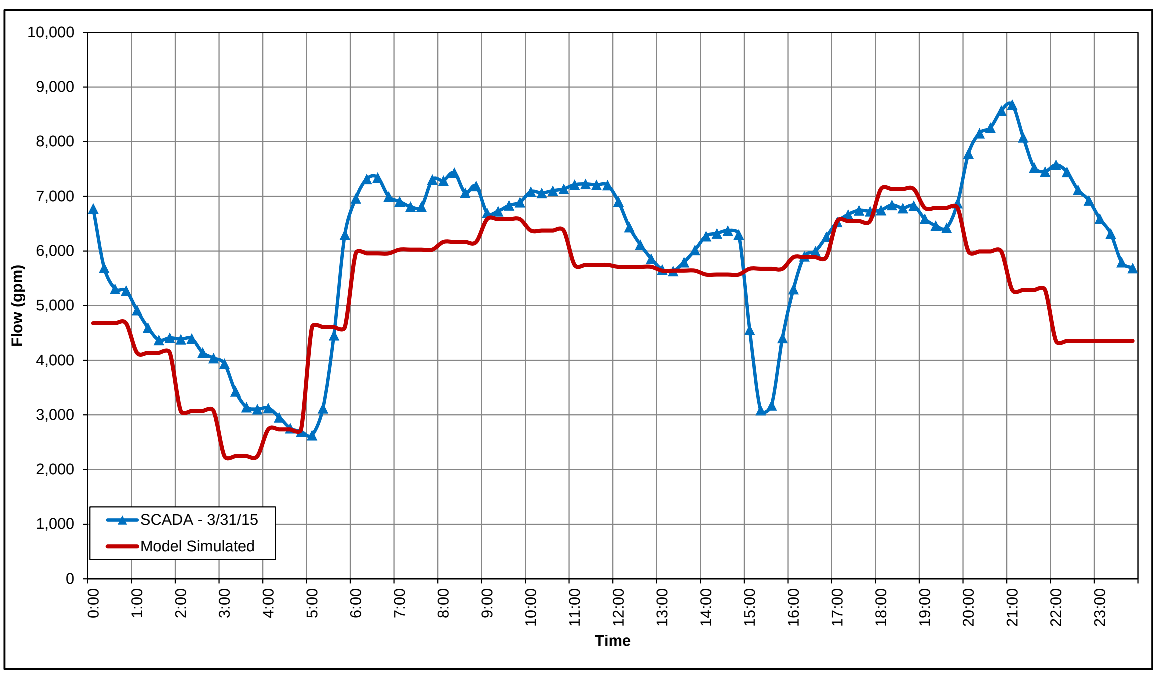


Figure 3 EPS Calibration Results - BS1 Flow

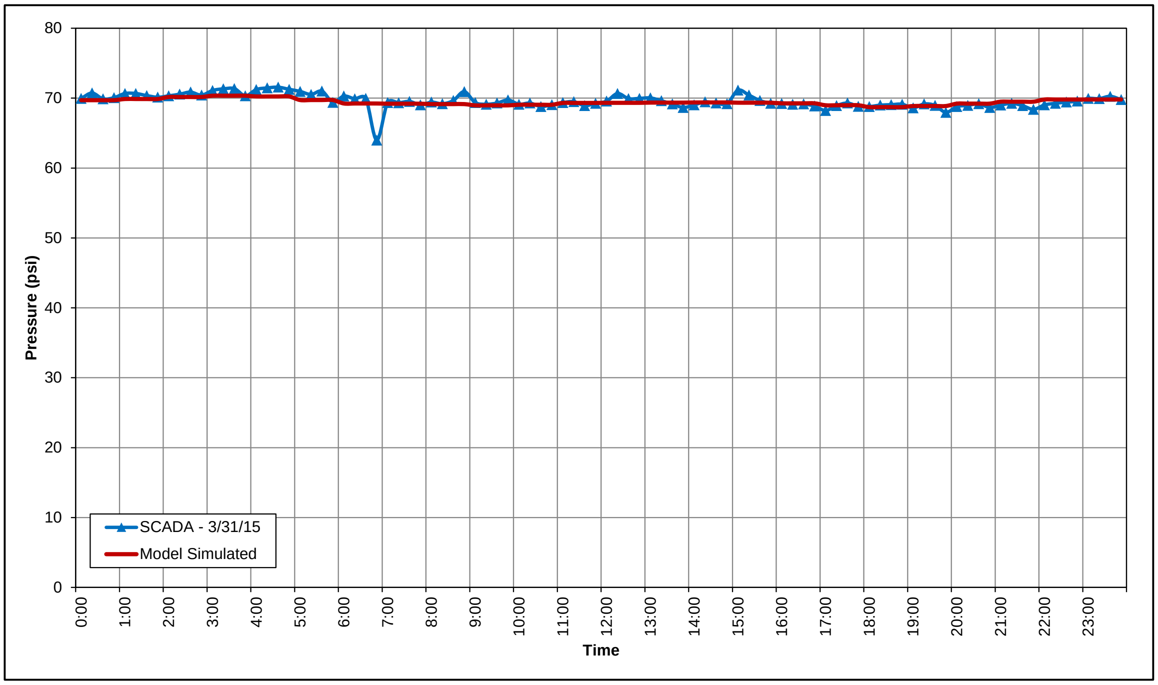


Figure 4 EPS Calibration Results - 3rd and K Pressure

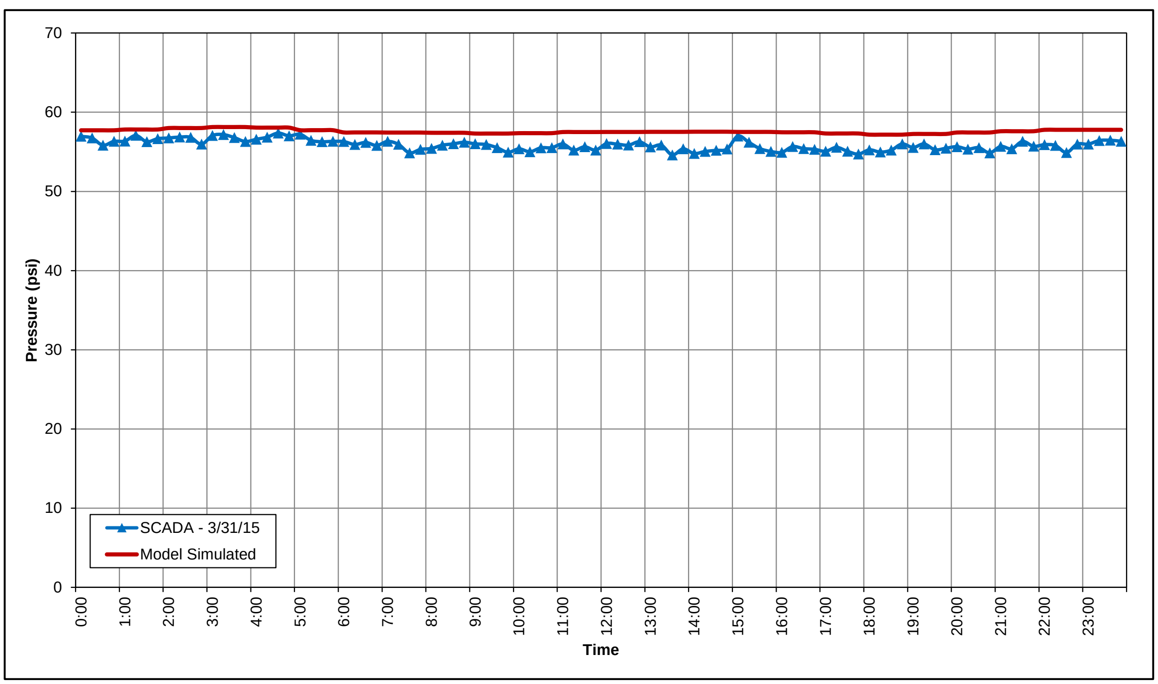


Figure 5 EPS Calibration Results Pressure Logger C1

Figures 3 and 4 present a comparison of model results to observed field conditions for Blending Station 1 (BS1) flow and the 3rd and K St. Pressure Station.

Figure 5 presents a comparison of models results to the pressure logger C1 site. The full EPS model results for each calibration point are presented in Appendix A.

3.3.4 Calibration Result Summary

Overall, it can be concluded that the trends seen in the field data are well predicted by the model, with some minor differences. The calibration results indicate the model predicts conditions very similar to those observed in the field. Based on the results of the calibration, it can be concluded that the model is sufficiently calibrated to conduct hydraulic analysis for the preparation of this PWIMP. The model provides an accurate representation of the City's distribution system and system operations to a level suitable for the distribution system analysis described in Table 1.

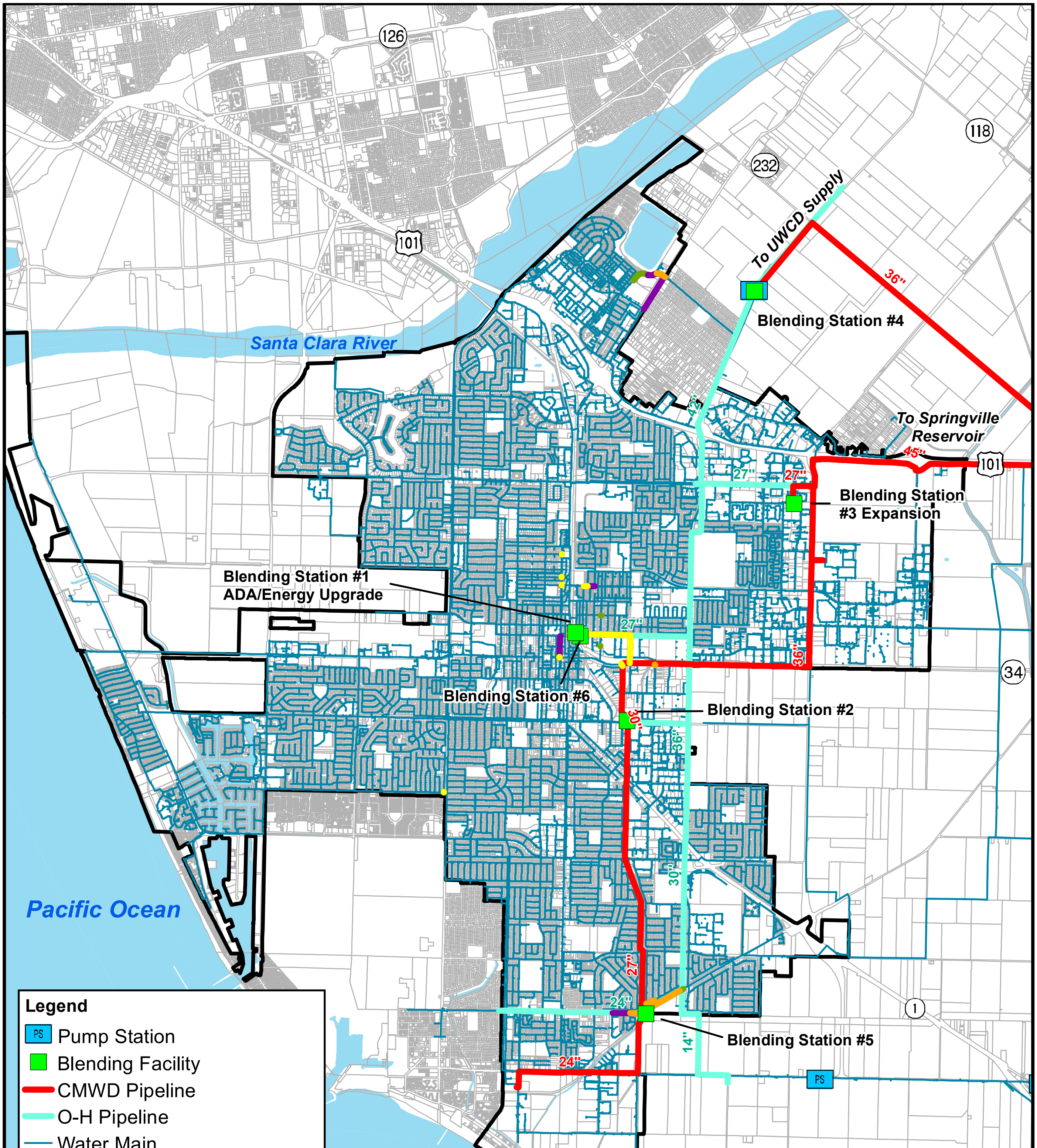
The model calibration comparison plots of all SCADA and pressure logger points used for the model calibration are included in Appendix A.

3.4 Pipeline Capacity Improvements

Pipeline capacity improvements are needed to meet level of service criteria (LOS) and also to accommodate growth in system that requires additional demands to serving new customers. The hydraulic model was run for estimated growth projections for existing conditions, 2020, 2030, and 2040. Pressure and velocity results were investigated and when either pressure or velocity exceeded LOS criteria (see Table 6) improvements were included to accommodate demands.

Table 6 summarizes the improvements that are needed - based on the growth projections, the calibrated model, and the LOS criteria - to accommodate future demands. This table reports the length of necessary improvements by pipeline diameter. Figure 6 illustrates the location of these improvements and when they are needed. Table 6 summarizes these improvements by phase and designates the year they are needed to meet the estimated demands. The line items for capacity improvements in Table 6 are not project specific. Additional investigation will be needed to combine the capacity improvements with other projects such as blending station improvements and pipeline rehabilitation projects needed due to age and condition.

At this stage in the analysis, individual project have not been explicitly defined but the improvements have been located and the lengths and diameters of new pipelines have been estimated. These lengths/diameters were used, along with unit costs, to estimate planning level costs by planning period to accommodate future demands. However, additional effort will be needed to define specific projects that can be further analyzed and put out for design and construction when needed.



PIPELINE CAPACITY IMPROVEMENTS

FIGURE 6

CITY OF OXNARD

PM NO.2.3 – INFRASTRUCTURE MODELING AND ALTERNATIVES

PUBLIC WORKS INTEGRATED MASTER PLAN

Table 6	Pipeline Replacement Length Needed due to Capacity Deficiencies Public Works Integrated Master Plan City of Oxnard							
Deficiency Condition	**Length of Pipeline Replacement Needed (ft) by Diameter (in)**							
	6	**8**	**10**	**12**	**14**	**24**	**30**	**Total**
Existing PHD	0	332	0	238	164	0	3,804	4,579
2020 PHD	69	391	1,011	2,447	0	0	0	3,877
2030 PHD	10	208	439	837	1,708	937	0	4,139
2040 PHD	22	25	804	160	745	0	0	1,756
Total	**101**	**956**	**2,254**	**3,682**	**2,617**	**937**	**3,804**	**14,351**

4.0 PRESSURE ZONE ANALYSIS

The City’s distribution system currently operates as a single pressure zone. The topography of the City's single pressure zone system slopes from a high elevation of 120 ft-msl in the northeast to a low elevation of 10 ft-msl in the southwest. The difference in elevation of 110 feet equates to a static pressure differential of approximately 50 psi. The City's customers in the northeastern part of the City have expressed concerns about low pressures. Conversely, customers in the southwestern part of the City have expressed concerns about high pressures. It is currently impossible for the City to supply all of their customers between 50 psi and 80 psi as established in Table 1 using only a single pressure zone because the static pressure differential of 50 psi in the existing distribution system is greater than the allowable range of 40 psi. In addition to the static system pressures, dynamic operational conditions cause additional pressure fluctuations.

Based on customer concerns, the City requested that a pressure zone analysis be conducted using the updated and calibrated model to assess whether the City would benefit from being split into two or three pressure zones. The methods and results of the pressure zone analysis are presented in this section of the PM. This pressure zone analysis is based on the 2015 planning demand of 27.9 mgd.

4.1 Pressure Zone Analysis Methodology

To determine optimal locations for pressure separation within the City, an initial pressure analysis was performed on the existing system. The results from the single pressure zone analysis combined with input from City staff, customer feedback, and existing inactive facilities guided the selection of locations for the proposed pressure zone divisions.

Once areas of high and low pressure were identified, future proposed pressure reducing facilities, as well as existing pressure reducing facilities were input into the model and activated. The model was run to determine the effect the pressure reducing facilities might have on the pressures of the system.

4.2 System Pressures Single Pressure Zone

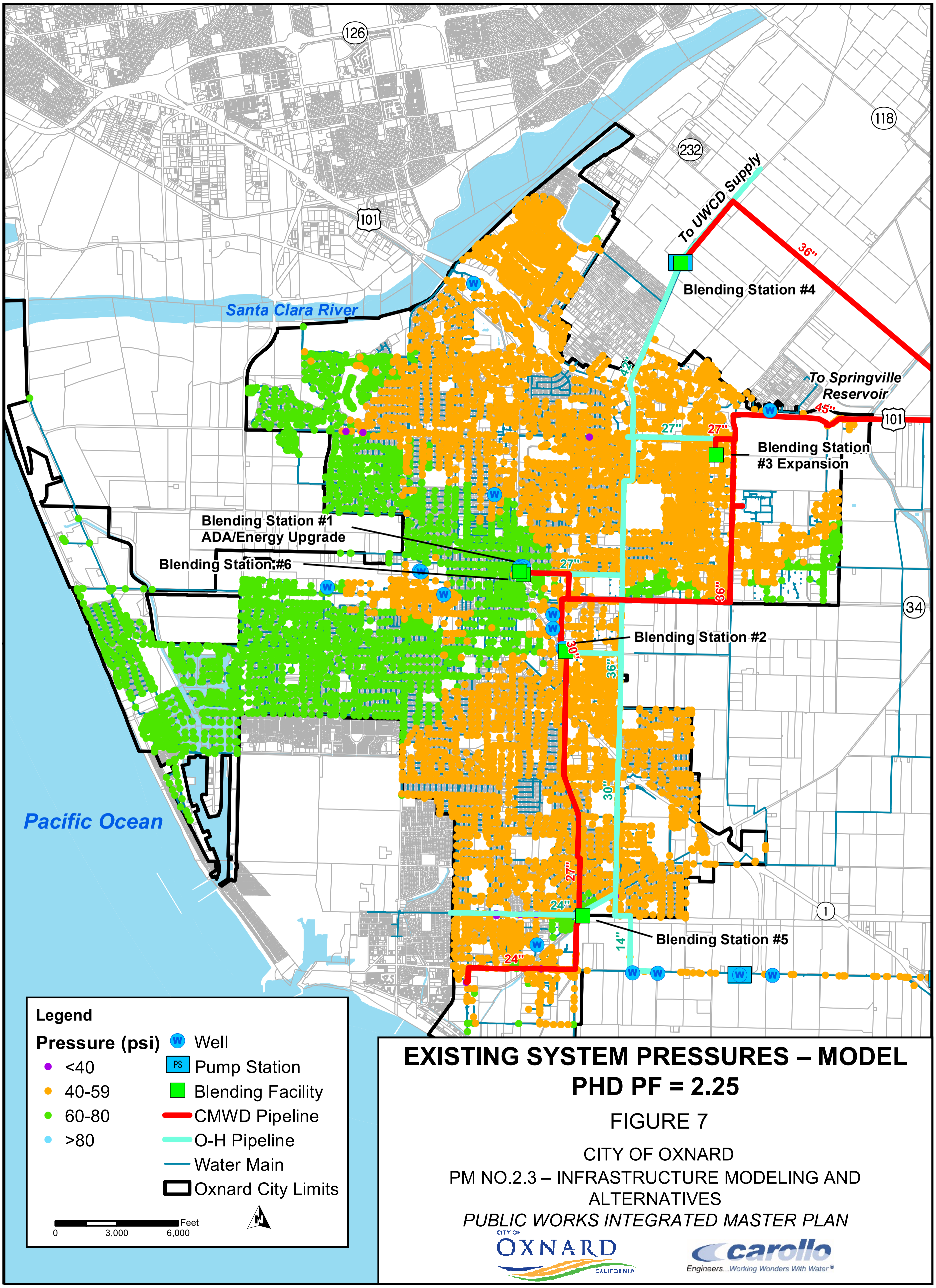
To determine the existing pressure variance, the hydraulic model was run under the existing single pressure zone configuration with current 2015 planning year demands. The model was run under each of the following conditions to determine the range of existing system deficiencies:

- Average Day Demand (ADD) - using a peaking factor of 1.0.
- Max Day Demand (MDD) - using a peaking factor of 1.5.
- Peak Hour Demand (PHD) - using a peaking factor of 1.5, applied to the maximum day peaking factor of 1.5 for a total peaking factor of 2.25.
- Minimum Hour Demand (MinHD) - using a peaking factor of 0.5, applied to the minimum day peaking factor of 0.7 for a total peaking factor 0.35.

In a water distribution system, PHD conditions are used to identify minimum system pressures while MinHD conditions are used to identify maximum system pressures. Both the PHD and MinHD conditions are displayed in Figure 7 and Figure 8, respectively.

Pressures lower than 40 psi are located in the northeastern portion of the City as shown in the PHD condition in Figure 7, during PHD conditions the distribution system experiences few demand nodes with high pressures. However, during the MinHD condition, as seen in Figure 8, pressures in excess of 80 psi are seen in the southern portion of the City.

Based on these initial pressure results, the City was grouped into four pressure zones and was rerun using an alternate analysis described in the next section.



EXISTING SYSTEM PRESSURES – MODEL
PHD PF = 2.25

FIGURE 7

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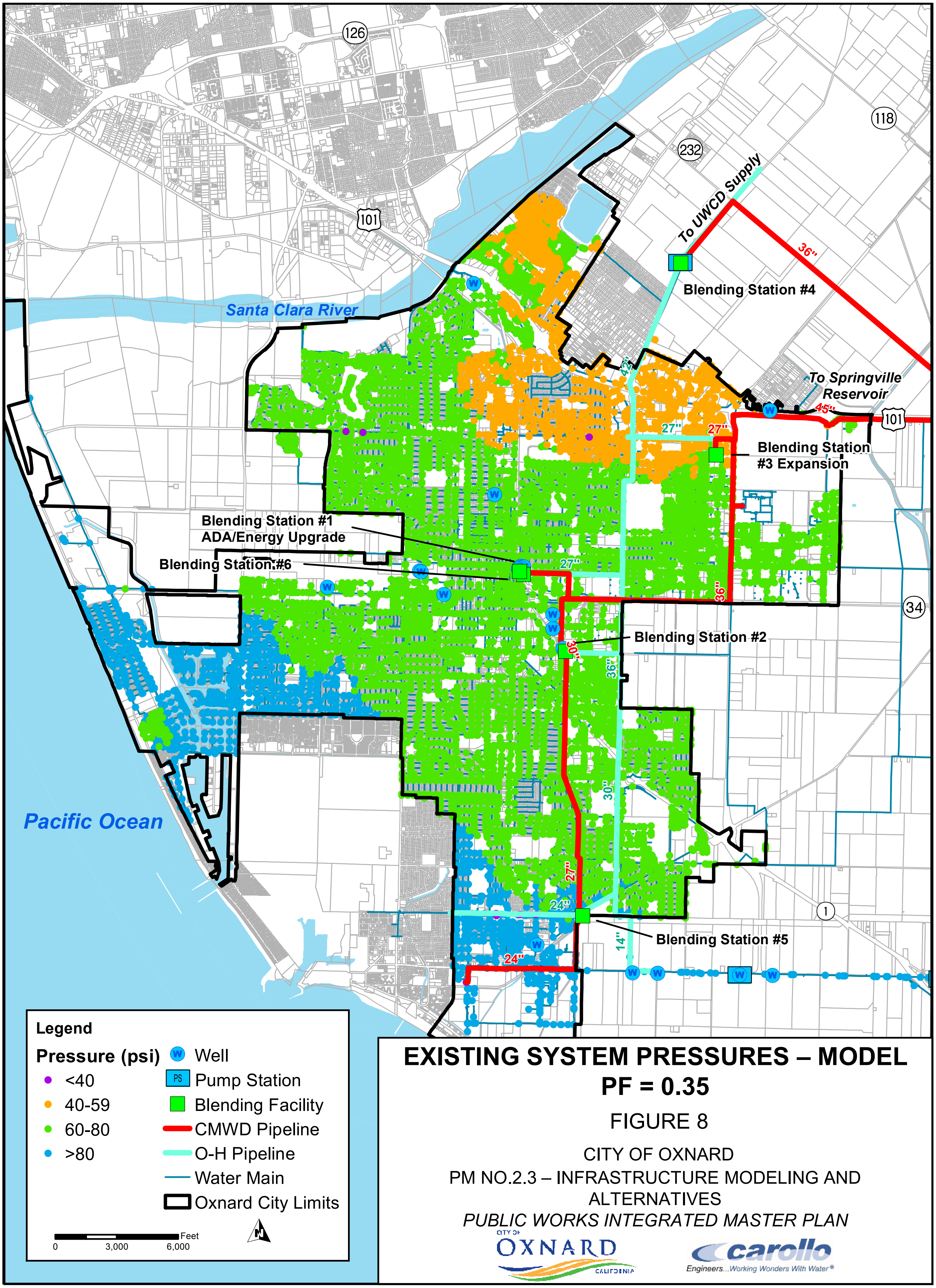

EXISTING SYSTEM PRESSURES – MODEL PF = 0.35

FIGURE 8

CITY OF OXNARD

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4.3 System Pressures Proposed Multiple Pressure Zones

As shown in Figure 7 andFigure 8, the low system pressures occur in the northeastern portion of the City, while the high pressures are predominantly located in the south and southwestern portions of the city. To reduce the pressure range and stay within the targeted pressures, the City's service area was divided into four pressure zones. To create four separate pressure zones for the northern, central, southern, and southeastern part of the City, the following key system modifications are needed:

- Modification #1: Activate the existing 3 pressure reducing stations (PRSs) along Gonzalez Road.
- Modification #2: Install 3 PRSs along East Pleasant Valley Road.
- Modification #3: Install 3 PRSs along South Victoria Avenue.

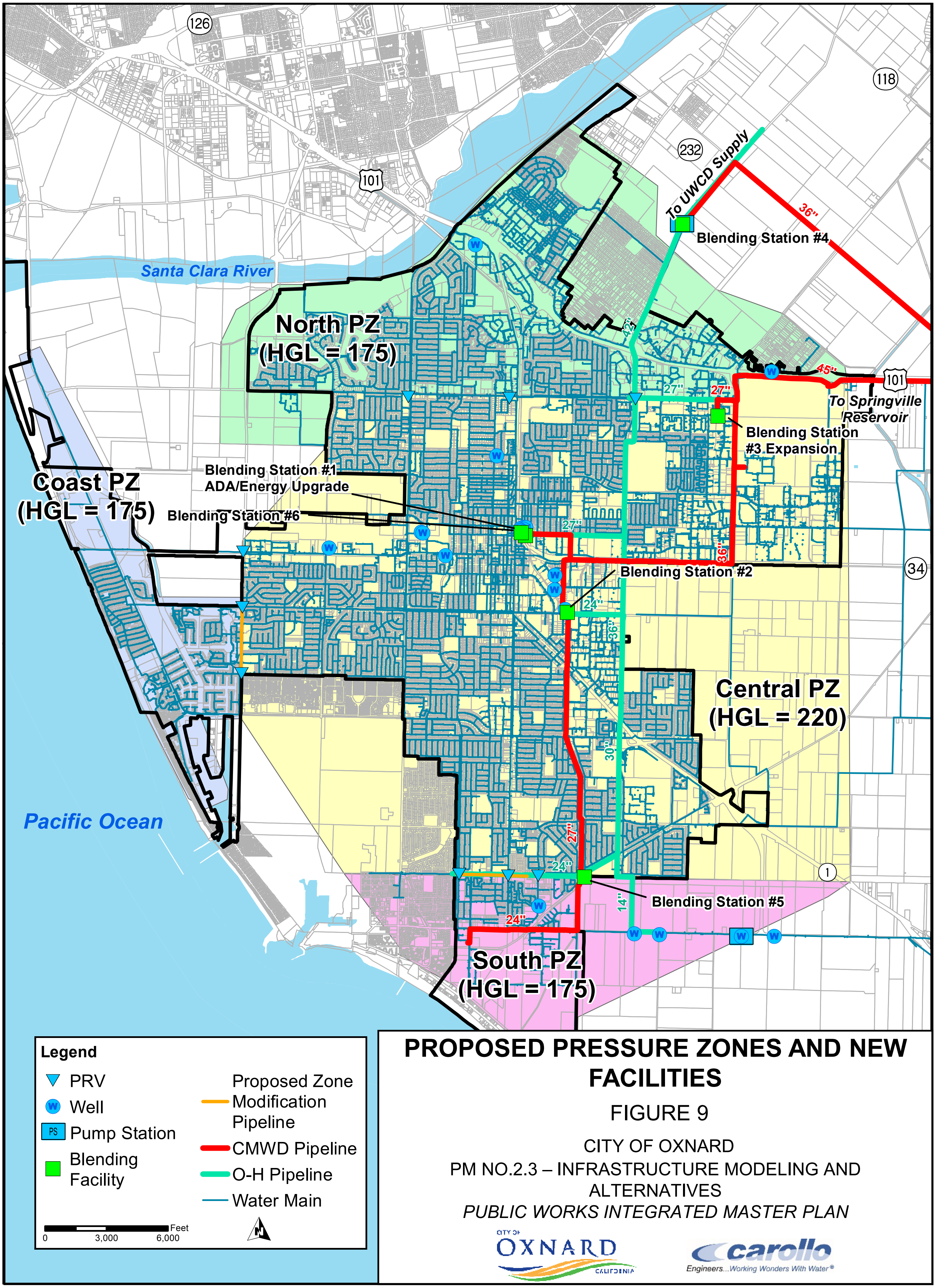
Implementation of these modifications, would divide the distribution system into four pressure zones. These projects would raise pressures in the north and lower pressures on the south and near the coast. The model was run again with these modifications in place to verify that the system will fall within the acceptable pressures range throughout the distribution system. The locations of the proposed PRVs and the zone breaks are shown in Figure 9.

4.4 Recommendations

Based on the pressure zone analysis presented above, it is recommended that The City reduce service pressures that exist outside of their established delivery pressure criteria by breaking their single pressure zone distribution system into four pressure zones as shown in Figure 9. The improvements necessary to convert the existing distribution system into 4 pressure zones are summarized below by pressure zone.

4.4.1 <u>North Pressure Zone Improvements</u>

- Increase Hydraulic Grade Line (HGL) at Blending Station 4 to 260 feet.
- Rehabilitation of 3 existing PRSs on Gonzales Road (HGL = 220 feet).
- Closure of pipeline segments between North Pressure Zone and Central Pressure Zone, along Gonzales Road.



PROPOSED PRESSURE ZONES AND NEW FACILITIES

FIGURE 9

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4.4.2 Coastal Pressure Zone Improvements

- Installation of 3 new PRSs on South Victoria Street (HGL = 175 feet):
  - At the intersection of South Victoria Street and West Hemlock Street.
  - At the intersection of South Victoria Street and West Wooley Road.
  - At the intersection of South Victoria Street and West 5th Street.

- Installation of 3,000 feet of 8 inch-diameter pipeline from West Hemlock Street to West 5th Street along South Victoria Street.

- Closure of pipeline segments between Coastal Pressure Zone and Central Pressure Zone along South Victoria Street, between West Hemlock Street and West 5th Street.

4.4.3 South Pressure Zone Improvements

- Installation of 3 new PRSs on West Pleasant Valley Road (HGL = 175 feet):
  - At the intersection of West Pleasant Valley Road and South J Street.
  - At the intersection of West Pleasant Valley Road and Saviers Road.
  - At the intersection of West Pleasant Valley Road and Cypress Road.

- Installation of 6,000 feet of 8 inch-diameter pipeline from South J Street to Cypress Road along West Pleasant Valley Road.

- Closure of pipeline segments between South Pressure Zone and Central Pressure Zone along West Pleasant Valley Road, between Cypress Road and South J Street.

5.0 FIRE FLOW ANALYSIS

A fire flow analysis was completed utilizing the evaluation criteria listed in Section 2.0. Based on these criteria, the existing fire flow system was evaluated to verify that a minimum pressure of 20 psi is met while maintaining a flow ranging from 1,500 gpm to 4,500 gpm within the corresponding land use category, which are shown in Table 1.

5.1 Evaluation Methodology

The corresponding firefighting requirements shown in Table 1 were applied to each demand node in the model. In the cases where model demand nodes served more than one land use type, the greater of the required fire flows was applied to the node. The model was then run using the built in fire flow analysis tool. This tool calculates the available pressure and flow at each of the fire flow nodes on a case-by-case basis and stores the results for analysis.

5.2 Hydraulic Analysis Results

Based on the fire flow analysis, 443 of the 980 fire flow nodes had residual pressures of less than 20 psi when each of their respective fire flow demands was applied. Each of these nodes was flagged as being possibly deficient and required additional analysis to determine if system improvements will be needed to comply with fire flow requirements. Figure 10 shows the location and severity of the deficient fire flow nodes.

Out of the 443 deficient fire flow nodes, 343 nodes were able to split. Splitting a fire flow is a term used to describe distributing the fire flow demand among two or more other nodes in close proximity. By splitting fire flows, the required capacity at the original node is decreased, and thus residual pressure at that node is increased.

100 nodes were not able to be corrected by splitting the required fire flow demand and were determined to be deficient. These deficient nodes create the need for 39 fire flow improvement projects. Figure 11 displays the locations of each of the fire flow improvements. Each of these improvements is detailed in Table 7.

Table 7 Recommended Fire Flow Improvements
Public Works Integrated Master Plan
City of Oxnard

CIP Project ID	Replacement Type	Description	Diameter (inches)	Pipeline Length (feet)
FF-01	R	Alvarado and E Ventura Blvd (beginning at Red & sons Furniture in back and connecting at E Ventura in front of store)	12	541
FF-02	R	Alley for Oxnard Truck Center to E Ventura Blvd	8	470
FF-03	N	Off of N C St in-between Hazelwood Dr and Ivywood Dr within St. Johns Lutheran School lot	8	517
FF-04	N	W Robert Ave at N C St about halfway down the street	8	384
FF-05	R	Maulhardt Ave at Latigo Ave to Camino Del Sol	12	1,740
	R	At Maulhardt down lot beside AAA Propane Services	8	209
FF-06	R	Felicia Ct at N Marquita St to N Marquita St	8	1,389
FF-07	N	At Camino Del Sol in ERG International Lot	8	72

Table 7	Recommended Fire Flow Improvements Public Works Integrated Master Plan City of Oxnard			
CIP Project ID	**Replacement Type**	**Description**	**Diameter (inches)**	**Pipeline Length (feet)**
FF-08	N	Canal St at Dunes Alley to W Wooley Rd	8	212
FF-09	R	W 5th St at Patterson to Oxnard Airport	14	156
	N	W 5th St at Patterson to Oxnard Airport	14	103
	R	W 5th St at Patterson to Oxnard Airport	8	275
FF-10	N	In Oxnard airport to the left of Extra Space Storage	8	241
FF-11	N	At the edge of Oxnard airport and to the left of S Ventura Rd	8	334
FF-12	N	Down the Alley off W 5th St Parallel to S G St	8	81
FF-13	R	At S Roosevelt Ave and E 3rd St into Shopping center Parallel to S Bonita Ave	8	617
FF-14	R	In the back of Fisher & Sons Warehouse lot between E 3rd St and Railroad tracks	8	176
FF-15	R	E Fifth Service St and E Fifth St at Wright Automotive lot to Pacific Ave	12	3,184
	R	Diaz Ave at E 5th St and Mountain View Ave	12	1,264
	R	At Mountain View Ave between Pacific and Diaz in Scarborough Farms lot Parallel to Pacific Ave	12	774
	R	At Mountain View between Pacific and Diaz in Gold Coast Steel & Supply lot	12	418
FF-16	N	At E Wooley Rd in Oxnard Parks Division lot	8	168
FF-17	N	Novato Dr to Miramar Walk	8	292
FF-18	R	Elm Ct down S G St onto W Guava St at Elm Ct start to just past S F St	8	1,390
FF-19	R	Benton Way at Hill St to Alley	8	249

Table 7 Recommended Fire Flow Improvements
Public Works Integrated Master Plan
City of Oxnard

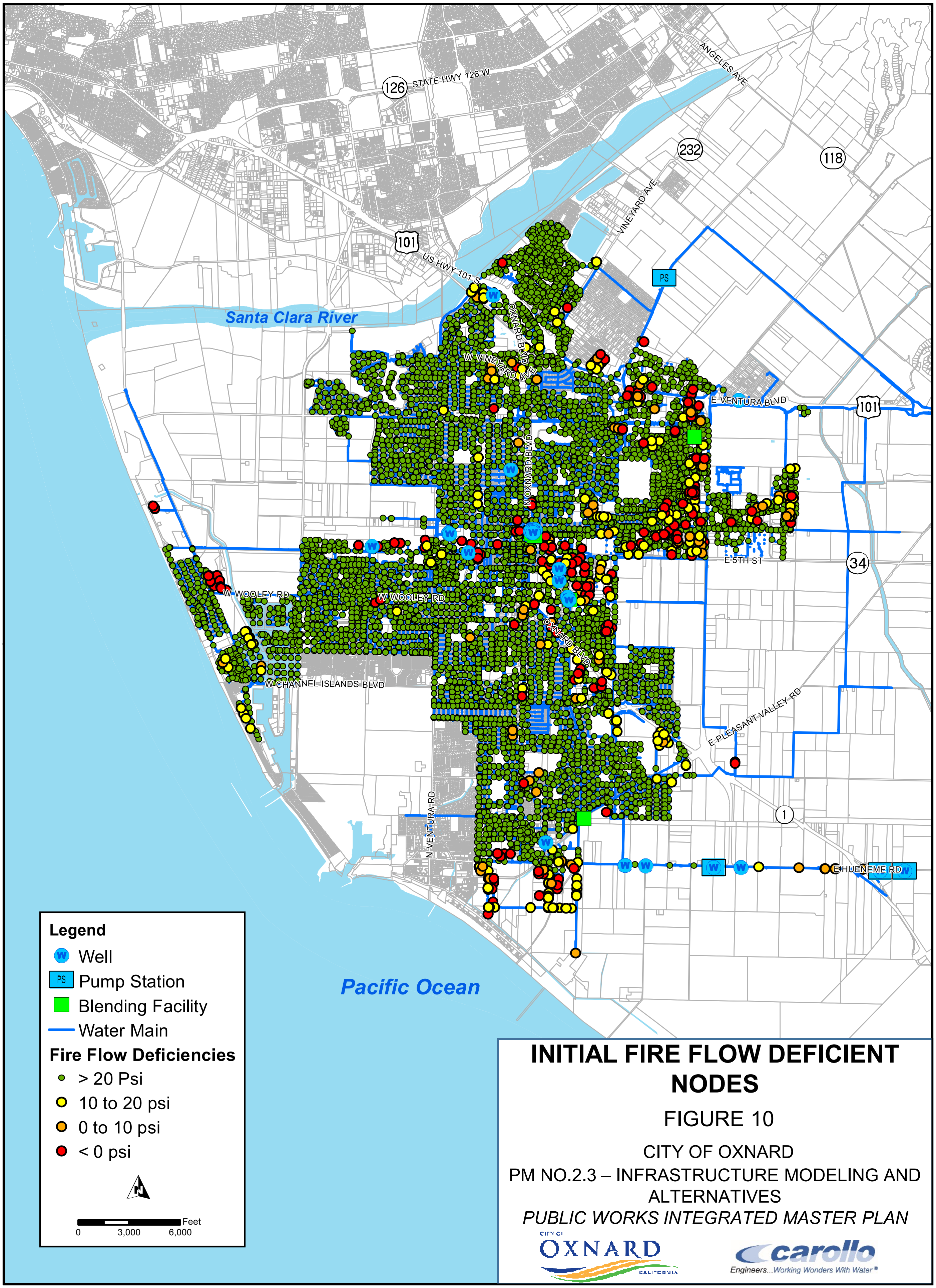
CIP Project ID	Replacement Type	Description	Diameter (inches)	Pipeline Length (feet)
FF-20	R	Rowe's Motor lot to Saviers Rd Parallel to Wolf St	8	103
FF-21	R	Channel Islands Refrigeration at Saviers Rd	8	171
FF-22	R	Alley off of E Wooley Rd next too Best Western Oxnard Inn to E Date St	8	2,664
	R	Alley between California St and Pacific Coast Hwy at E Ash St and E Date St	8	1,232
FF-23	R	E Wooley Rd at Best Western Oxnard Inn to Mercantile St	12	1,832
	R	Industrial Ave at E Wooley Rd and F St	12	549
FF-24	R	E Elm St at Saviers Rd and Gisler Ave	8	1,886
FF-25	R	Sunkist Cir at Shooters Paradise of Oxnard	12	110
FF-26	R	Rocket Team Sales lot at Statham Blvd	12	300
FF-27	R	Parking Corporation of America lot parallel to Statham Pkwy at Statham Blvd	12	644
FF-28	R	S A St at W Channel Islands Blvd to W Yucca St	8	1,400
FF-29	R	Johnson Rd and Justin Way at Saviers Rd to E Bard Rd	8	1,628
FF-30	R	Public Junior High School lot at Olds Rd	8	121
FF-31	R	Curran St between 7-Eleven and Reeder Ave	8	415
FF-32	R	Island Pacific Supermarket lot at S Rose Ave	8	219
FF-33	R	Parkway behind homes at Longfellow Way and Jefferson Square	8	557

Table 7	Recommended Fire Flow Improvements Public Works Integrated Master Plan City of Oxnard			
CIP Project ID	**Replacement Type**	**Description**	**Diameter (inches)**	**Pipeline Length (feet)**
FF-34	N	Small Section beginning at end of E Clara St to start of intersection with Cypress Rd	8	79
FF-35	N	Courtland St at Carlisle Ct and W Hueneme Rd	8	686
	N	Small section on Cuesta Del Mar Dr to connect pipeline at Courtland St	8	70
FF-36	N	Rear of New-Indy Containerboard LLC at McWane Blvd parallel to Perkins Rd	12	1,157
FF-37	R	Magellan Ave at Perkins Rd	12	332
FF-38	N	BMW of North America lot at Arcturus Ave	8	271
FF-39	R	Channel Islands Logistics lot at Arcturus Ave	12	540
Total	**N/A**	**N/A**	**N/A**	**32,222**

Notes:
N - new, R - replace.

5.3 Recommendations

As shown in Table 7, 39 fire flow improvements have been proposed involving upsizing existing pipelines and/or completing pipeline loops with a combined length of approximately 32,000 feet (or 6 miles). As shown on Figure 1, the majority of these fire flow improvements are located in the center of the city near industrial users.



INITIAL FIRE FLOW DEFICIENT NODES

FIGURE 10

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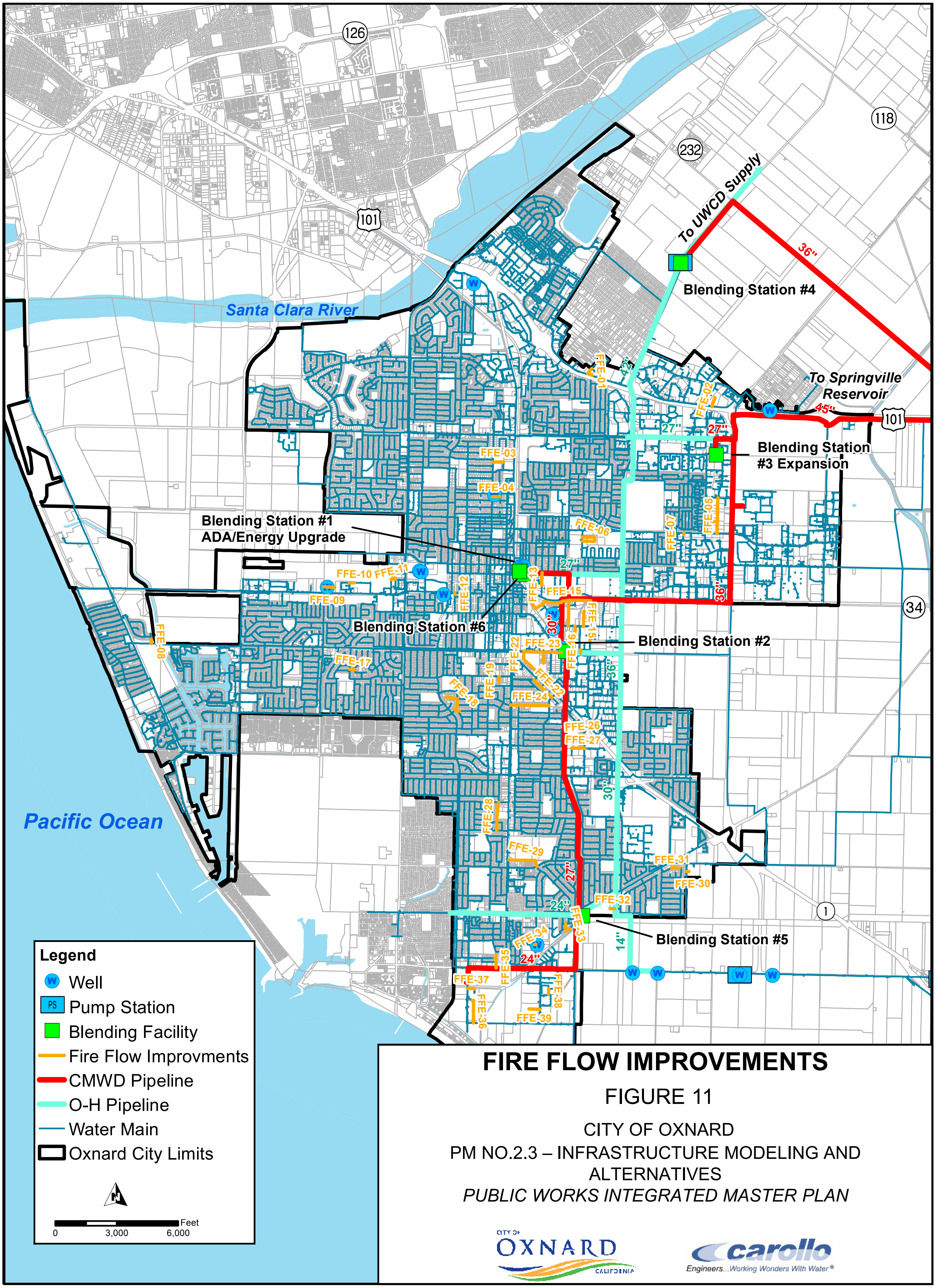

FIRE FLOW IMPROVEMENTS

FIGURE 11

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6.0 STORAGE ANALYSIS

6.1 Existing and Future System Analysis

The City's distribution system currently contains no above ground, engineered storage reservoirs. All water is ether pumped from groundwater wells or imported through the Calleguas Municipal Water District (CMWD) or the United Water Conservation District (UWCD). The 18.0 million gallon (MG) Springville Reservoir is owned by CMWD and 70 percent of the reservoir's volume is dedicated to the City. Therefore, 12.5 MG is considered as the total volume of storage available to the for the storage analysis. As described in Section 2.4, the storage criteria consists of the following three components:

1. Operational storage.
2. Fire flow storage.
3. Emergency storage.

Based on the well information provided in PM 2.1, *Water System - Background Summary*, the City has backup generator capacity for their groundwater supply wells. Therefore, it is reasonable to assume that the emergency storage capacity for the City comes from their local groundwater system. This will supply roughly 25 percent of their current demand needs during MDD conditions.

The fire flow storage was set at the highest fire flow requirements. The highest fire flow requirement in the City's service is 4,500 gpm for four (4) hours, which equates to 1.1 MG and is typically provided with above ground storage. The operational storage criteria, set at 25 percent of MDD, is also typically provided with above ground storage.

An assessment of these three storage needs as it relates to the City's future projected water demands was conducted. The need was then compared with the available storage at the Springhill Reservoir. A summary of the required and available storage volumes, for existing and future system demand, is presented in Table 8.

6.2 Recommendations

As shown in Table 8, the existing storage analysis demonstrates that the City has no need to construct any storage facilities until 2025. By 2040, it is recommended that and additional 1.5 MG of above ground storage be constructed.

If the City decides to break the single pressure zone water distribution system into multiple pressure zones, the future storage should be constructed in the zone with the highest HGL. Constructing the storage in the highest zone enables the child zones to also benefit from this improvement.

Table 8	Existing and Future System Storage Analysis Public Works Integrated Master Plan City of Oxnard						
Storage Needed	**Storage Criteria**	**Existing (MG)**	**2020 (MG)**	**2025 (MG)**	**2030 (MG)**	**2035 (MG)**	**2040 (MG)**
ADD, mgd		27.9	29.9	30.4	31.6	32.9	34.1
MDD, mgd							
Operational, MG	25% of MDD	10.5	11.2	11.4	11.9	12.3	12.8
Fire Flow, MG	4,500 gpm for 4 hours	1.1	1.1	1.1	1.1	1.1	1.1
Emergency, MG	Stored as Groundwater	0.0	0.0	0.0	0.0	0.0	0.0
Total, MG		11.5	12.3	12.5	12.9	13.4	13.9
Springville Reservoir, MG		12.5	12.5	12.5	12.5	12.5	12.5
Oxnard Required, MG		**-1.0**	**-0.2**	**0.0**	**0.4**	**0.9**	**1.3**

Note:
(1) ADD comes from Table 10 in PM 2.2; this table also identifies the MDD peaking factor to be 1.5.

It is likely that this amount of storage will be constructed as part of additional permeate storage included in a desalter expansion at Blend Station 1/6. The details of this are included in PM 2.5, *Water System - Supply and Treatment Alternatives*.

7.0 AGE REPLACEMENT ANALYSIS

7.1 Evaluation Methodology

The GIS Pipeline database was used to identify the installation year and pipeline material of each of the pipe segments in the City's distribution system. The average useful life for each material type seen in the City is listed in Table 2. Using this table in conjunction with each pipe segments installation year, an approximated year of failure for each pipe segment can be estimated. This analysis was performed using Carollo's Below Ground Assets Management spreadsheet tool or BAM.

7.2 Pipeline Installation History

A summarization of the City's 613 - miles of pipeline age, materials, and diameters is provided in PM 2.1, *Water System Background Summary*. Figure 12 shows the length of pipeline that was installed on an annual basis. It should be noted that approximately 430,000 feet of pipeline with an unknown installation year is not shown in Figure 12.

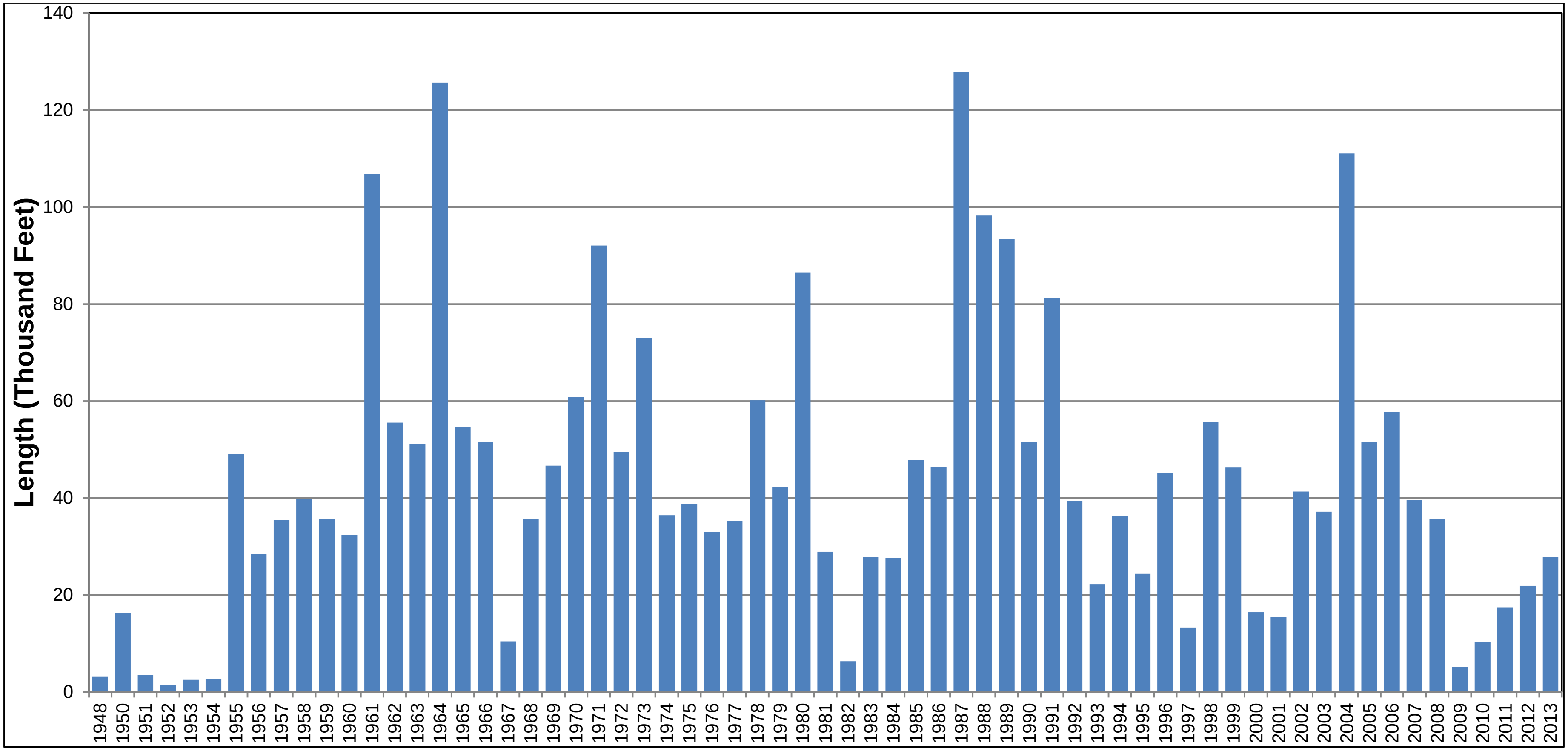


Figure 12 Length of Pipeline Installation by Year

7.3 BAM Analysis Results

The results of the BAM analysis are presented in Figure 13. Approximately 50 miles of pipelines would require replacement by year 2040. This amount includes 15 miles of pipeline that has outlived its average remaining useful life. It is recommended that these pipelines are inspected right away to determine the actual condition, estimate the remaining useful life, and prioritize replacements based on these findings, as the remaining 35 miles of pipelines will pass its remaining useful life by 2040. The annual replacement length is shown on Table 9 and summarized by pipe length in Table 10. The annual replacement length varies from nearly zero to 15 miles per year and peaks around year 2040. However, pipeline failures and actual replacement needs occur within a range of years around the expected useful life and an average replacement rate of 2.0 miles per year (50 miles/25 years) can be used for CIP planning.

As seen in Figure 13, the majority of pipeline replacements are actually required beyond year 2040, the planning horizon of this master plan. Hence, a proactive replacement program will need to be implemented in the near-term as the majority of the “replacement bubble” that echoes the installation history needs to be replaced beyond 2040.

7.4 Recommendations

Table 9 summarizes the recommended pipeline replacement length by pipe diameter through year 2040. As noted above, 51.6 miles of pipeline reach their end of useful life and need to replace by the year 2040. There was 2,743 feet of pipeline with unknown diameter included in this analysis. For the purposes of conservative planning this length was grouped in with the 48 inch-diameter pipeline totals. It is recommended that the City use the lengths and diameters presented in Table 10 to reserve budget to proactively replace older pipelines throughout the distribution system.

8.0 RECOMMENDED PROJECTS FOR WATER DISTRIBUTION SYSTEM

Based on the findings in this PM, several projects have been identified to ensure the water distribution system is functioning based on the criteria established in Table 1. Table 11 summarizes all of the recommended projects needed through 2040. These projects are needed not only for meeting the projected 2040 demand, but also for providing a reliable, redundant, and sustainable water supply into the future.

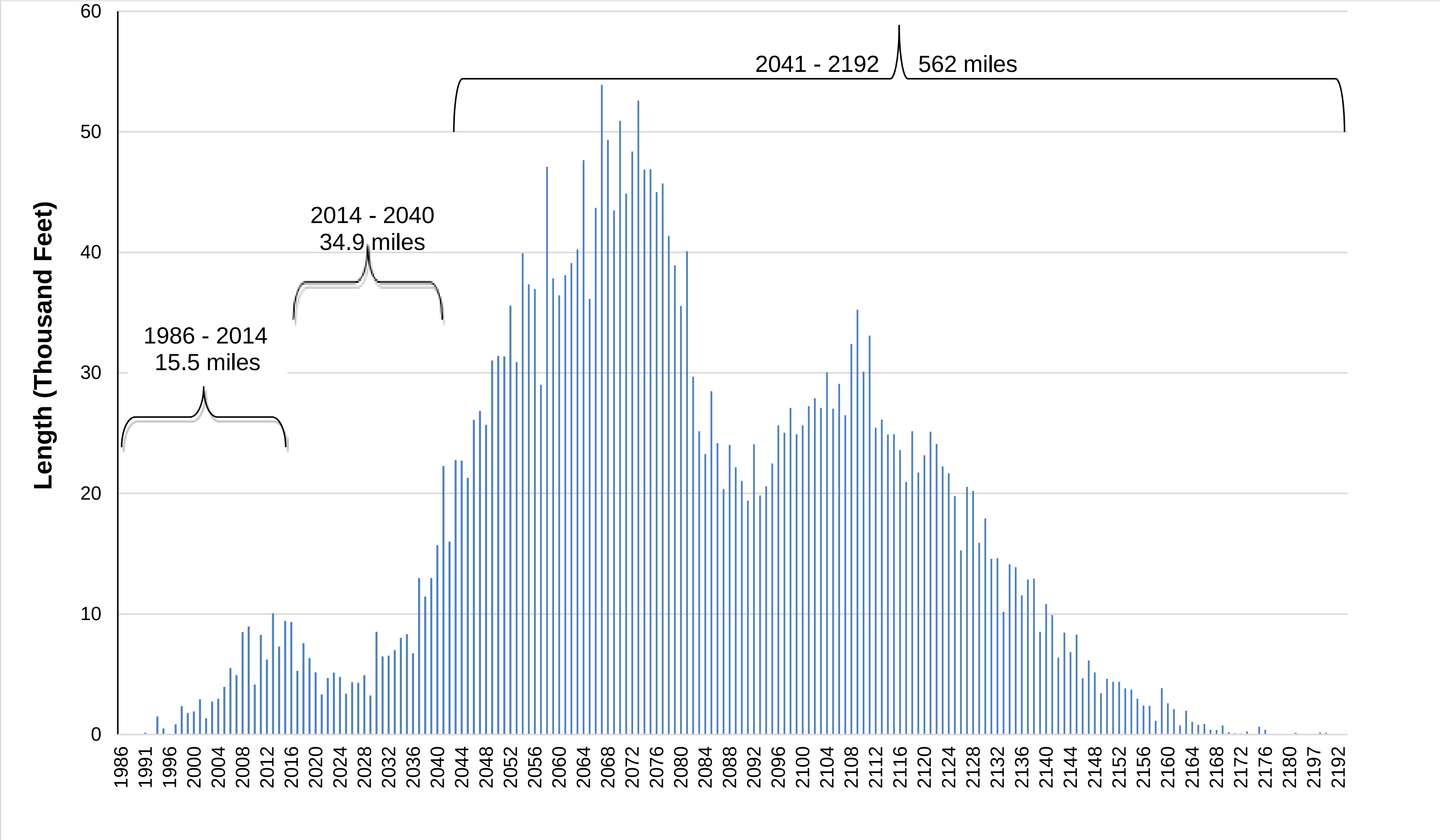


Figure 13 Length of Pipeline to be Replaced by Year

Table 9 Pipeline Replacement Length by Year
Public Works Integrated Master Plan
City of Oxnard

Replacement Year	Pipeline Length (ft)	Pipeline Length (mi)
Pre 2014	88,364	16.75
2014	6,120	1.16
2015	10,001	1.89
2016	4,121	0.78
2017	7,451	1.41
2018	4,595	0.87
2019	6,010	1.14
2020	8,342	1.58
2021	5,393	1.02
2022	2,731	0.52
2023	3,422	0.65
2024	5,303	1.00
2025	3,586	0.68
2026	3,367	0.64
2027	3,620	0.69
2028	4,896	0.93
2029	3,688	0.70
2030	4,092	0.77
2031	4,730	0.90
2032	6,460	1.22
2033	8,403	1.59
2034	8,026	1.52
2035	8,387	1.59
2036	11,166	2.11
2037	8,727	1.65
2038	9,895	1.87
2039	16,506	3.13
2040	15,134	2.87
Total	**272,610**	**51.63**

Table 10 Present to 2040 Pipeline Replacement Length by Diameter Public Works Integrated Master Plan City of Oxnard		
Pipeline Diameter (in)	**Pipeline Length (ft)**	**Pipeline Length (mi)**
6	109,241	20.69
8	47,803	9.05
10	56,986	10.79
12	27,750	5.26
14	4,949	0.94
16	4,001	0.76
24	7,720	1.46
36	4,976	0.94
42	5,343	1.01
48	3,841	0.73
Total	**272,610**	**51.63**

9.0 RECOMMENDED PROJECTS - PRIORITY, COSTS, AND SCHEDULE

Cost estimates, implementation priority, and schedule were also developed for the recommended projects for the water distribution system, as summarized in the previous section. This information will be included in the overall Capital Improvement Program (CIP) and used as the basis for the financial analysis portion of the PWIMP to determine financial impact of the project to the City and its rate payers.

There are three main drivers for the water distribution costs as noted in the section above: 2) Rehabilitation and Replacement (R&R), 2) Pressure Zone Separation and 3) Fire Flow Upgrades. Each of the drivers is described in more detail below.

9.1 Water Supply

All of the projects designated as 'water supply' under the Recommended Projects are considered needed for maintaining sustainable water supply and meeting projected customer demand through the planning period.

9.2 Rehabilitation and Replacement (R&R)

Several analysis conducted as part of the PWIMP have assessed the condition of the City's existing water and infrastructure system assets. The following PMs address the existing asset assessments that were made:

- PM 2.4,- Water System - Condition Assessment – Assessed the R&R needs of and developed priorities for the water blend stations and pipeline infrastructure of the water system.
- PM 2.7, Water System - Cathodic Protection Assessment – Phases 1 and 2 – Assessed the cathodic protection needs of the water system and developed a list of recommended projects to address deficiencies.

Table 11 Recommended Facilities to Meet Water Supply Needs through 2040
Public Works Integrated Master Plan
City of Oxnard

Facility	Description	Location	Quantity	Unit	Capacity
Water System					
North Zone Modifications					**--**
	Rehab 3 PRS	3 locations on Gonzalez Road	3	Valves	--
	BS#3 Reconfigure 24" Pipeline to feed North Zone	From BS#3 up Solar Road to Gonzalez Road			
	Minor Piping Modification	Along Gonzalez Road			--
Coastal Zone Modifications					
	3 new PRS	3 locations on S. Victoria Avenue	3	Valves	--
	New 8" Parallel Pipeline	S. Victoria Avenue	3,000	lf	--
	Minor Piping Modification	Along S. Victoria Avenue			--
South Zone Modifications					
	3 new PRS	3 locations on E. Pleasant Valley Road	3	Valves	--
	New 8" Parallel Pipeline	E. Pleasant Valley Road	6,000	lf	--
	Minor Piping Modification	Along E. Pleasant Valley Road			--
Fire Flow Improvements					
	8 inch-diameter pipeline	Vary	18,500	feet	--
	12 inch-diameter pipeline	Vary	13,500	feet	--
	14 inch-diameter pipeline	Vary	250	feet	--

Table 11 Recommended Facilities to Meet Water Supply Needs through 2040
Public Works Integrated Master Plan
City of Oxnard

Facility	Description	Location	Quantity	Unit	Capacity
New Storage Reservoir	Construct a new tank for Storage	TBD	1	tank	1.5 MG
Pipeline Capacity Improvements				--	--
	Replace 6" Pipeline	Vary	101	lf	--
	Replace 8" Pipeline	Vary	956	lf	--
	Replace 10" Pipeline	Vary	2,254	lf	--
	Replace 12" Pipeline	Vary	3,682	lf	--
	Replace 14" Pipeline	Vary	2,617	lf	--
	Replace 24" Pipeline	Vary	937	lf	--
	Replace 30" Pipeline	Vary	3,804	lf	--
Age Based Replacements(1)				**--**	**--**
	Replace 6" Pipeline	Vary	109,100	lf	--
	Replace 8" Pipeline	Vary	47,000	lf	--
	Replace 10" Pipeline	Vary	55,000	lf	--
	Replace 12" Pipeline	Vary	24,000	lf	--
	Replace 14" Pipeline	Vary	2,300	lf	--
	Replace 16" Pipeline	Vary	4,000	lf	--
	Replace 24" Pipeline	Vary	3,700	lf	--
	Replace 36" Pipeline	Vary	5,000	lf	--
	Replace 42" Pipeline	Vary	5,300	lf	--
	Replace 48" Pipeline	Vary	3,800	lf	--

Table 11 Recommended Facilities to Meet Water Supply Needs through 2040
Public Works Integrated Master Plan
City of Oxnard

Facility	Description	Location	Quantity	Unit	Capacity
GREAT Projects[(2)]					
	Freemont North Neighborhood Replacement				
	Bryce Canyon South Neighborhood Replacement				
	Redwood Neighborhood Replacement				
	La Colonia Neighborhood Replacement				

Notes:
(1) Age replacement recommendations were reduced by the equivalent length of pipe replaced due to capacity needs.
(2) As documented in the City's GREAT program CIP, February 18, 2015. (included in PM 2.5, *Supply and Treatment Alternatives*, Appendix I).

In addition, some additional R&R items already identified by the City in their current GREAT Program CIP (circa February 2015) were also included. As well, the fire flow upgrades recommended in this PM are also included under R&R.

9.3 Pressure Zone Separation

The driver for the pressure zone separation projects is to provide a more consistent pressure range over varying demand conditions throughout the City. The details of this analysis are included in Section 4.0 of this PM.

9.4 Cost Summary

The Water System improvement project costs are presented in Table 12 and are based on the results found in this and supporting PMs. Project costs are estimated based on unit costs developed from estimating guides, equipment manufacturer's information, unit prices and construction costs of similar facilities and other locations. A more detailed discussion of the basis of costs is included in PM 1.5, *Overall - Basis of Cost*.

The project drivers are noted next to each project along with their anticipated start year and length of project completion. The projects are categorized by priority which loosely also follows timing of the projects: 1) Priority 1 – Immediate needs; 2) Priority 2 – Near-Term Needs; and 3) Priority 3 – Long-Term Needs.

The Overall Project Costs for the Recommended CIPs are summarized in Table 13. PM 2.5, *Water System - Supply and Treatment Alternatives* includes an overall schedule for completion of the water supply, treatment, and distribution projects.

The costs and timing presented in this PM represent Carollo's best professional judgment of the capital expenditure needs of the City and of the timing needed to maintain a reliable and compliant system that can meet current and future water demands and wastewater generation needs. Timing of the projects was set to align with the seven master plan drivers, namely: R&R, regulatory requirements, economic benefit, performance benefit, growth, resource sustainability, and policy decisions. Project timing is also based on input from City staff and the condition assessments performed.

Though the costs developed in this PM match the costs analyzed as part of the Cost of Service (COS) Study (Carollo, 2015), the timing presented may differ. The COS Study will balance not only the CIP projects identified but also the rates and rate payer affordability based on a yearly balance along with the integrated costs for the different City funds and enterprises.

Table 12	Recommended Water Distribution System Project Costs[1] Public Works Integrated Master Plan City of Oxnard			
Project Name	**Driver**	**Start Year**	**Years to Implement**	**Un-escalated Project Cost ($)**
Phase 1				
Replacement of AMR Devices	R&R	2016	6	$14,000,000
Oxnard Conduit - Replace deep anode beds and rectifiers #1, #2, and #3[2]	R&R	2016	1	$330,000
3rd Street Oxnard Extension - Replace deep anode bed and rectifier; bond UWCD pipeline to Oxnard extension at rectifier[2]	R&R	2016	1	$110,000
Freemont North Neighborhood CIP Replacement[3]	R&R	2016	0.5	$1,700,000
Bryce Canyon South Neighborhood CIP Replacement[3]	R&R	2016	0.5	$1,100,000
Redwood Neighborhood CIP Replacement[3]	R&R	2016	0.5	$2,100,000
La Colonia Neighborhood CIP Replacement[3]	R&R	2016	0.5	$1,500,000
Fire Flow Improvements - 18,500 feet of 8" pipe	R&R	2016	2	$4,600,000
Fire Flow Improvements - Install/replace 13,500 feet of 12" pipe	R&R	2016	2	$4,400,000
Fire Flow Improvements - Install 250 feet of 14" pipe	R&R	2016	1	$100,000
North Zone Modifications				
BS#3 Reconfigure Pipeline to feed Coast Zone	Pressure Zone Separation	2016	2	$600,000
Rehab 3 PRS	Pressure Zone Separation	2016	2	$400,000
Minor Piping Modification	Pressure Zone Separation	2016	2	$100,000
Coast Zone Modifications				
3 new PRS	Pressure Zone Separation	2016	2	$700,000
3,000 ft of 8" Parallel Pipeline	Pressure Zone Separation	2016	2	$800,000
Minor Piping Modification	Pressure Zone Separation	2016	2	$100,000
South Zone Modifications				
3 new PRS	Pressure Zone Separation	2016	2	$700,000
6,000 ft of 8" Parallel Pipeline	Pressure Zone Separation	2016	2	$1,500,000
Minor Piping Modification	Pressure Zone Separation	2016	2	$100,000
Capacity Improvements - 322 feet of 8" pipe	Water Supply	2016	1	$80,000
Capacity Improvements - 238 feet of 12" pipe	Water Supply	2016	1	$80,000

Table 12 Recommended Water Distribution System Project Costs[1]
Public Works Integrated Master Plan
City of Oxnard

Project Name	Driver	Start Year	Years to Implement	Un-escalated Project Cost ($)
Capacity Improvements - 164 feet of 14" pipe	Water Supply	2016	1	$60,000
Capacity Improvements - 3,804 feet of 30" pipe	Water Supply	2016	1	$2,500,000
		Phase 1 TOTAL:		**$37,700,000**
Phase 2				
Del Norte Forced Main - 48" & 36" CMCL PL - Locate and Repair discontinuity near the ease end of Del Norte Pl[2]	R&R	2018	1	$30,000
3rd Street Oxnard Extension - Locate and repair discontinuity near Chem Building at BS 1/6	R&R	2018	1	$50,000
Industrial Lateral - Install new test stations at 6 locations [2]	R&R	2018	1	$30,000
Gonzalez 36" Pipeline - Replace test station lids and test CP	R&R	2018	1	$5,000
Oxnard Conduit - Install new test stations, conduct CIS, locate/excavate/bond across approx. 3 points of electrical isolation[2]	R&R	2018	1	$160,000
Capacity Improvements - 69 feet of 6" pipe	Water Supply	2018	1	$20,000
Capacity Improvements - 391 feet of 8" pipe	Water Supply	2018	1	$100,000
Capacity Improvements - 1,011 feet of 10" pipe	Water Supply	2018	1	$300,000
Capacity Improvements - 2,447 feet of 12" pipe	Water Supply	2018	1	$800,000
		Phase 2 TOTAL:		**$1,500,000**
Phase 3				
Del Norte Forced Main - Replace rectifiers and anodes; resurvey[2]	R&R	2021	1	$390,000
Del Norte Forced Main - Install new test stations and leads[2]	R&R	2021	1	$30,000
Wooley Road / United - Replace test stations and install 2 additional stations[2]	R&R	2021	1	$30,000
Wooley Road / United - Replace rectifier and anode; resurvey[2]	R&R	2021	1	$130,000
Capacity Improvements - 32 feet of 6" pipe	Water Supply	2028	2	$10,000
Capacity Improvements - 233 feet of 8" pipe	Water Supply	2028	2	$60,000
Capacity Improvements - 1,243 feet of 10" pipe	Water Supply	2028	2	$400,000
Capacity Improvements - 997 feet of 12" pipe	Water Supply	2028	2	$330,000

Table 12	**Recommended Water Distribution System Project Costs[1] Public Works Integrated Master Plan City of Oxnard**			
Project Name	**Driver**	**Start Year**	**Years to Implement**	**Un-escalated Project Cost ($)**
Capacity Improvements - 2,453 feet of 14" pipe	Water Supply	2028	2	$1,000,000
Capacity Improvements - 937 feet of 24" pipe	Water Supply	2028	2	$600,000
Age Replacement 109,100 feet of 6" pipe	R&R	2033	2	$25,500,000
Age Replacement 47,000 feet of 8" pipe	R&R	2034	2	$11,700,000
Age Replacement 55,000 feet of 10" pipe	R&R	2035	2	$17,100,000
Age Replacement 24,000 feet of 12" pipe	R&R	2036	2	$7,900,000
Age Replacement 2,300 feet of 14" pipe	R&R	2037	1	$900,000
Age Replacement 4,000 feet of 16" pipe	R&R	2037	1	$1,700,000
Age Replacement 3,700 feet of 24" pipe	R&R	2037	2	$2,300,000
Age Replacement 5,000 feet of 36" pipe	R&R	2038	2	$3,900,000
Age Replacement 5,300 feet of 42" pipe	R&R	2039	2	$5,500,000
Age Replacement 3,800 feet of 48" pipe	R&R	2040	2	$4,100,000
			Phase 3 TOTAL:	**$83,600,000**

Notes:
(1) 20-City Average Index ENR CCI of 9,962 was used for February 2015. A R.S. Means Location Factor of 106.6 for Oxnard was used.
(2) Costs derived from Cathodic Protection Recommended Projects outlined in PM 2.7.
(3) Costs derived from the City’s GREAT program CIP, 02/18/2015.

Table 13 Overall Water Distribution System Project Costs by Priority (1)
Public Works Integrated Master Plan
City of Oxnard

Priority	Total Priority Cost
1	$37,700,000
2	$1,500,000
3	$83,600,000
Total	**$122,800,000**

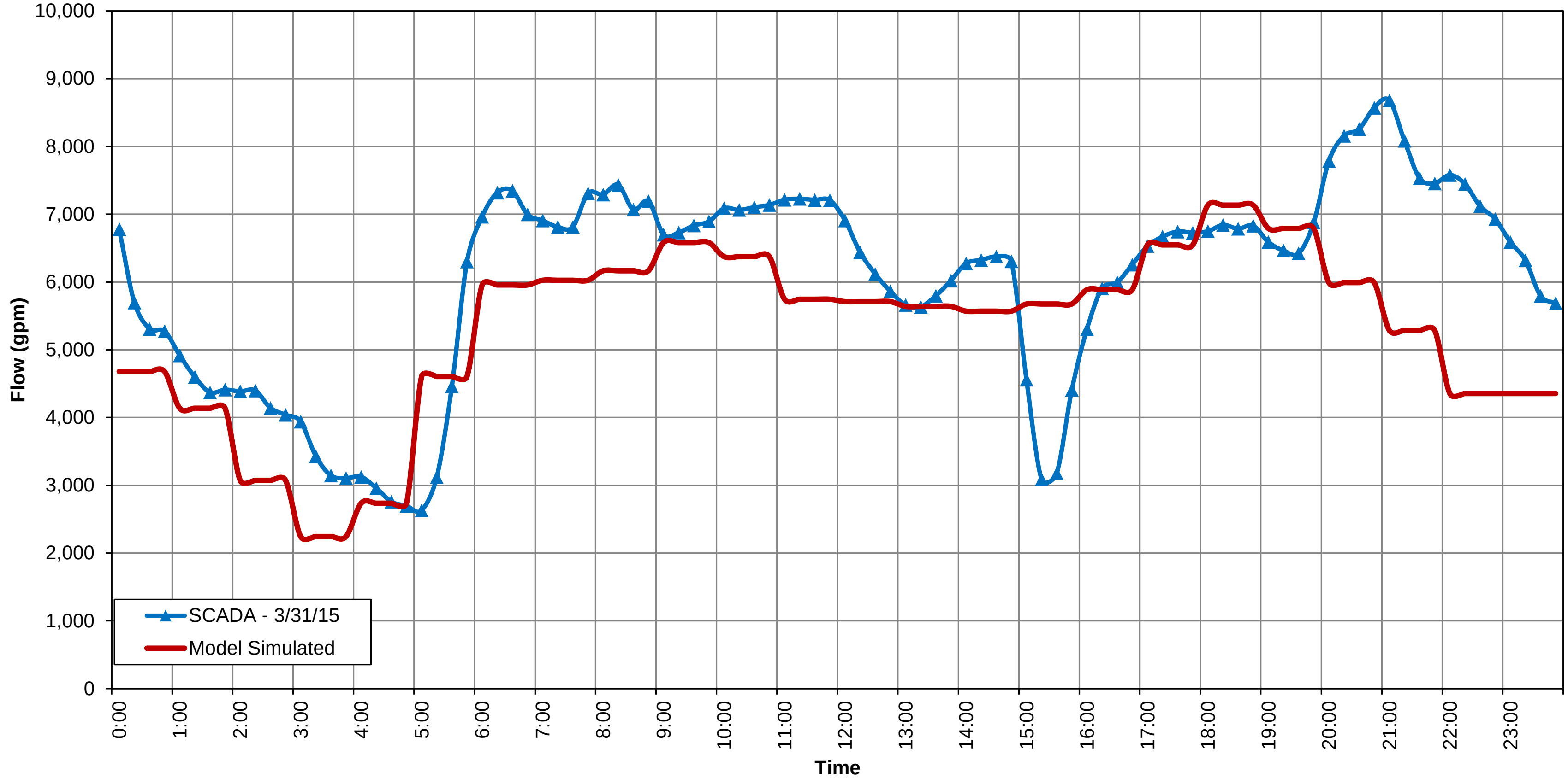
Note:
(1) 20-City Average Index ENR CCI of 9,962 was used for February 2015. A R.S. Means Location Factor of 106.6 for Oxnard was used.

APPENDIX A – EPS CALIBRATION RESULTS

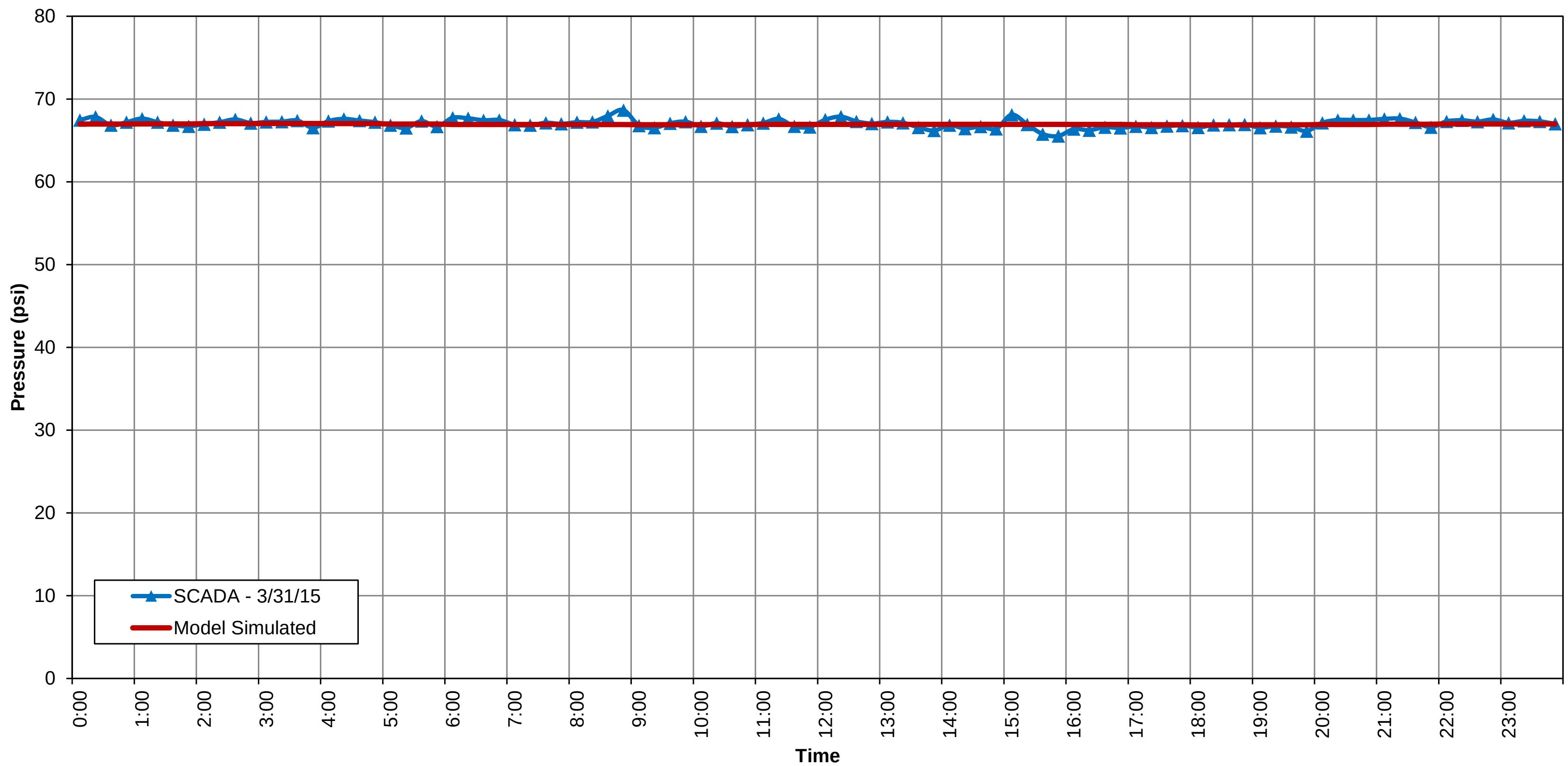
CITY OF OXNARD CALIFORNIA

EPS Calibration - BS1 PLANT FLOW
Public Works Integrated Master Plan
City of Oxnard

carollo



EPS Calibration - BS1 PLANT PRESSURE
Public Works Integrated Master Plan
City of Oxnard



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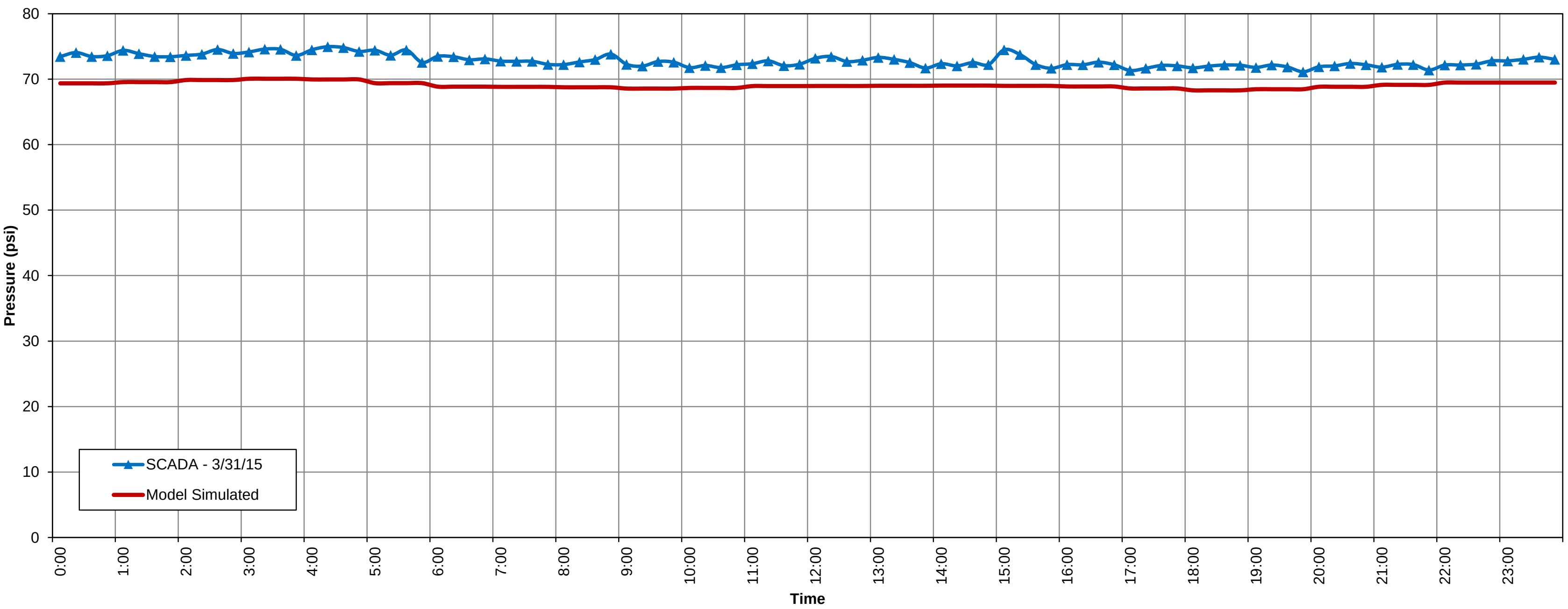
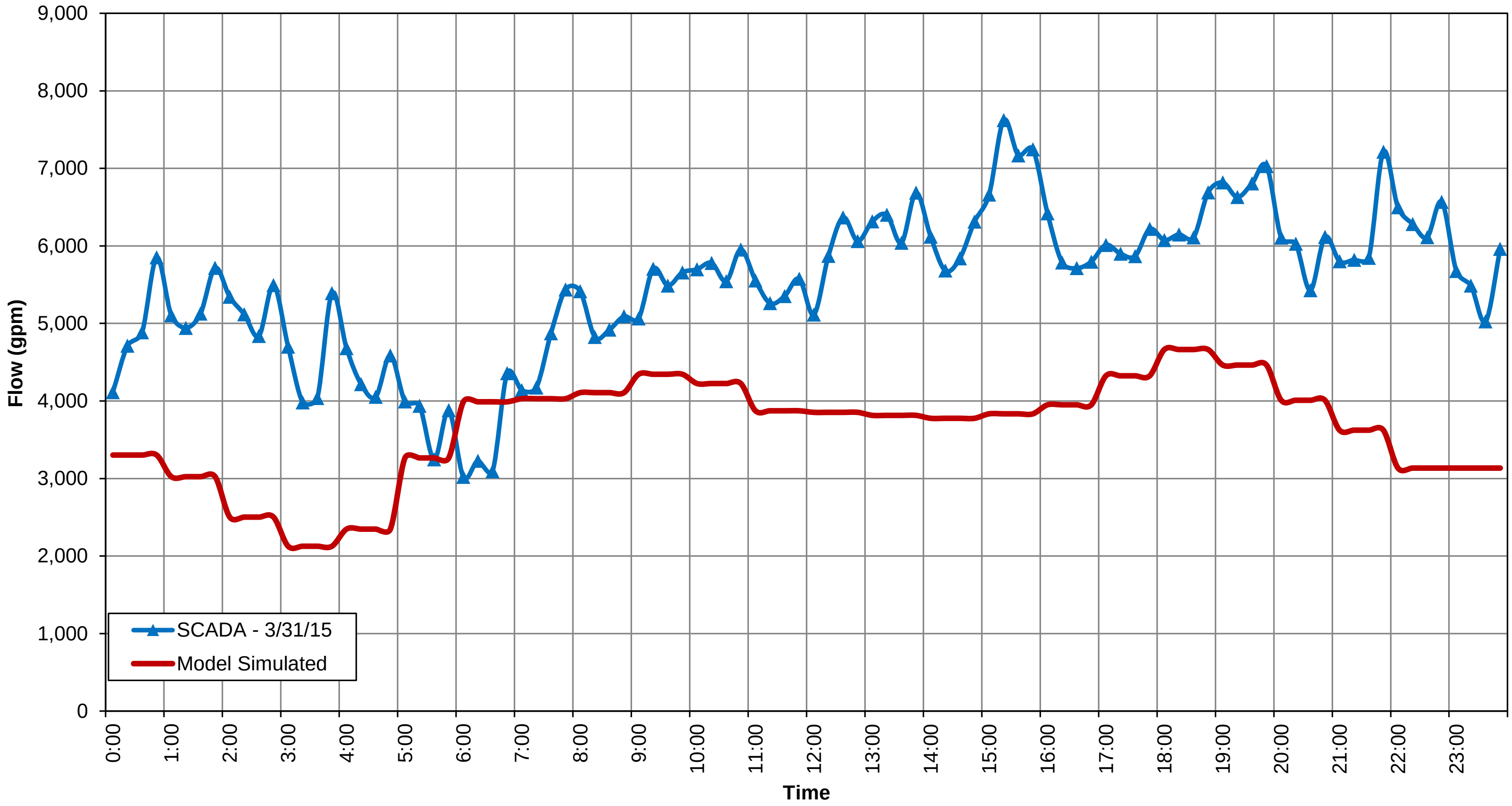
Public Works Integrated Master Plan
City of Oxnard



EPS Calibration - BS3 PLANT FLOW
Public Works Integrated Master Plan
City of Oxnard



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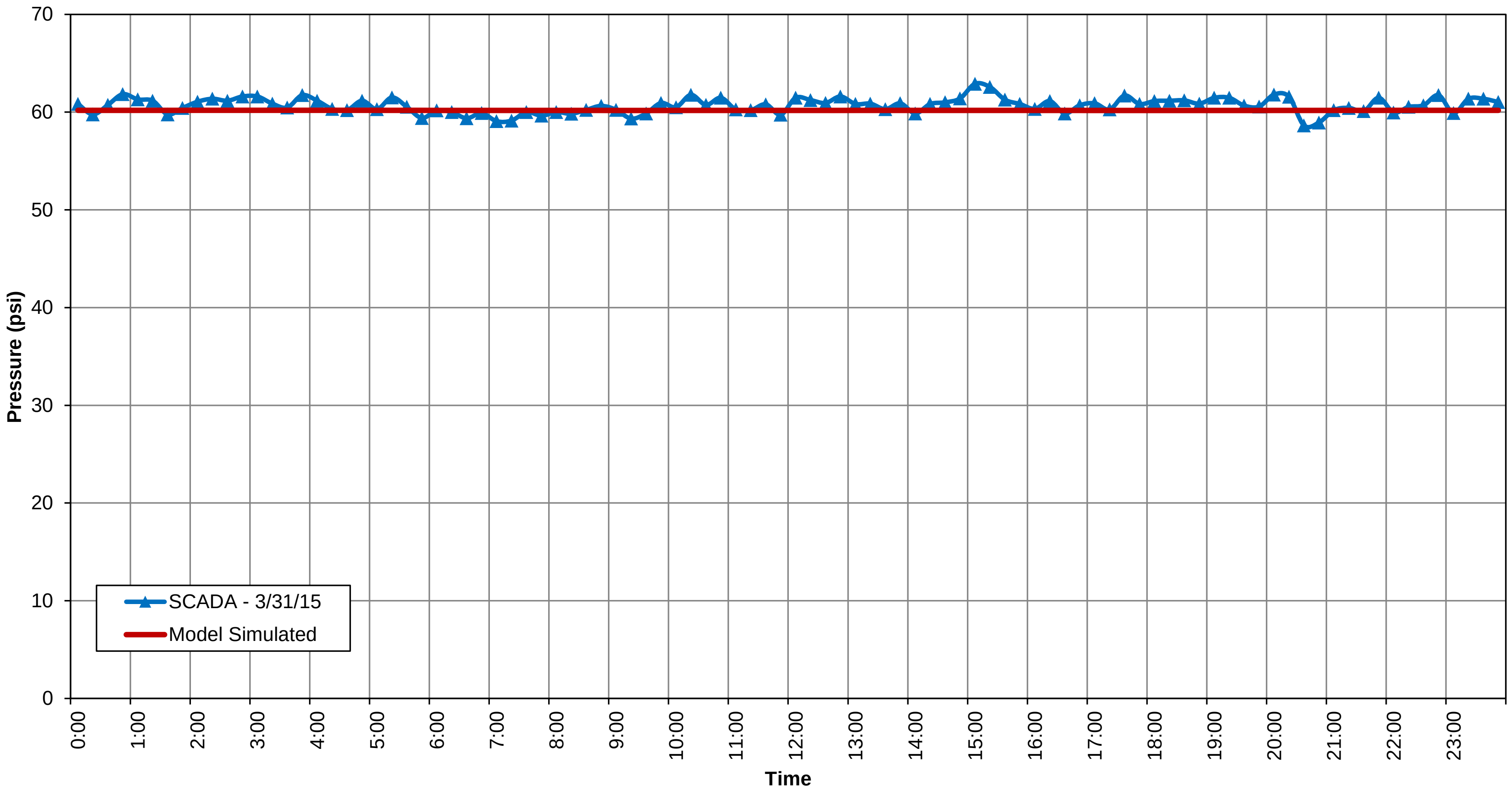
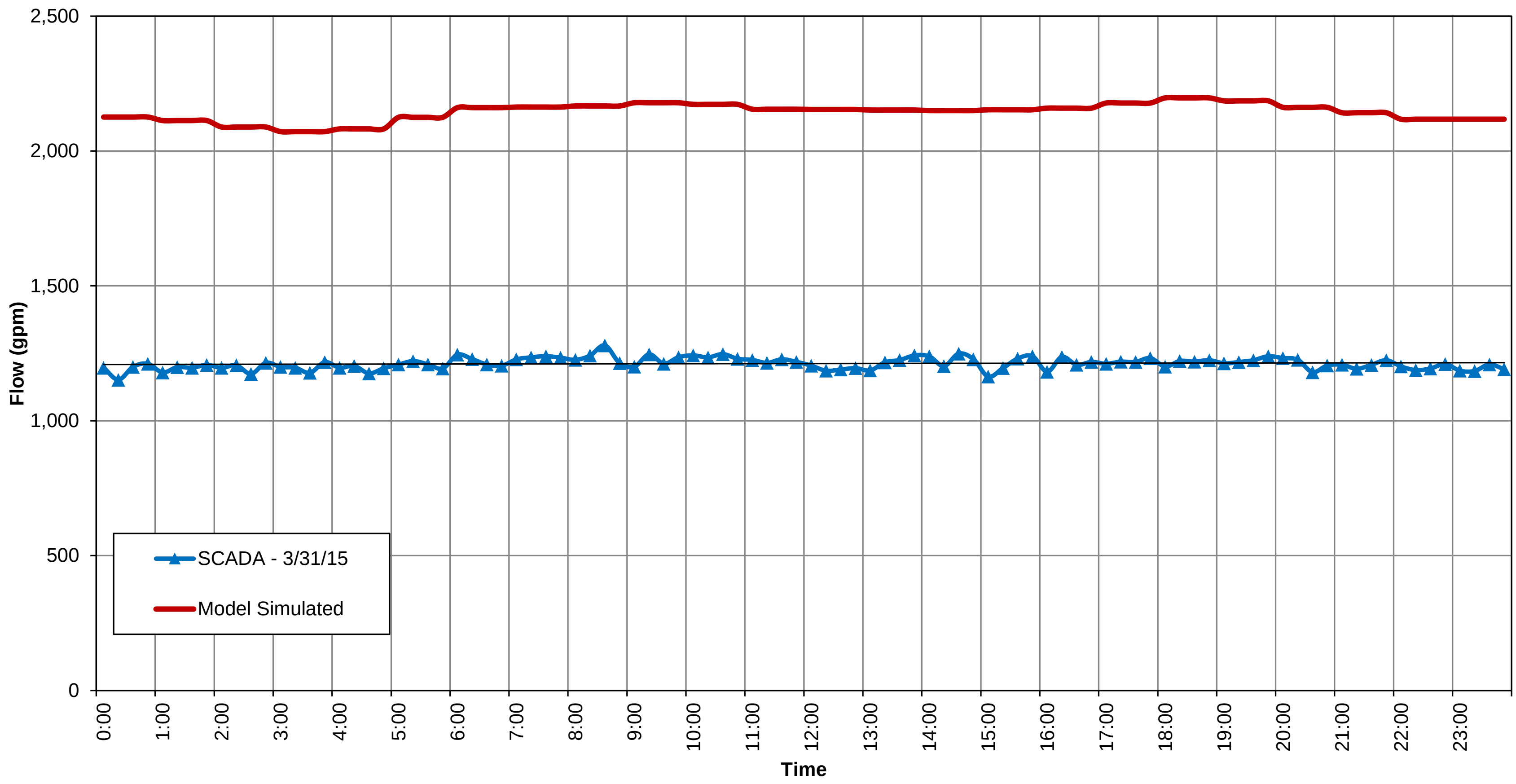
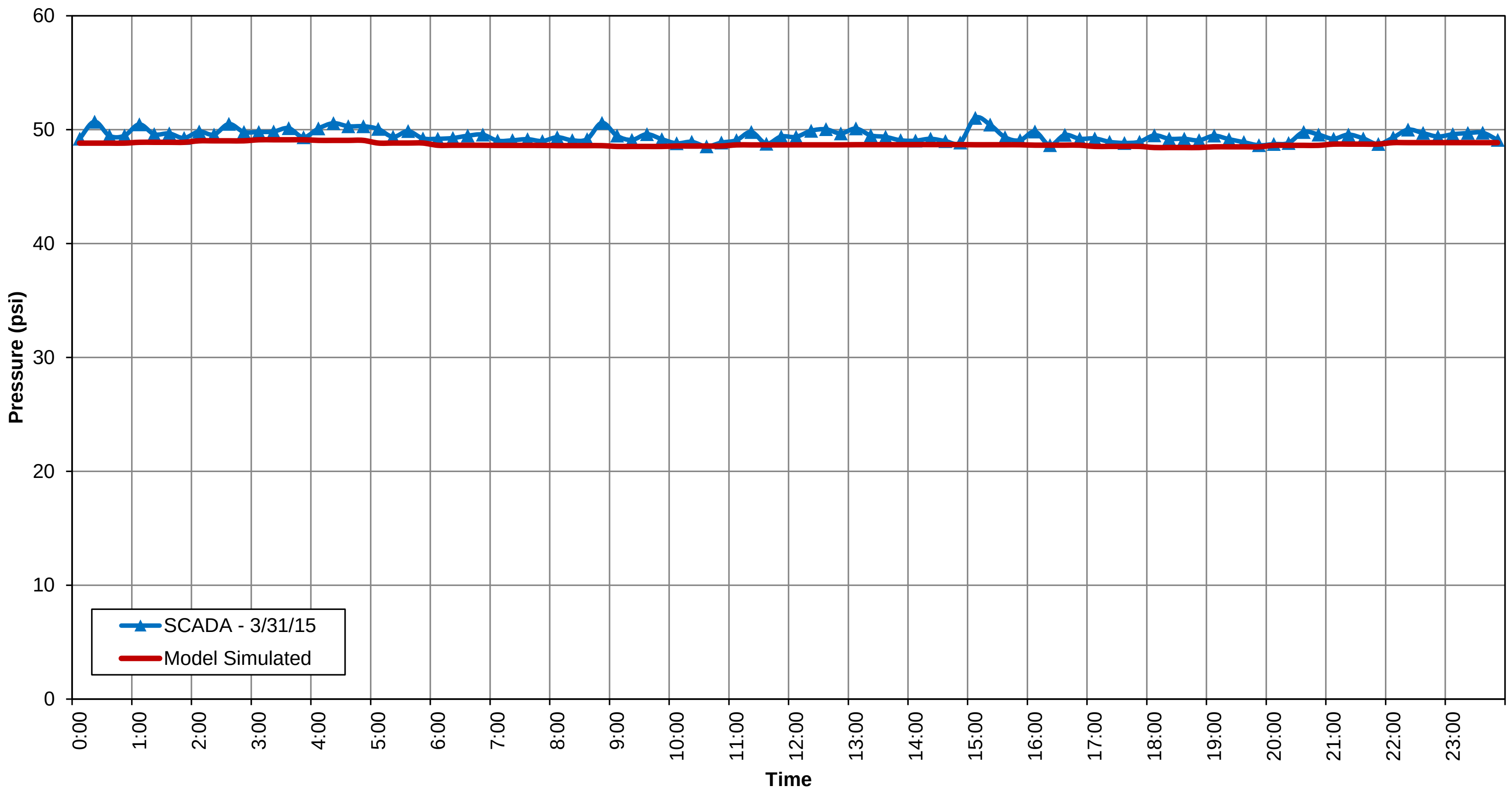
Public Works Integrated Master Plan
City of Oxnard



EPS Calibration - BS4 PLANT FLOW
Public Works Integrated Master Plan
City of Oxnard



EPS Calibration - BS4 PLANT PRESSURE
Public Works Integrated Master Plan
City of Oxnard



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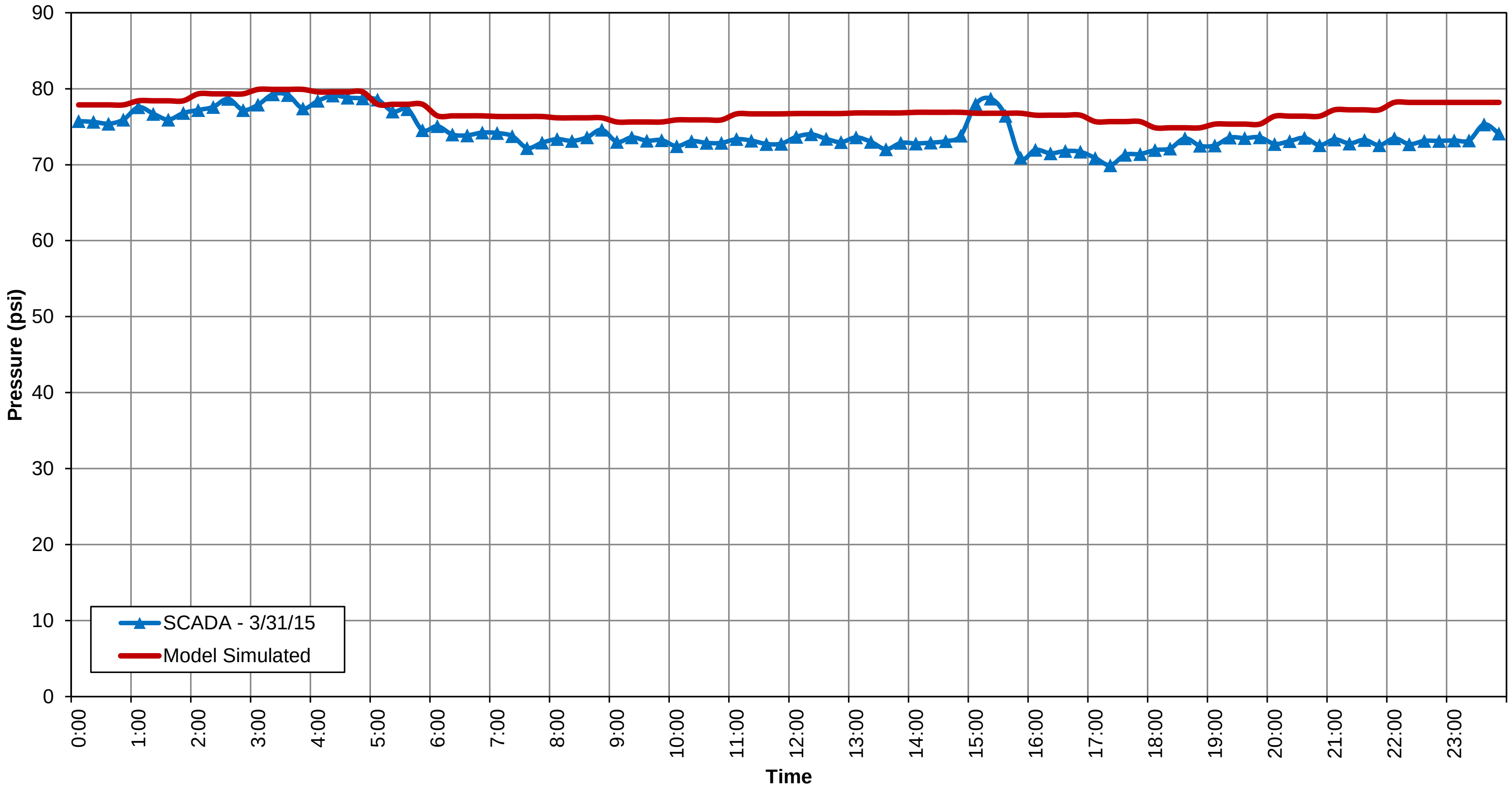
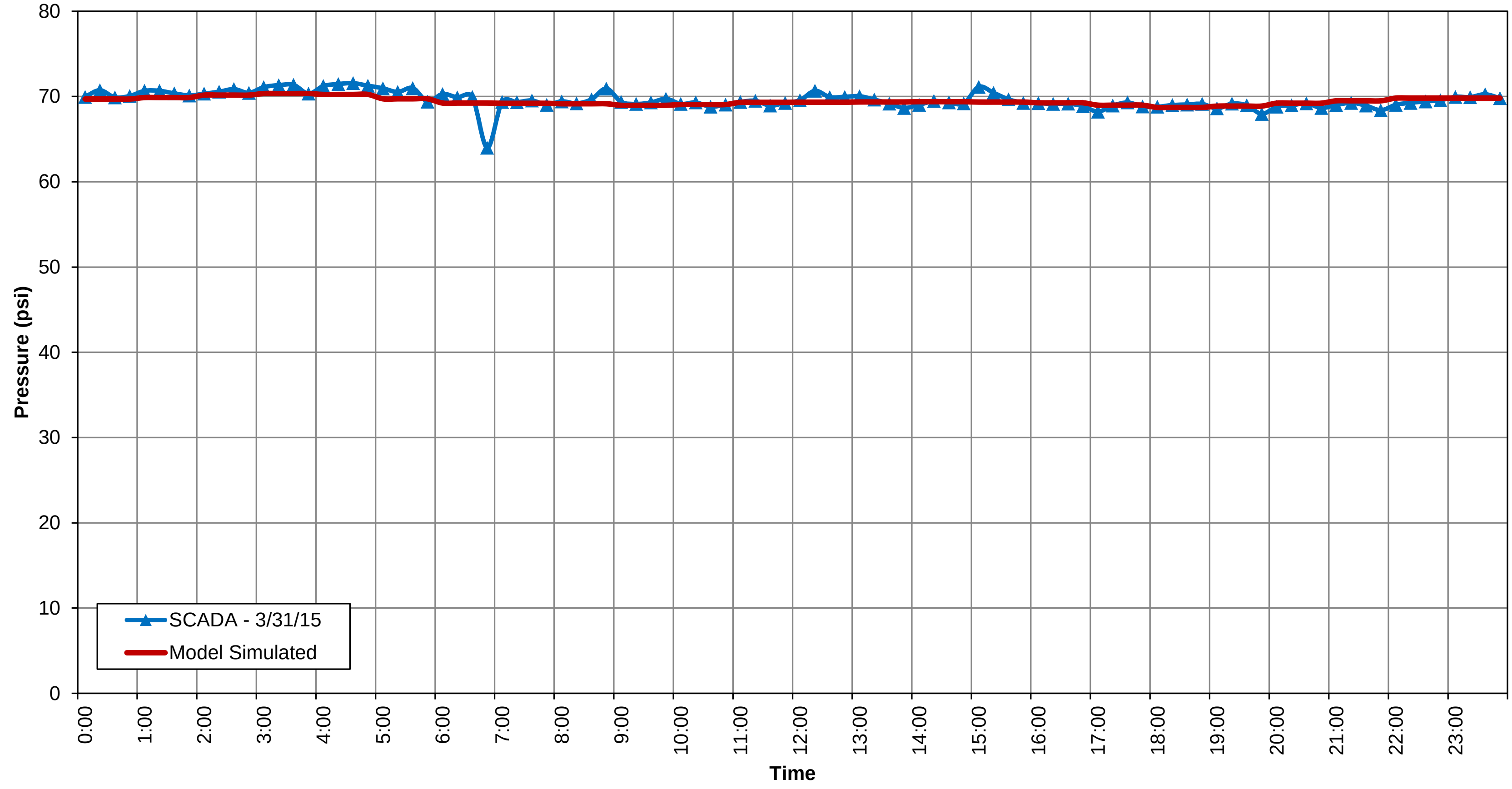
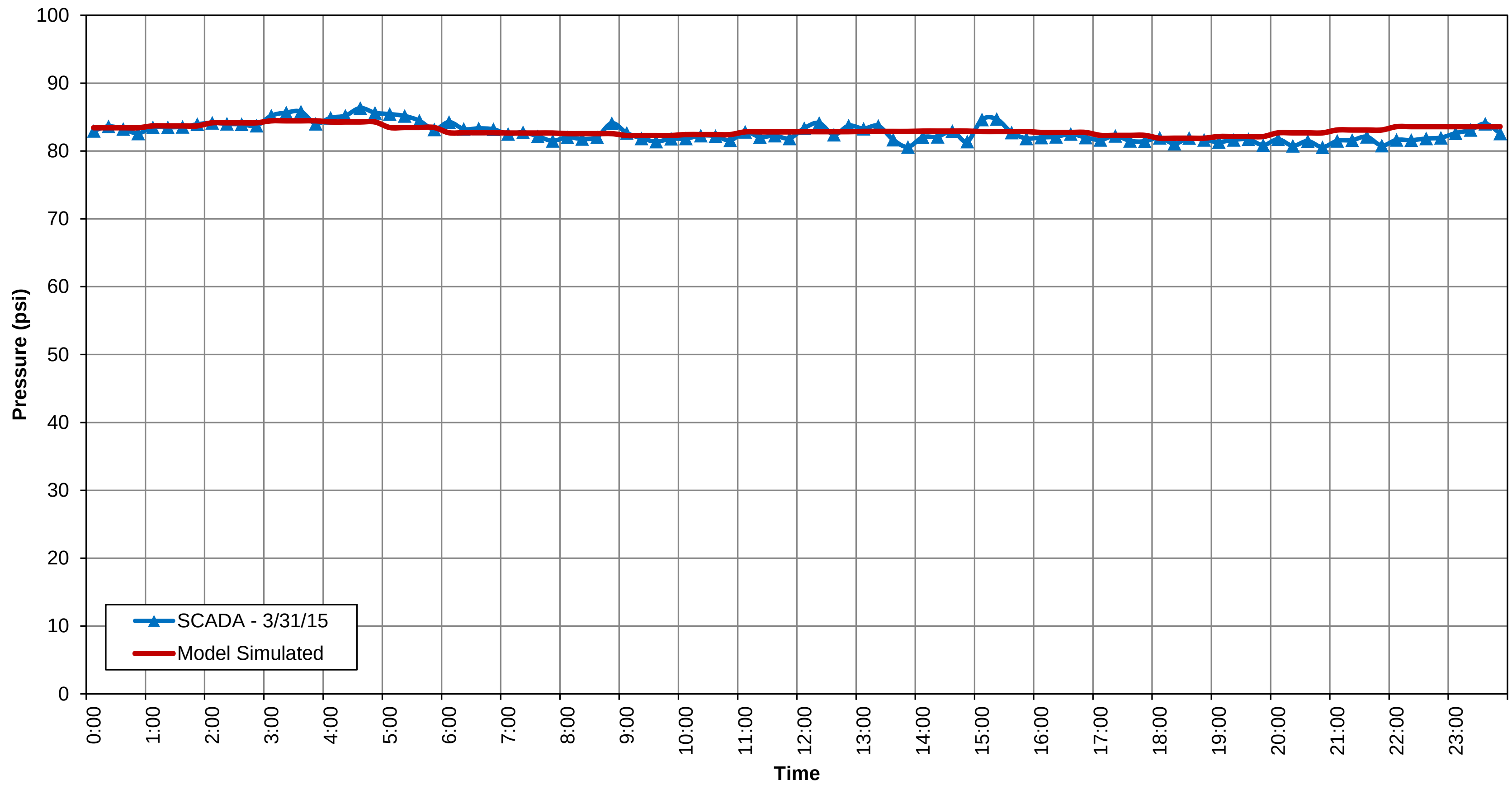
Public Works Integrated Master Plan
City of Oxnard



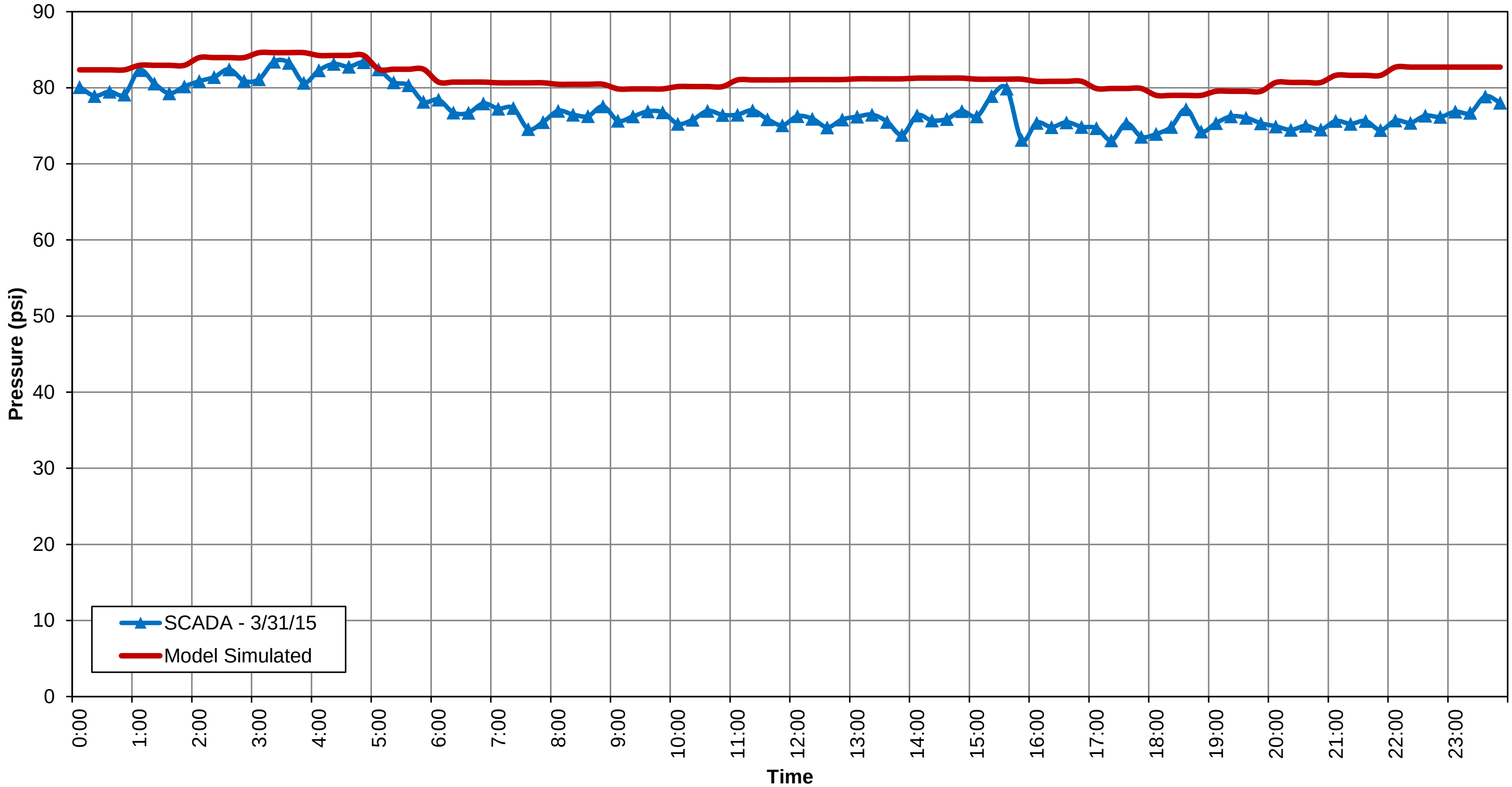
EPS Calibration - 3RD_K PRESSURE
Public Works Integrated Master Plan
City of Oxnard



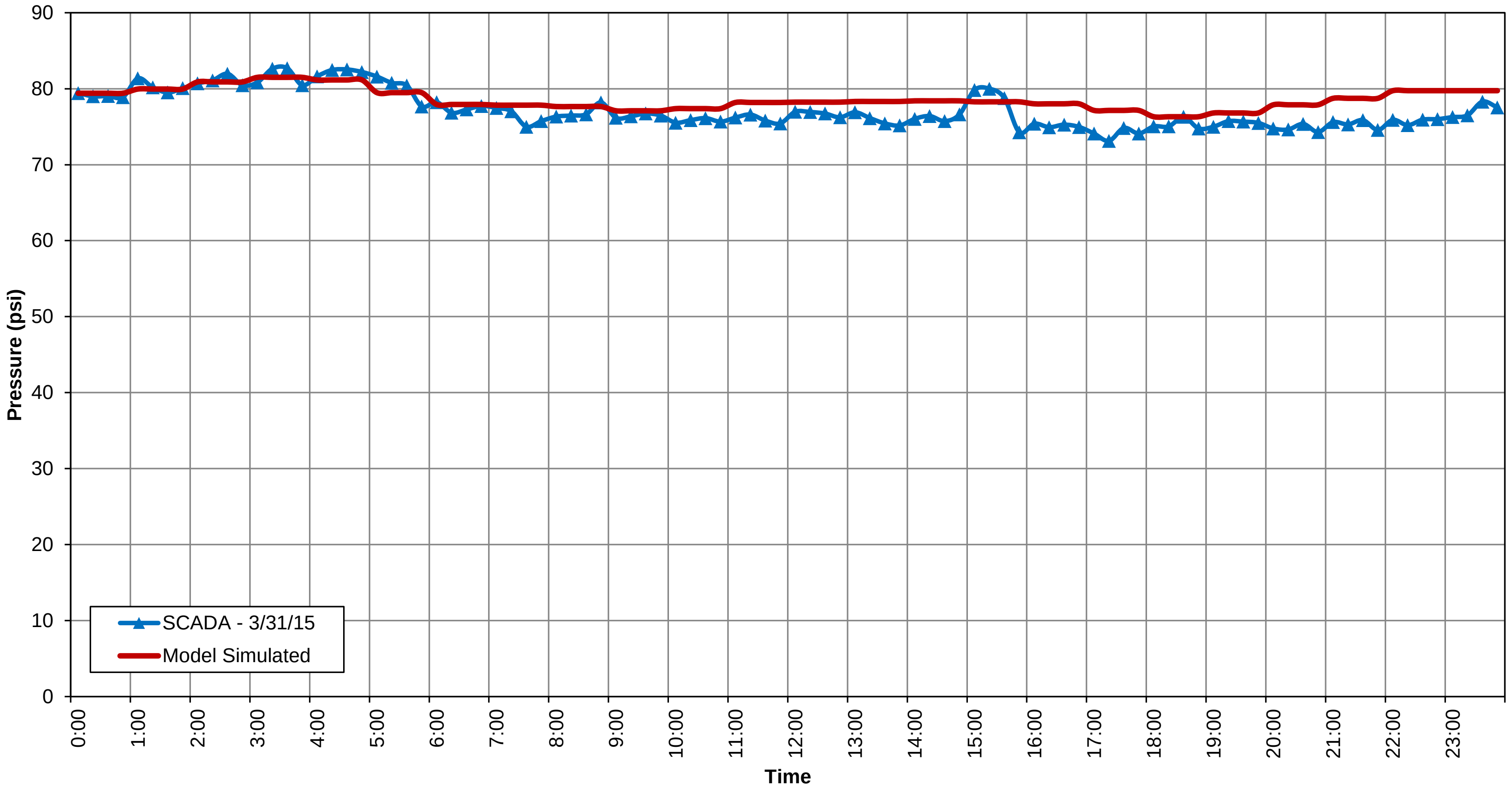
EPS Calibration - 5TH_HARBOR PRESSURE
Public Works Integrated Master Plan
City of Oxnard



EPS Calibration - ARCTURUS PRESSURE
Public Works Integrated Master Plan
City of Oxnard



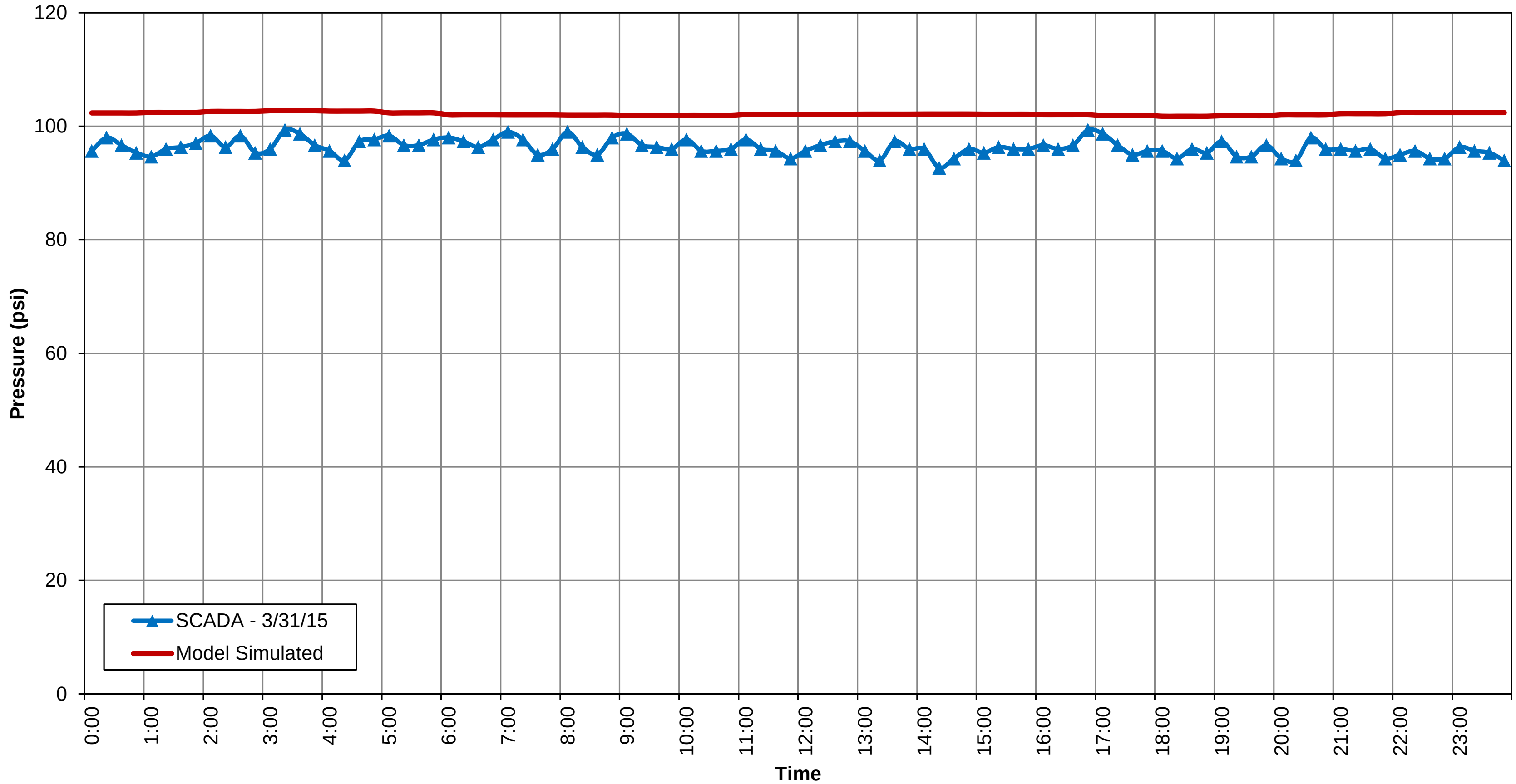
EPS Calibration - PV_PERKINS PRESSURE
Public Works Integrated Master Plan
City of Oxnard



CITY OF OXNARD CALIFORNIA

EPS Calibration - P&G PRESSURE
Public Works Integrated Master Plan
City of Oxnard

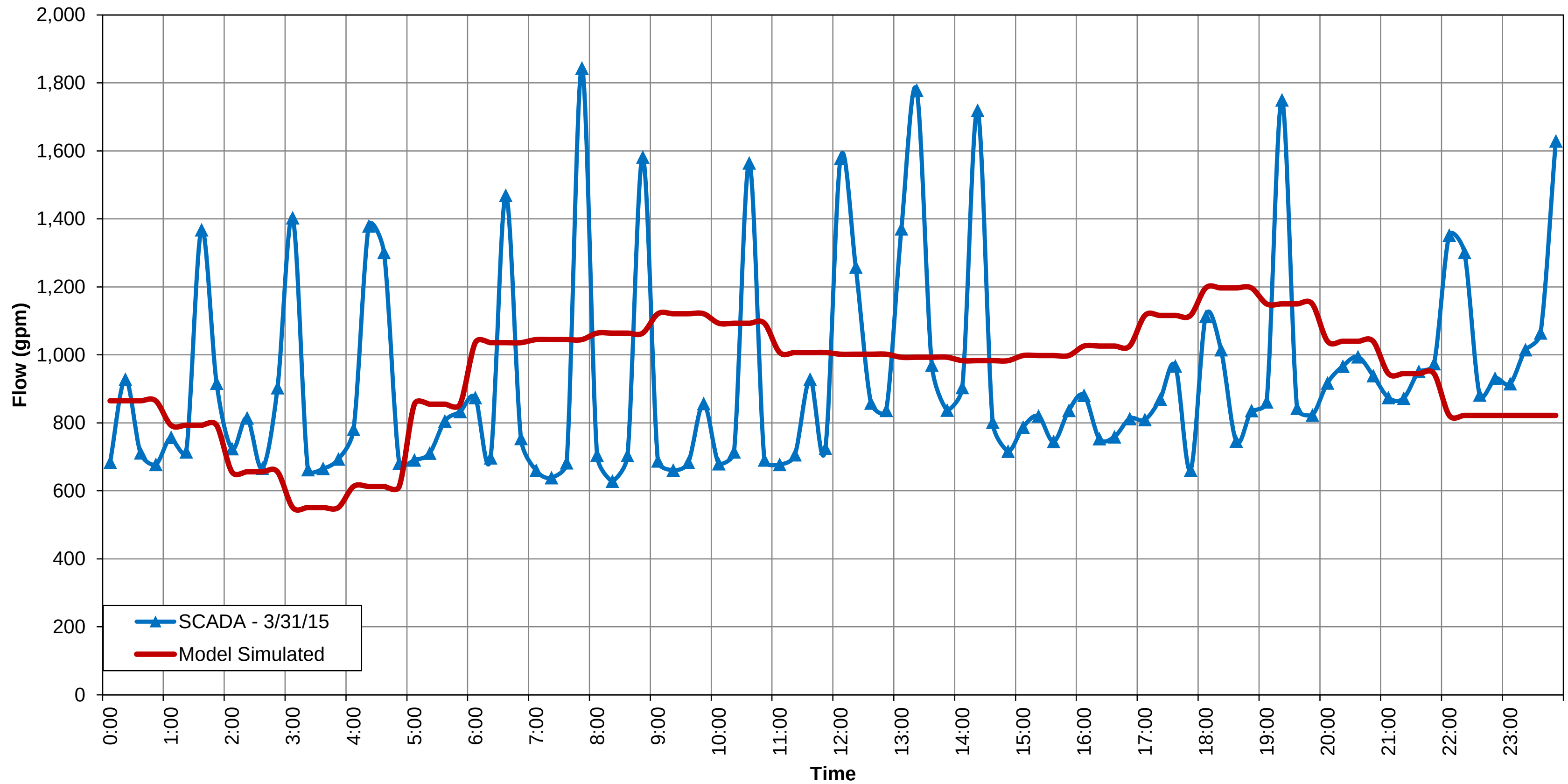
carollo



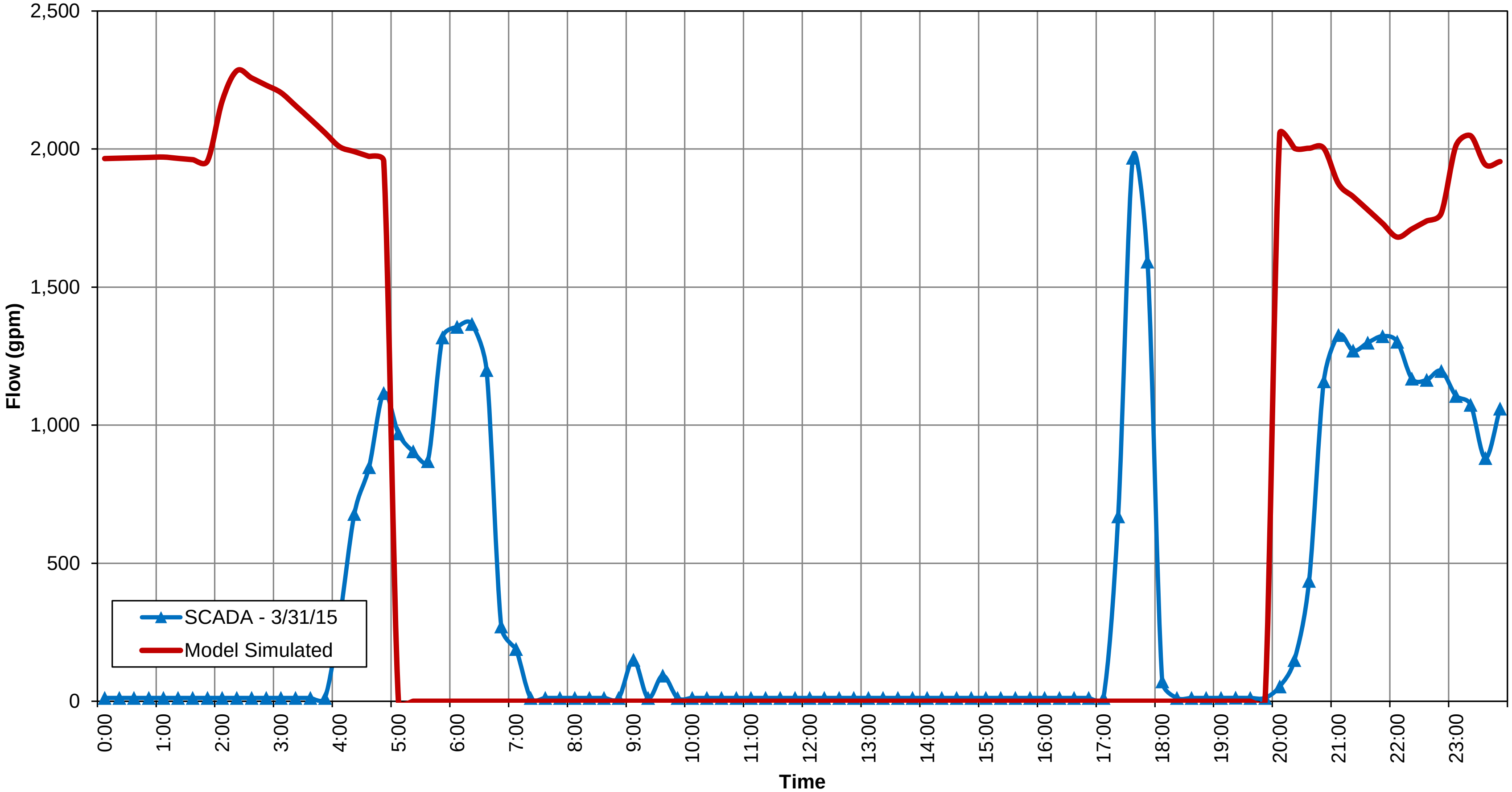
CITY OF OXNARD CALIFORNIA

EPS Calibration - P&G FLOW
Public Works Integrated Master Plan
City of Oxnard

carollo



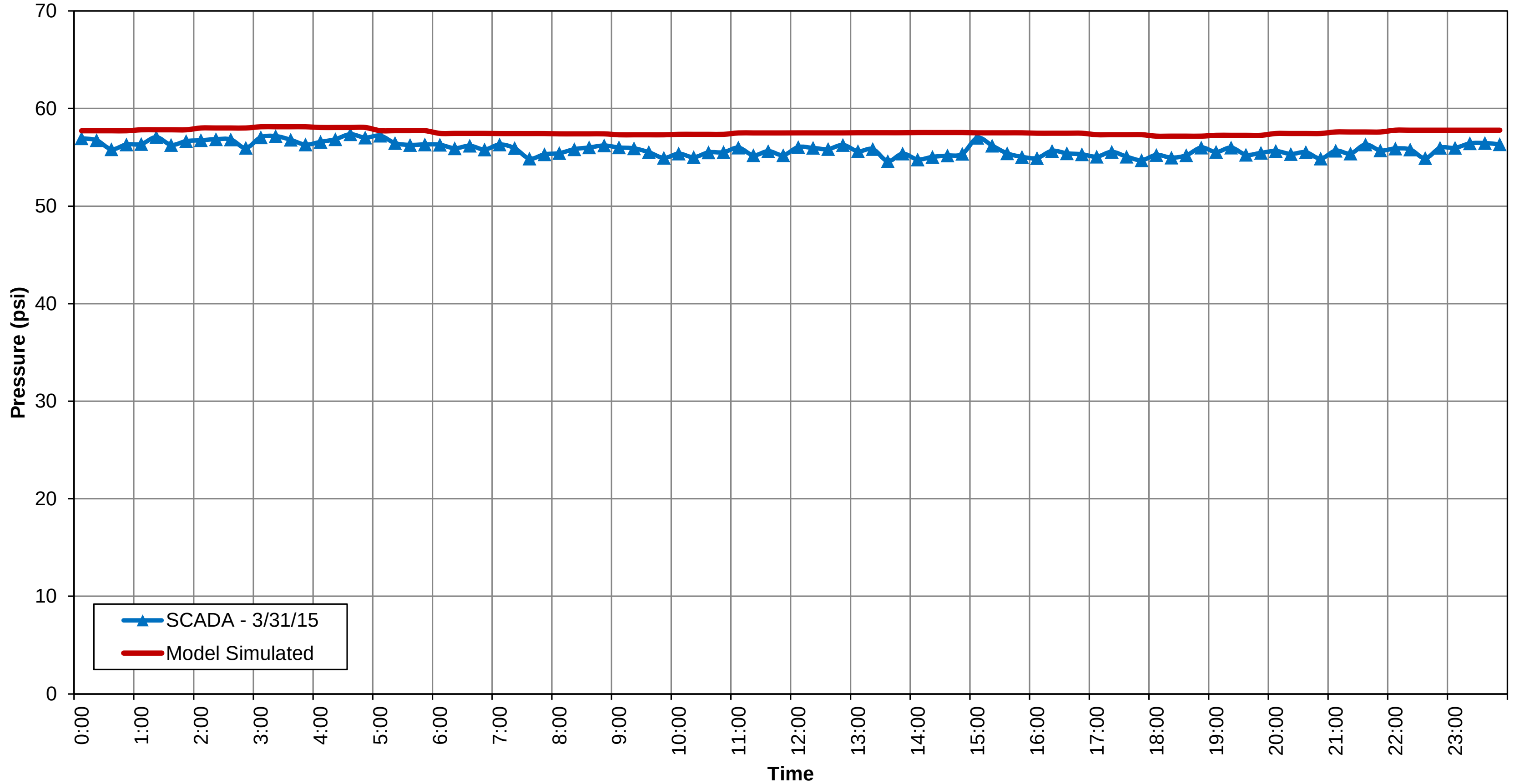
EPS Calibration - PHWA FLOW
Public Works Integrated Master Plan
City of Oxnard



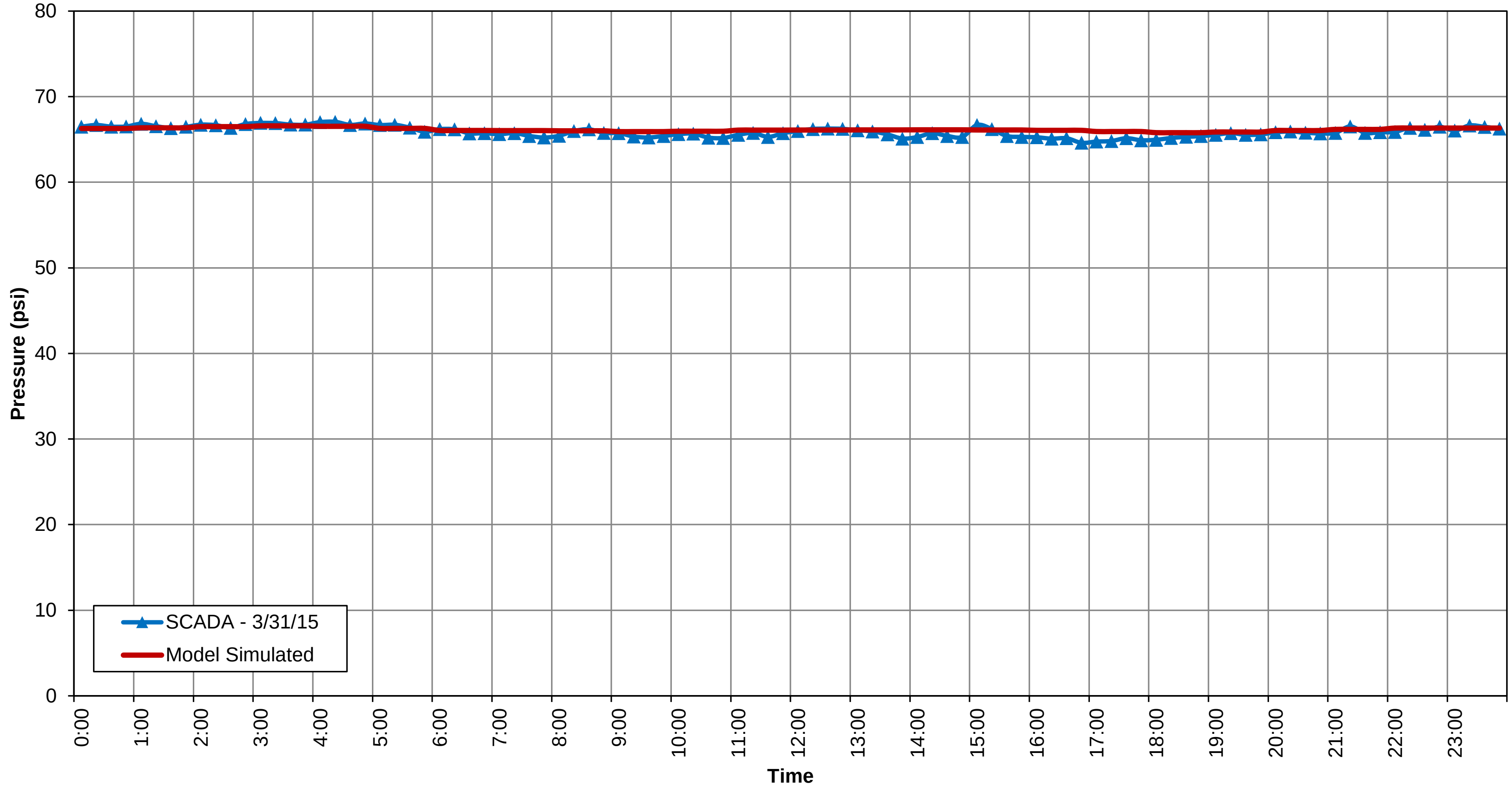
CITY OF OXNARD CALIFORNIA

EPS Calibration - PRESSURE LOGGER C1
Public Works Integrated Master Plan
City of West Sacramento

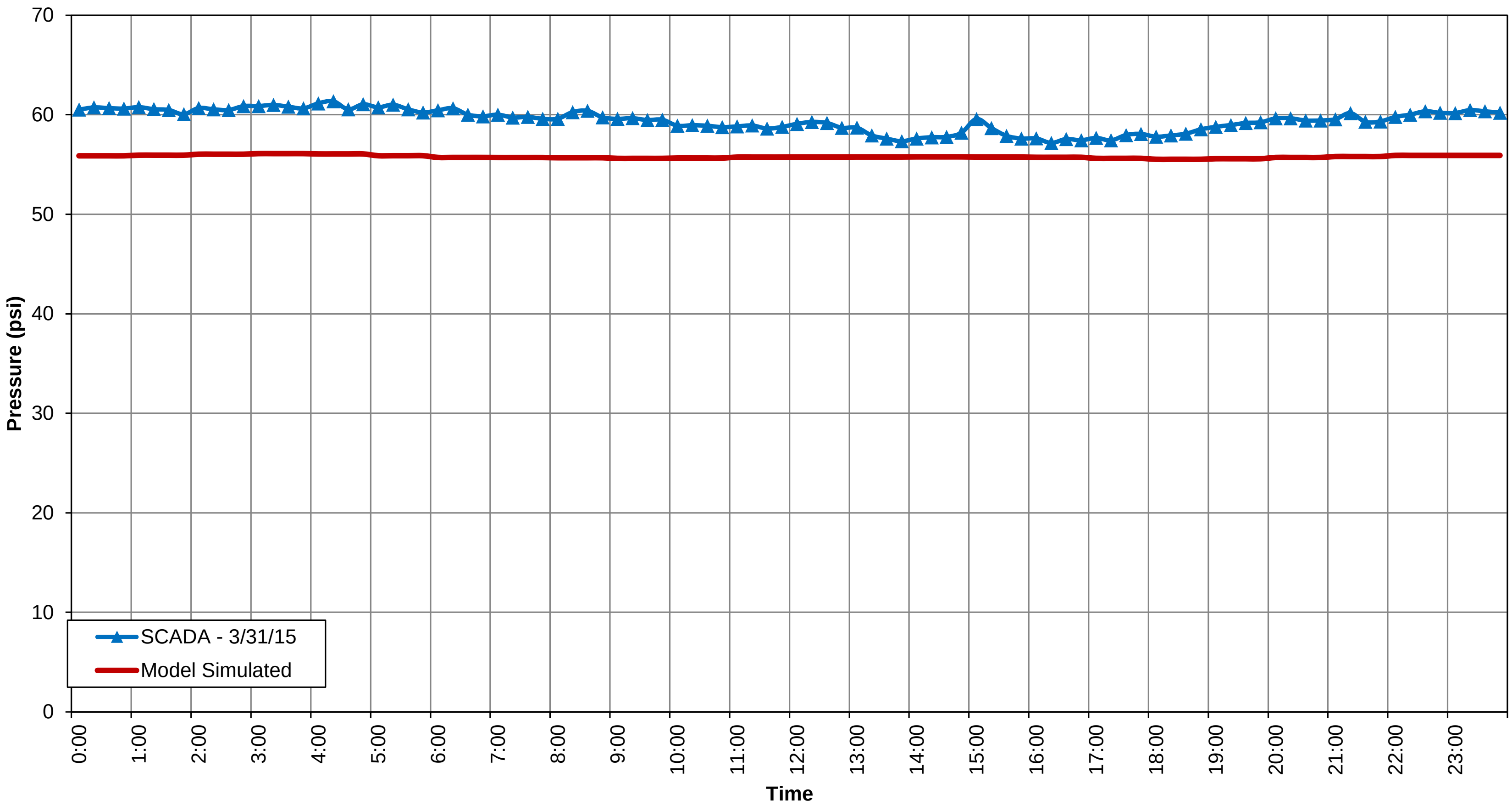
carollo



EPS Calibration - PRESSURE LOGGER C2
Public Works Integrated Master Plan
City of West Sacramento



EPS Calibration - PRESSURE LOGGER C3
Public Works Integrated Master Plan
City of West Sacramento



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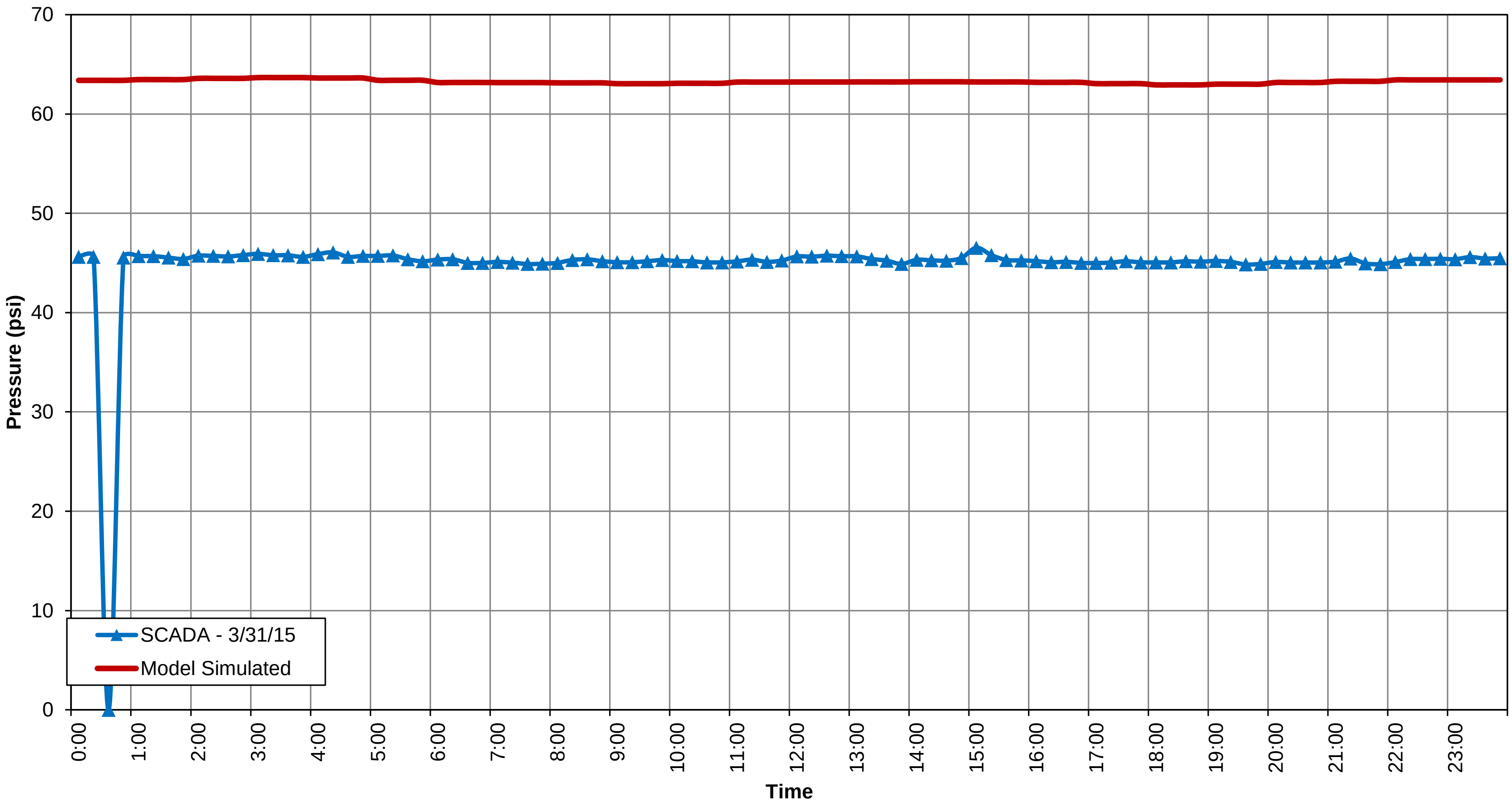
Public Works Integrated Master Plan
City of West Sacramento



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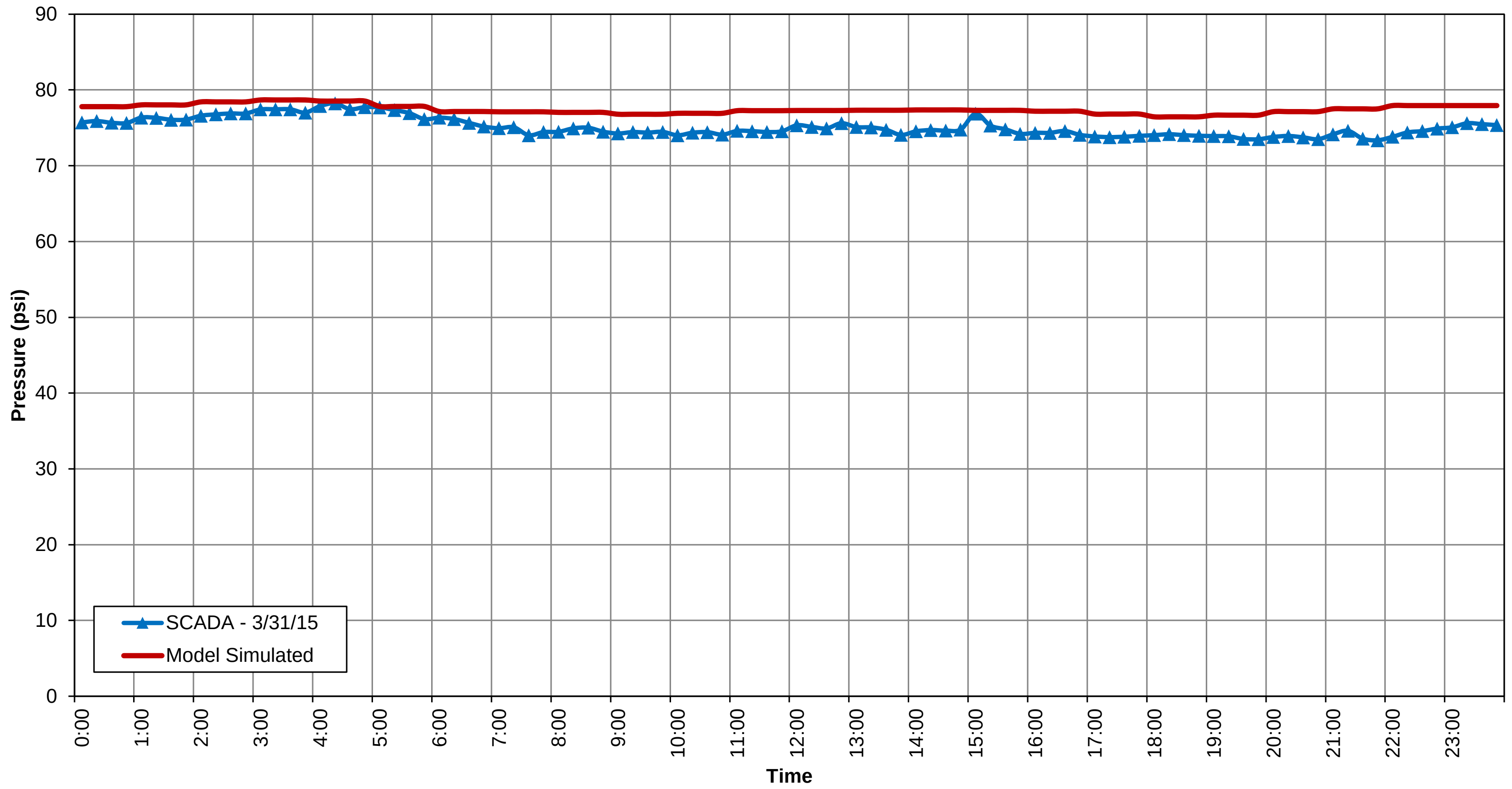
Public Works Integrated Master Plan
City of West Sacramento



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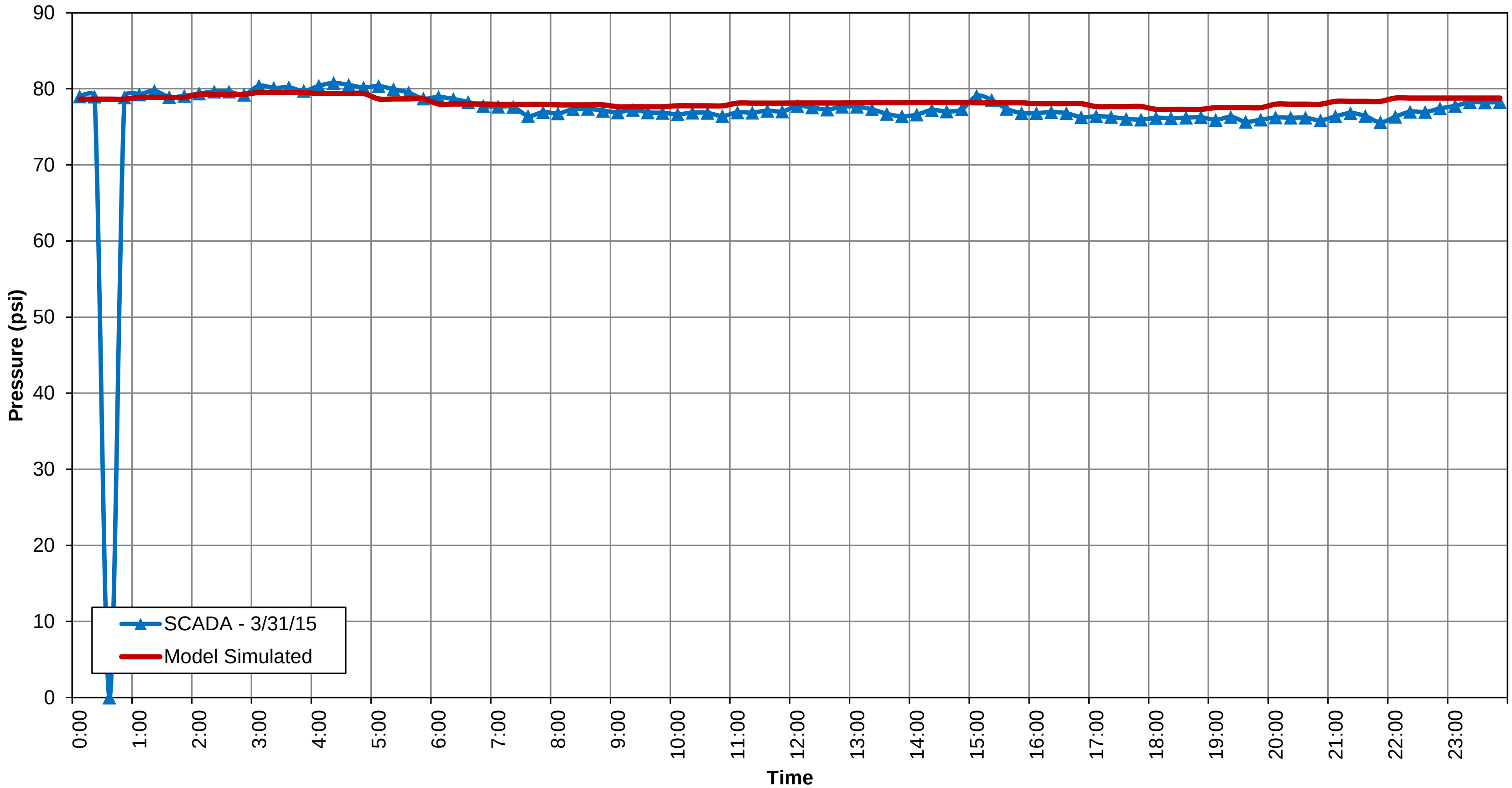
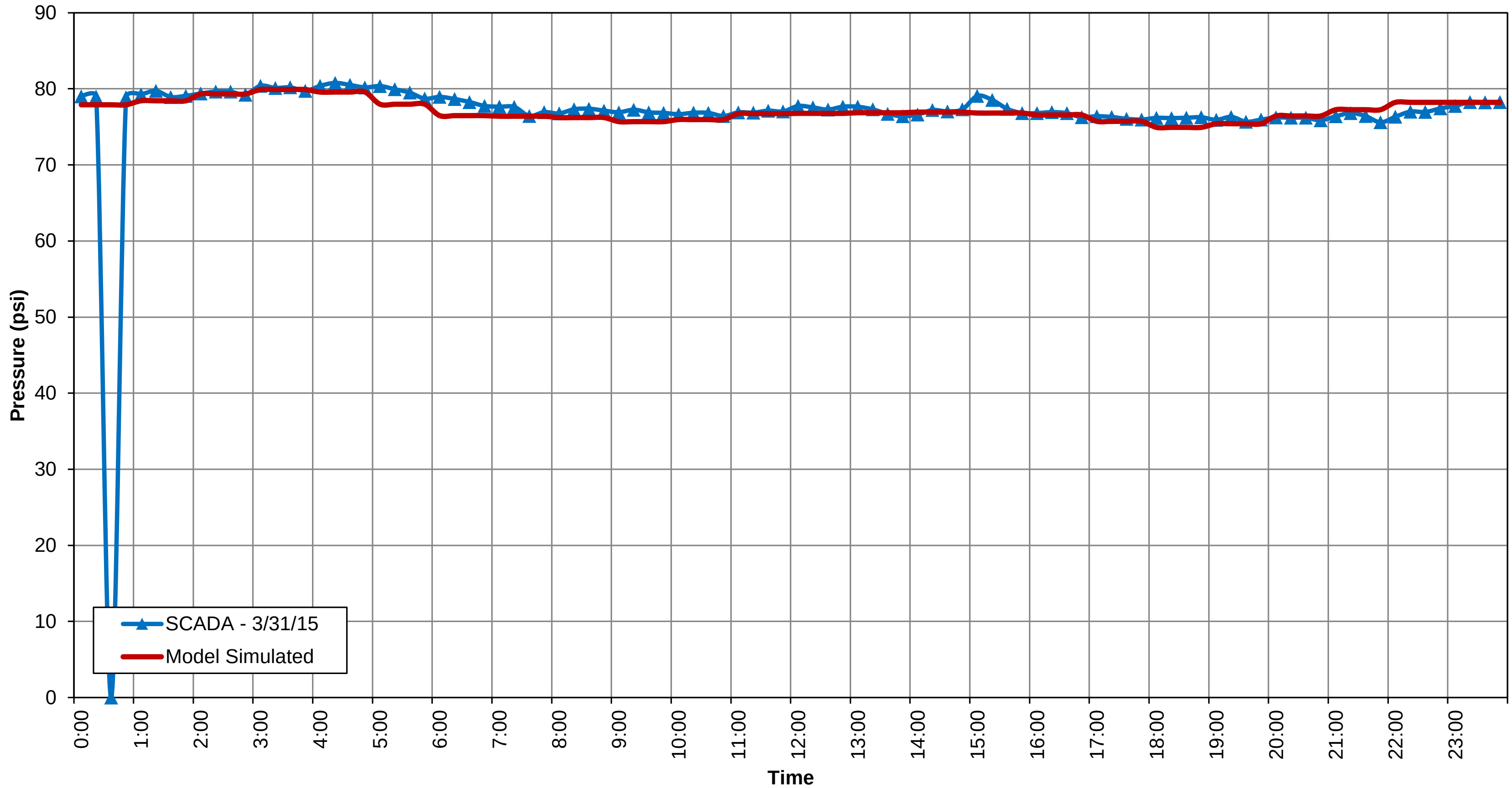
Public Works Integrated Master Plan
City of West Sacramento



CITY OF OXNARD CALIFORNIA

EPS Calibration - PRESSURE LOGGER C9
Public Works Integrated Master Plan
City of West Sacramento

carollo



EPS Calibration - PRESSURE LOGGER C10
Public Works Integrated Master Plan
City of West Sacramento