CHAPTER 6
Hydraulic Model Development

This chapter describes the development and calibration of the City's water system hydraulic model. To develop the City's hydraulic network model, West Yost completed the following steps:

- Developed a geodatabase of the City's water distribution system;
- Created a hydraulic model of the City's water distribution system;
- Verified that the hydraulic model system configuration (pipeline sizes, alignments, connections, and other facility sizes and locations) was representative of the current City's water system;
- Allocated existing water demands by geocoding City customer addresses to properly distribute demands spatially within the hydraulic model; and
- Calibrated the City's water system hydraulic model to simulate pressures and flows observed in the field.

To accomplish these tasks, West Yost worked closely with the City and Severn Trent staff to obtain and review:

- Available information regarding existing transmission and distribution mains, storage tanks, groundwater wells, pump stations and other water facilities;
- As-built drawings and maps detailing sections of the system to confirm pipeline sizes, material type, age, locations and alignments; and
- Available metered data.

The water distribution system model was then further calibrated using tank level, flow, and pressure data observed in the field during June 2016. The hydraulic model development and calibration are described below.

6.1 GIS DATA DEVELOPMENT

The City has maintained the mapping of the spatial location of system facilities in AutoCAD. As part of the WSMP, and before developing the City's hydraulic model, West Yost created a geodatabase containing the geospatial location of the City's existing pipelines and other major facilities based on data provided by the City. City staff provided West Yost with AutoCAD files that contained the City's existing pipelines, hydrants, system valves, and locations of major facilities. The City also provided Excel spreadsheets with the field-obtained coordinates for hydrants and valves and available as-built drawings of major facilities. The geodatabase developed for use with the hydraulic model was developed using available data and has not been field verified for spatial accuracy. The geodatabase developed has been aligned with the GIS files developed by Solano County for background purposes such as aerials, parcel information, and streets.

6.1.1 Pipeline Features

The pipeline features were exported from AutoCAD to GIS. The AutoCAD linework only contained the spatial location of the pipelines. Pipeline data, such as diameter or material, were separate text. West Yost was able to spatially join the text for pipeline diameter and material from AutoCAD to the nearest pipeline to allow for the initial population of data in the geodatabase file. West Yost conducted an initial review of this pipeline data and populated missing diameter and material information where possible. For locations where the water system network was unclear, West Yost requested additional information from the City for clarification (e.g., disconnected pipes, parallel pipes, intersecting pipes, pipeline diameters, etc.).

The system-wide maps are typically printed at a small scale and depicting system valves at their actual location results in areas where valve clusters appear as a single valve. To be able to show a valve cluster at pipeline intersections, the valve locations within the City's AutoCAD file were drawn to graphically depict how valves are located along the pipeline and not based on actual spatial location. The AutoCAD file also did not include valve locations for fire hydrants. In addition to the AutoCAD file, the City provided West Yost with an Excel spreadsheet that contained the global positioning system (GPS) data collected for system valve and hydrant locations. Unfortunately, the GPS coordinate points provided were not at a high level of accuracy. Therefore, the AutoCAD file and GPS data were not used in the development of the system valve and hydrant features.

The WSMP scope did not include field data collection to develop a new data set for the system valves and hydrants. Therefore, the development of the system valve and hydrant files was performed by City staff. City provided West Yost with shapefiles for the system valves and hydrants to use for the development of the hydraulic model. The City spatially located the system valves and hydrants to align with the Solano County GIS files.

6.1.2 Major Water System Facilities

The City's system-wide AutoCAD drawing shows the general location for the City's major facilities, but did not contain details about the groundwater wells, storage tanks and booster pump station facilities. West Yost used as-built drawings, well logs, and operational information provided by the City and Severn Trent to develop feature classes which represent the storage tanks, groundwater wells, and the booster pump station details.

6.1.3 Geodatabase Spatial Alignment

As mentioned above, the geodatabase developed for the City's water system was not field verified as part of the WSMP. The City does use the Solano County GIS information for background, and therefore the water system geodatabase was spatially aligned to match the Solano County 2015 high resolution aerial imagery (Solano aerial). The water system pipeline feature class created for the geodatabase was compared to the Solano aerial to determine the spatial accuracy between the AutoCAD linework and Solano aerial. It was determined the AutoCAD linework did not align with the Solano aerial. In some locations, the pipeline alignments depicted features outside of the road right-of-ways and under private properties.

West Yost used the system valve locations provided by the City and the Solano aerial to spatially adjust the pipeline features. Figure 6-1 shows an example of the adjustments made to the pipelines in the location of Rehrmann Drive and Pheasant Run Drive.

6.2 HYDRAULIC MODEL DEVELOPMENT

West Yost developed a hydraulic model of the City's water system using a series of steps that included the following:

- Description of the Model and Element Definitions
- Pipelines, Nodes, and Junctions Imported into InfoWater
- Roughness Factors Assigned in InfoWater
- Elevations Allocated to Nodes and Junctions
- Water System Facilities Incorporated into InfoWater
- Naming Scheme Applied in InfoWater
- Accounts Spatially Located in GIS
- Water Demands Allocated in InfoWater

Each of these steps is discussed in the following sections.

6.2.1 Description of Model and Model Elements

Innovyze's InfoWater program is the hydraulic modeling software used to represent the City's water system. This computer simulation model transforms information about the physical water distribution system into a mathematical model that solves for various flow conditions based on specified water demands and system operations. The computer model generates information on pressure, flow, velocity, and head loss, which can be used to analyze water system performance and identify deficiencies. In addition, the model can be used to verify the adequacy of recommended or proposed system improvements. For this study, a steady-state (static) hydraulic model was developed for the City for evaluating the City's existing water system. In addition, an extended period simulation model was developed to perform more complex water system hydraulic evaluations (e.g., water quality evaluations).

The hydraulic model consists of a network of elements referred to as nodes, junctions and pipes. Nodes are typically locations of no water demand such as at a tank or location where pressure is monitored. Junctions are locations where water demands may occur. Pipelines are the connections between nodes or between nodes and junctions. Table 6-1 provides a brief description for each type of model element.

Table 6-1. Description of Model Elements

Model Element	Purpose	Data Requirement(s)
Node	• Represents transitions in pipeline characteristics (e.g., diameter or material type) or points in the system where pressure is monitored • Represents locations in the system where metered water demands do not exist (e.g., at a pump station or reservoir site)	• Elevation
Junction	• Represents transitions in pipeline characteristics (e.g., diameter or material type) • Represents locations in the system where water demands may exist	• Elevation • Water demand
Pipe	• Represents facilities that convey water from one point in the system to another	• From/To Node or Junction • Length • Diameter • Hazen-Williams C-factor (roughness factor) based on diameter and material type
Tank (a type of node)	• Tanks have known volumes and water surface elevations that change with time as water flows into or out of the tank	• Location • Diameter for cylindrical tanks • Depth vs. Volume relationship for variable area tanks • Bottom and overflow elevations • Initial tank level
Pump (a type of node)	• Represents locations where the hydraulic grade line is raised to overcome elevation differences and friction losses	• Location • Elevation • Pump curve or design point • Pump efficiency test results, if available
Valve (a type of node)	• Regulates either flow or pressure	• Location • Elevation • Diameter • Type and Setting

6.2.2 Pipelines, Nodes, and Junctions Imported into InfoWater

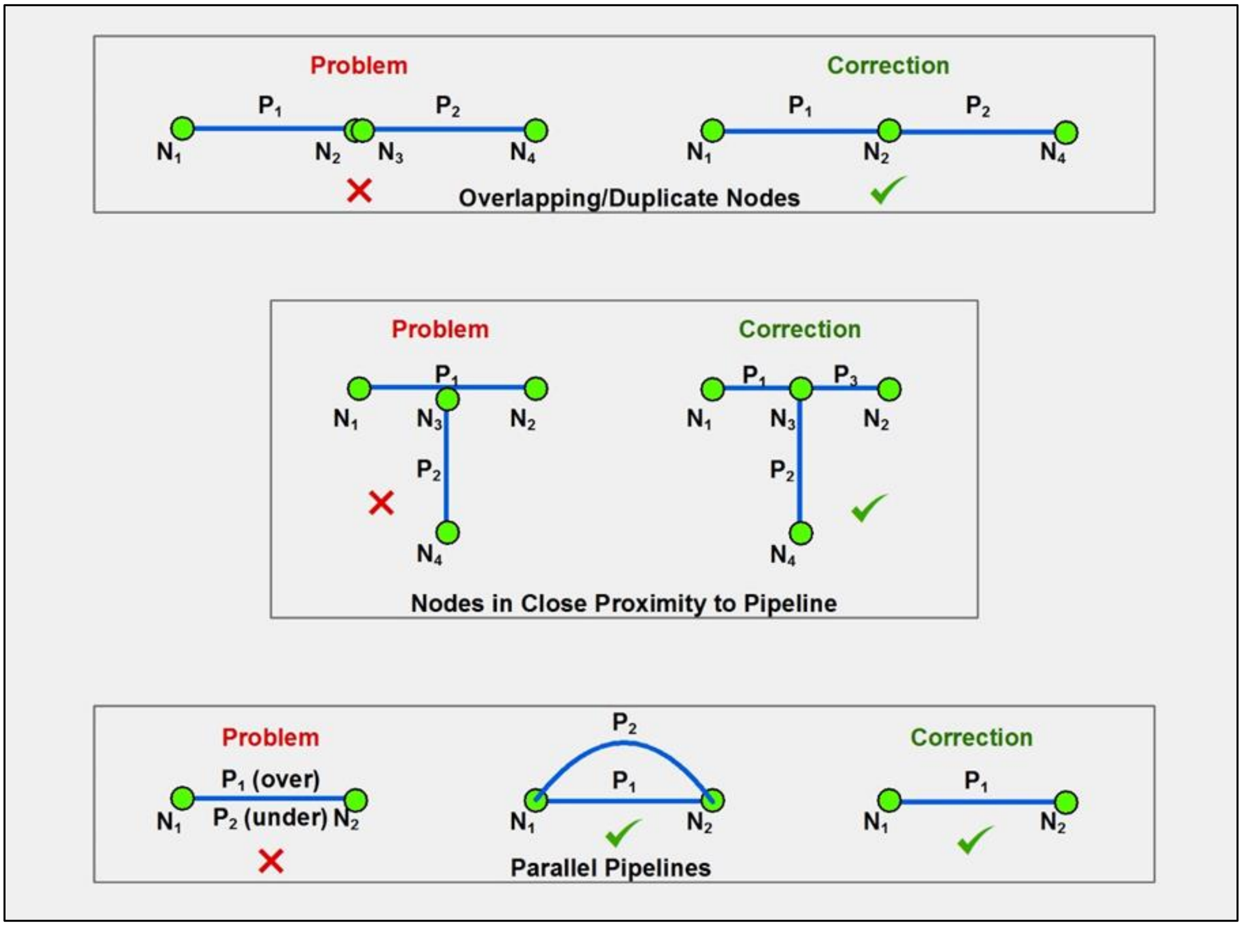
The GIS water pipeline geodatabase, developed by West Yost, was imported into the hydraulic model software to build the model. Importing the pipeline file does not build "from" and "to" nodes (i.e., points designating the beginning and end of the pipeline). Consequently, InfoWater's Append Nodes feature was used to create and assign the beginning and end-points for the existing pipelines.

West Yost conducted a review of the imported pipelines using InfoWater's Connectivity and Network Review tools to confirm pipeline connections were representative of field conditions. The connectivity tools allow the review of issues which include:

- Locating overlapping/duplicate nodes – This issue may be potential disconnects in pipelines where two or more junctions overlap each other, but there is no pipeline connecting the two nodes (see Figure 6-2 for an example).
- Locating nodes in close proximity to pipelines – This issue may be potential locations where one pipeline should intersect a second pipeline, but instead the node is close or overlays the pipeline without connection to the pipeline (see Figure 6-2 for an example). Fitting locations such as tees or crosses are common areas where this occurs.
- Locating parallel pipes – This issue may be potential duplicate pipelines that overlay each other resulting in locations with two pipelines instead of a single pipeline (see Figure 6-2 for an example).
- Identifying diameter discrepancies – This issue may be potential locations where a wrong diameter was entered in the model resulting in a smaller diameter pipeline connected in series to a larger diameter pipeline.

The review of the hydraulic model showed several locations where pipelines with cross or tee fittings were overlaid on a pipeline and did not intersect. West Yost corrected the connection issues to create a hydraulic model that accurately matched the system hydraulics.

Figure 6-2. Illustration of Network Connection Issues



6.2.3 Pipeline Characteristics

The City's existing water pipeline information did not include roughness factors, but contained data that identified pipeline material type and diameter. The age of the City's pipelines was not included in the AutoCAD files, but it is generally known. The City's system is fairly young with the majority of the system constructed after 1970. Consequently, West Yost assigned preliminary C-factors based on experience and professional judgement to each pipeline by using diameter and material type. Table 6-2 presents the preliminary C-factors assigned to each of the different pipeline material types within the City's water system. These C-factors were then validated during calibration of the hydraulic model, which is further described in *Section 6.3 Hydraulic Model Calibration*.

Table 6-2. Preliminary Pipeline C-factors Assigned in the Hydraulic Model

Pipeline Material Type	Hazen-Williams C-factor
Asbestos Cement (ACP)	130
Polyvinyl Chloride (PVC)	140
Unknown	130

6.2.4 System Elevations

The City's service area is fairly flat with elevations sloping from a high of approximately 80 feet in the southwest to approximately 40 feet in the east. West Yost obtained elevation data for the City's service area from the Central Valley Floodplain Evaluation and Delineation Program (CVFED) shared by the California DWR. DWR provides the CVFED elevation data to public agencies upon request. The CVFED collected data using Light Detection and Ranging (LiDAR) which produces high accuracy elevation data. The elevation data was collected in 2008. The CVFED data was used in GIS to assign an elevation to each node or junction in the hydraulic model. The vertical datum of the elevation shapefile is in the North American Vertical Datum (NAVD) of 1988 in US foot units.

6.2.5 Water System Facilities Incorporated into InfoWater

After the pipelines and nodes/junctions were incorporated into the hydraulic model, major system facilities (e.g., pump stations, wells, and storage reservoirs) were added to the hydraulic model. Each of these facilities was entered into the model based on as-built drawings (when available) and/or other available information provided by City staff.

6.2.6 Naming Scheme Applied in InfoWater

West Yost assigned a unique model ID to each model element based on the model element type, the element's location, and a sequential numerical value. By assigning each model element a unique model ID, users of the hydraulic model will be able to easily locate specific elements or more readily identify potential problems during the calibration and system evaluation process. The City's hydraulic model was populated using the naming scheme presented in Table 6-3.

Table 6-3. Naming Scheme for Hydraulic Model Network Elements

Model Component	Naming Scheme
Pipelines	P-NZ-1000 "1000" = Sequential Number "NZ" = North Zone "CZ" = Core Zone "SZ" = South Zone "P" = Pipeline
Junctions	J-NZ-1000 "1000" = Sequential "NZ" = North Zone "CZ" = Core Zone "SZ" = South Zone "J" = Junction
Nodes	N-NZ-1000 "1000" = Sequential Number "NZ" = North Zone "CZ" = Core Zone "SZ" = South Zone "N" = Node
Wells	W-DW-54 "54" = Well Number "DW" = Deep Well "W" = Reservoir
Well Pumps	PMP-DW-37 "37" = Well Number "DW" = Deep Well "PMP" = Pump
Tanks	T-WATSON-1 "1" = Tank Number "WATSON" = Tank Name "T" = Tank
Booster Pumps	BPS-PARKLANE-PMP1 "PMP1" = Pump Number "PARKLANE" = Station Name "BPS" = Booster Pump Station

6.2.7 Accounts Spatially Located in GIS

City staff provided West Yost with a billing database file containing metered accounts and their corresponding water consumption data by address and billing code for each month from 2006 to 2015. The City reads meters on a bi-monthly schedule. It was decided to use the metered water consumption data from calendar year 2014 to allocate existing water demands to the hydraulic model.

The City does not have a GIS file for customer meter locations. To spatially allocate demands in the model, West Yost developed a separate water service location file containing the address and spatial location of the metered accounts based on the centroid from the County parcel database. West Yost reviewed this water service connection geodatabase and found that some account numbers had multiple records (duplicate account numbers) and some records were associated to multiple account numbers. West Yost corrected the water service connection shapefile to (1) combine the duplicate records into a single spatially accurate record and (2) separate the multiple account numbers into unique records. This updated water service connection shapefile was then linked to the 2014 billing database by account number to provide spatially located meter accounts that could be used to allocate demands into the hydraulic model.

Approximately 96 percent of the account addresses were linked to the water service connection shapefile and assigned a spatial location. To spatially locate the remaining water demands, West Yost used the addresses from the remaining metered accounts in the billing database and the City's GIS street shapefile to geocode (spatially locate) the remaining 4 percent of the accounts. These remaining accounts generally represented irrigation services such as roadway medians which do not have an exact address associated with them.

6.2.8 Water Demand Allocation in InfoWater

Water demands were allocated in the hydraulic model using the spatially located water service connection demand data described in the previous section. The model's Demand Allocator tool analyzes the water service connection demand data to identify the closest pipeline to each water service connection point. The tool then applies the metered water demand to the closest junction of the selected pipeline. West Yost reviewed the demand allocation to confirm that the metered water demands were properly allocated.

6.3 HYDRAULIC MODEL CALIBRATION (STEADY-STATE)

The City's hydraulic model was calibrated to confirm that the computer simulation model can accurately represent the operation of the City's water distribution system under varying conditions. Calibration of the hydraulic model used data gathered through hydrant tests as described in the following sections.

6.3.1 Development of Hydrant (C-factor) Tests

After developing the hydraulic model, eight sets of hydrant tests (six planned locations and two alternative locations) were chosen for possible hydrant flow testing (see Figure 6-3). The selection of these hydrant test sites was based only on specific pipeline size, material type, and approximate age. These hydrant tests were used to evaluate pipeline friction factors (C-factors) and to calibrate the model to ensure that the hydraulic model closely represented actual observed pressure conditions in the field. West Yost provided the City with a technical memorandum detailing the hydrant test procedures before performing the field testing (see Appendix A).

Hydrant flow testing was scheduled and performed on June 29 and June 30, 2016. Each hydrant test involved flowing water through pipelines of a specific size and material type, and then measuring the pressure drops along the pipelines to determine friction losses. The hydrant test procedure consisted of monitoring discharge and pressure at the key flowing hydrant, and pressures at other hydrants along the supply routes to that key hydrant. Static pressures were measured while the key hydrant was closed, and residual pressures were measured while the key hydrant was flowing.

Pipelines in the City’s water system range in size from 4-inch to 14-inches in diameter. The City distribution system consists mostly of ACP and PVC material.

Prior to any model runs, each pipeline was assigned a preliminary C-factor based on the pipeline size and material type as presented in Table 6-2. Consequently, each hydrant flow test was then simulated using the hydraulic model of the City’s water system. Results were compared to the field data to determine the accuracy of the model. The differences between observed static and residual pressures for the field hydrant test, compared to readings predicted by the model, were calculated. The goal of the calibration effort was to achieve no greater than a 5 psi differential between the field hydrant test data and model-simulated results. Results from the hydrant tests are discussed in more detail in the following section.

6.3.2 Hydrant (C-factor) Test Results

The results of the simulated hydrant flow tests generally validated the system pipeline configuration and confirmed the preliminary C-factors presented in Table 6-2. Approximately 88 percent of all C-factor comparison points were found to be within 5 percent or 5 psi of the field data, while the remaining 12 percent were all within 13 psi of the field observed values. The results from Test Location 3 showed the only variance above 5 psi. The difference in results for this location could be attributed to various issues such as the operation of the School Well during the field testing, a valve not being fully closed, or a pipeline diameter discrepancy between the model and what is constructed. The City will verify the pipeline diameter on West A Street.

A summary of the calibration results can be found in Appendix B. Based on the comparison of the collected hydrant flow test data and model simulation results, the assumed C-factor for ACP material pipelines was adjusted to 135 in the model to achieve the desired calibration goals.

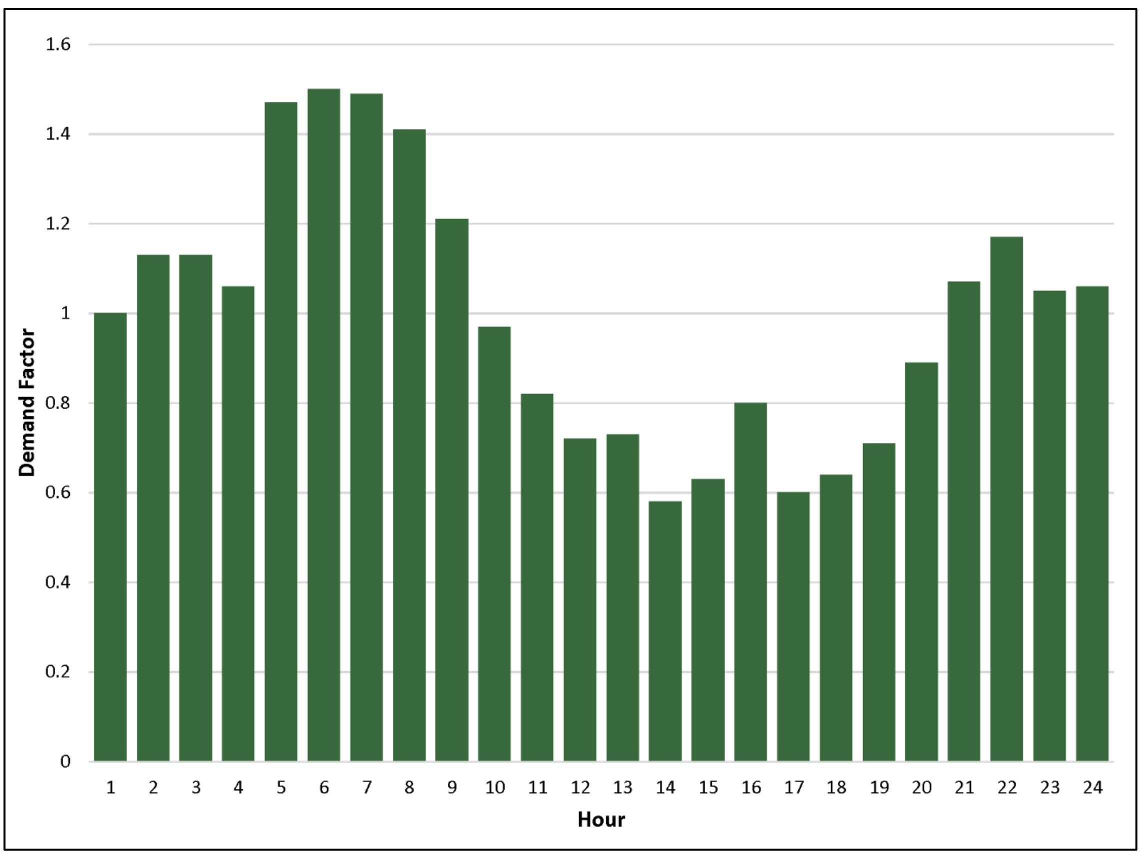
6.3.3 Diurnal Curve Development

To add the time variable to the City's hydraulic model and create an extended period simulation (EPS) model, West Yost developed a representative 24-hour diurnal pattern for the City's service area.

Severn Trent provided West Yost with screenshot information from Supervisory Control and Data Acquisition (SCADA), on tank level, flows, and pump discharge pressures for the City's tanks and wells. This information was collected during the period of June 28 to June 30, 2016 to develop the diurnal curve. Hourly production data from the tank and wells were summed based on the estimated flow recordings and SCADA information to represent the total demand in the City's water system on this date.

The City's water system is supplied water from groundwater wells. Three of the City's groundwater wells pump directly into tanks and then into the system through booster pump stations. The other two groundwater wells pump directly into the distribution system, but these wells are used as backup supply and are not normally operated. Since the supply wells pump into the storage tanks directly, the flow from the system booster pump stations can be used to develop the diurnal curve. The resulting diurnal pattern is shown in Figure 6-4. As shown, peak demands occur in the early morning hours and again in the evening hours as would be expected for water systems with primarily residential customers.

Figure 6-4. City of Dixon Diurnal Pattern

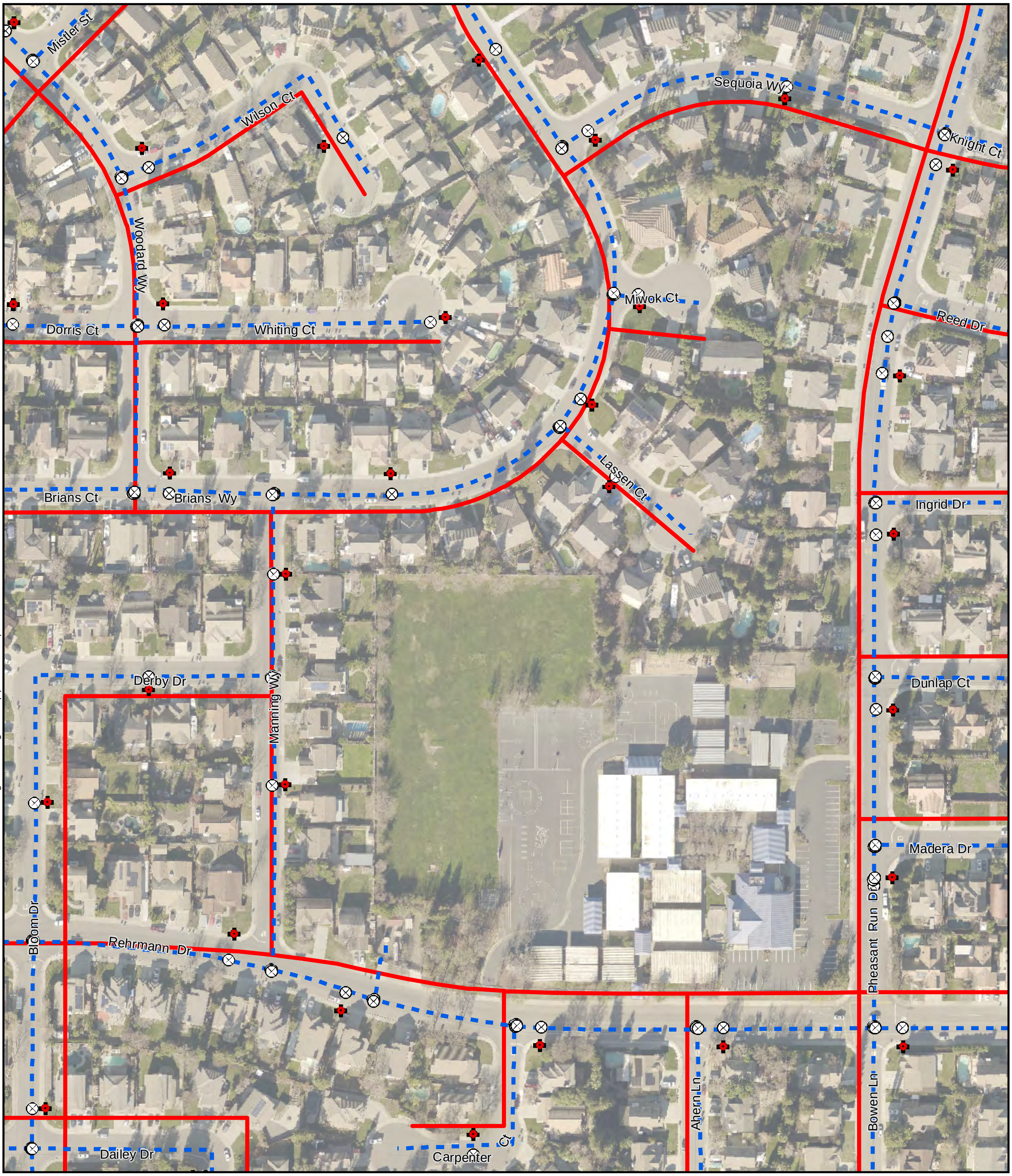


6.4 HYDRAULIC MODEL FINDINGS AND CONCLUSIONS

In summary, the results from the hydrant tests indicate that the hydraulic model is fairly well calibrated using the preliminary adjusted pipeline C-factors, and can accurately simulate a fire flow or other large demand conditions within the City's service area.

Overall, the results from the calibration process validated the system configuration and demand allocation in the hydraulic model. It is recommended that the City continue to update/verify pipeline system configurations in the model as new facilities are constructed.

Based on the results of the hydraulic model calibration, it can be concluded that the hydraulic model provides an accurate operational representation of the City's water distribution system, and is adequate for use as a planning tool.



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Symbology

- System Valves
- Fire Hydrants
- AutoCAD Linework
- Spatially Adjusted Pipelines

Note:
The AutoCAD linework reflects the pipelines exported from the file *DSMWS Distribution System (10-30-07).dwg* provided by the City on April 8, 2016.

N

0 100 200
Scale in Feet

DIXON CALIFORNIA

WEST YOST ASSOCIATES

Figure 6-1

GIS Pipeline Development

City of Dixon
Water System Master Plan and Hydraulic Model Update

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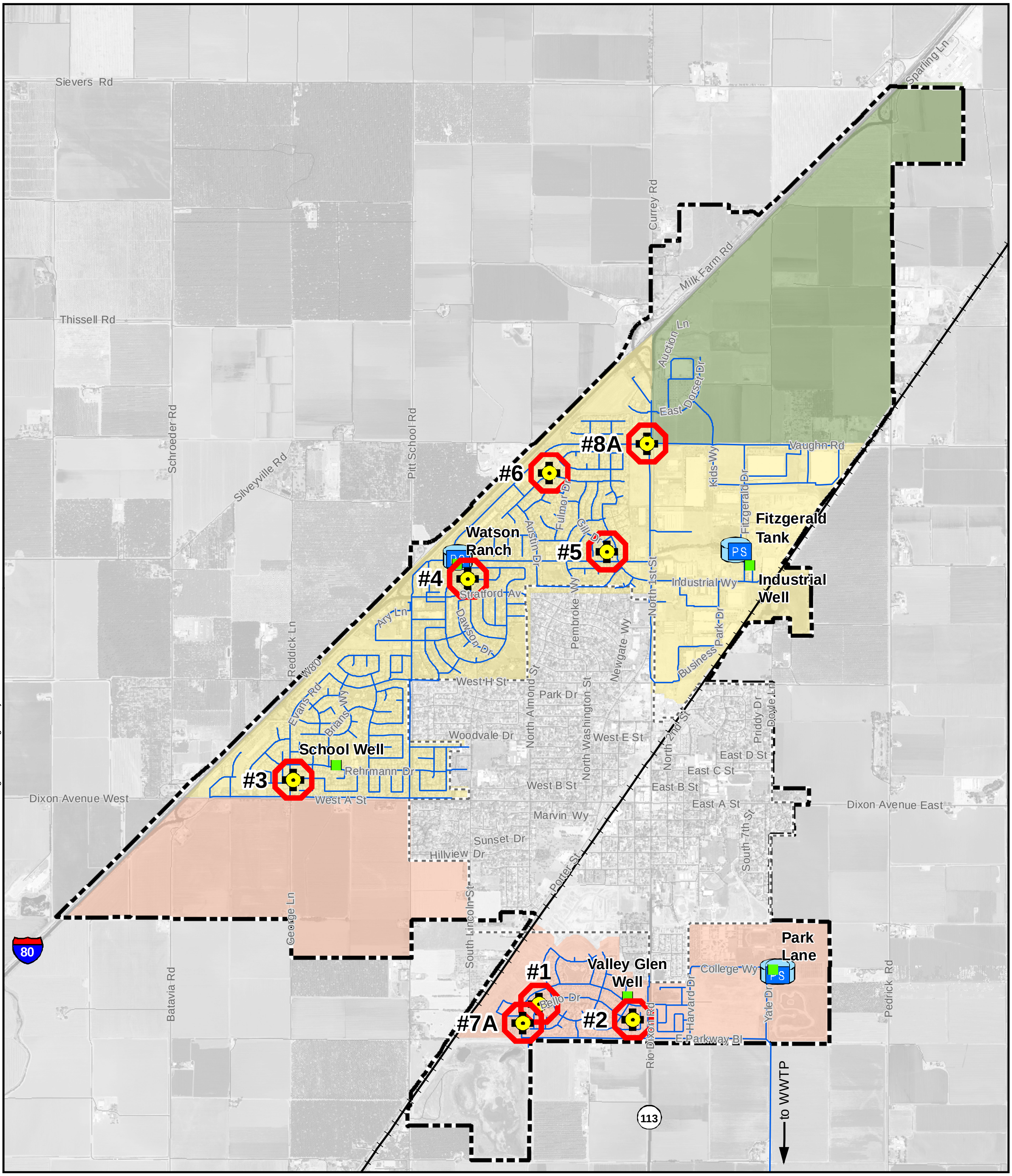

Symbology

- Hydrant Test Location
- Well
- PS Booster Pump Station
- Tank
- Pipelines
- Dixon City Limits
- Cal Water Service Area

City Water Service Area

- Core Zone
- North Zone
- South Zone

N

0 1,500 3,000

Scale in Feet

DIXON CALIFORNIA

WEST YOST ASSOCIATES

Figure 6-3
Hydrant Test Locations

City of Dixon
Water System Master Plan and
Hydraulic Model Update

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CHAPTER 7
Existing Water System Evaluation

This chapter presents an evaluation of the City's existing water distribution system and its ability to meet the City's recommended performance and planning criteria under existing demand conditions. This existing water system evaluation includes both facility capacity and hydraulic performance evaluations. The system facility capacity evaluation assesses existing supply capacity, pumping capacity and storage capacity. The hydraulic performance evaluation assesses the existing water system's ability to meet recommended performance standards under maximum day demand, maximum day demand plus fire flow, and peak hour demand conditions.

The hydraulic model developed by West Yost, and described in Chapter 6, was used to conduct a hydraulic evaluation of the existing City water system and identify any existing water distribution system deficiencies. Recommendations have been made to address any existing system deficiencies, and these recommendations were then used to develop a prioritized CIP, including an estimate of probable construction costs (see Chapter 10).

7.1 EXISTING SYSTEM DEMANDS

Existing demand conditions used in the hydraulic model evaluation are based on the City's 2014 demands which totaled 1,772 AF, for an average day demand of 1.58 mgd (1,100 gpm). Actual maximum day and peak hour demand data are not collected by the City; therefore, the City's demand peaking factors described in Chapter 3 were used to calculate the existing (2014) maximum day demand to be 3.48 mgd (2,420 gpm) and the existing (2014) peak hour demand to be 5.21 mgd (3,630 gpm).

The City's existing (2014) demands were allocated in the hydraulic model using the spatially located meter demand data. This allocated the existing demands to the City's three sub-areas (zones). The City's existing (2014) demands by zone are shown in Table 7-1.

Table 7-1. Existing System Demands by Zone

Zone	Average Day Demand, gpm	Maximum Day Demand, gpm[a]	Peak Hour Demand, gpm[b]
North Zone	15	33	50
Core Zone	861	1,894	2,841
North and Core Zone Subtotal	876	1,927	2,891
South Zone	223	491	736
Total	1,100	2,420	3,630

(a) Maximum Day Demand = 2.2 times Average Day Demand
(b) Peak Hour Demand = 3.3 times Average Day Demand

7.2 EXISTING WATER SYSTEM FACILITY CAPACITY EVALUATION

To evaluate the existing water system, analyses addressing the following system facilities were conducted:

- Maximum Supply Capacity,
- Pumping Capacity, and
- Storage Capacity.

The results of the existing water system facility analyses are discussed below.

7.2.1 Maximum Supply Capacity

As discussed in Chapter 4, the City currently operates five groundwater wells with a total available capacity of approximately 8,500 gpm (12.2 mgd). Since the City's North and Core Zones do not interconnect with the South Zone, the firm well capacity for each of the zones is calculated separately, as shown in Table 7-2. The firm well capacity is calculated based on the largest well out of service within each zone.

Table 7-2. Existing Groundwater Well Capacity

Well No.	Facility Name	Well Capacity, gpm
North and Core Zones		
1	DW-37: Watson Ranch Well	1,500
2	DW-44: Industrial Park Well	800
3	DW-48: School Well	1,800
	North and Core Zones Total Capacity	4,100
	North and Core Zones Firm Capacity	2,300
South Zone		
4	DW-52: Valley Glen Well	1,900
6	DW-54: Park Lane Well	2,500
	South Zone Total Capacity	4,400
	South Zone Firm Capacity	1,900

Source: City of Dixon Division of Drinking Water Supply Permit No. 02-04-14P-4810009, 2014.

Based on the City's current firm groundwater supply, adequate supplies are available in both the North/Core Zone and the South Zone to meet the City's existing (2014) maximum day demands. As described below, peak hour demands are supplemented as needed with supplies pumped from the City's storage tanks.

7.2.2 Pumping Capacity

The City's pumping capacity was evaluated to assess its ability to deliver a reliable firm capacity to the City's existing service area. Firm capacity assumes a reduction in total pumping capacity to account for pumps that are out of service at any given time due to mechanical breakdowns, maintenance, water quality, or other operational issues. For the City's booster pump stations, the criteria for firm pumping capacity assumes the largest pump is a stand-by pump. The North and Core Zones are evaluated as a single zone since they are hydraulically connected, and the South Zone is evaluated as an independent zone.

The pumping capacity criterion for the City, described in additional detail in Chapter 5, requires the City's existing water system to have sufficient pumping capacity to meet the greater demand scenario of a peak hour demand or a maximum day demand concurrent with a maximum fire flow event. For the City's existing system, the maximum day demand with a concurrent fire flow is the greater demand scenario. The results of the pumping capacity evaluation are summarized in Table 7-3, based on the pumping capacity of each station shown in Table 2-5.

Table 7-3. Evaluation of Existing Firm Pumping Capacity

Location	Firm Pumping Capacity[a], gpm	Peak Hour Demand[b], gpm	Maximum Day Demand plus Fire Flow[c], gpm	Pumping Surplus/(Deficit), gpm
North and Core Zones	4,790[d]	2,891	5,427	(637)
South Zone	4,560[e]	736	3,991	569

(a) Firm pumping capacity includes booster pump stations (with largest pump assumed for standby and not included in the capacity calculations) and any wells which pump directly into the distribution system.

(b) Existing peak hour demand based on 2014 demands (see Table 7-1).

(c) Existing maximum day demand based on 2014 demands (see Table 7-1). Fire flow based on requirements shown in Table 5-4.

(d) Includes firm pumping capacity of Fitzgerald Drive Booster Pump Station (1,330 gpm), Watson Ranch 2 Booster Pump Station (1,660 gpm) and the School Well (1,800 gpm) which pumps directly into the distribution system.

(e) Includes firm pumping capacity of Park Lane Booster Pump Station (2,660 gpm) and the Valley Glen Well (1,900 gpm) which pumps directly into the distribution system.

The pumping capacity analysis indicates that the City's existing firm pumping capacity meets the pumping capacity criterion for the City's South Zone but does not have adequate pumping for the North/Core Zones. As shown in Table 7-3, the City has a pumping capacity surplus of 569 gpm for the South Zone and a pumping deficit of 637 gpm for the North and Core Zones during maximum day demand plus concurrent fire flow conditions.

No improvements are recommended in the existing water system for the South Zone pump station capacity. However, for the North/Core Zones, there is an existing pumping capacity deficit. Additional pumping capacity is recommended to be placed at the City's Fitzgerald Drive booster pump station. The Fitzgerald facility contains the City's largest tank and is located in an industrial area of the City where the largest fire flow demands occur. To increase the pumping capacity in the North and Core Zones, it is recommended that a fourth pump with 1,000 gpm capacity be added at the Fitzgerald Drive booster pump station.

While the North and Core Zones do not have adequate pumping capacity for a maximum day demand with a concurrent fire flow, the firm flow from the City's booster pump stations and wells pumping directly into the City's distribution system is sufficient to meet demands during a peak hour demand for all zones.

7.2.3 Storage Capacity

The principal advantages that storage provides for the water system are the ability to equalize demands on supply sources, production facilities, and transmission mains; to provide emergency storage in case of supply failure; and to provide water to fight fires.

The City has available storage in the City's tanks and the groundwater basin. Together, these sources of storage must be sufficient to meet the City's storage criteria for the City's existing water system. The volume required for each storage component is detailed below:

- Operational Storage: 20 percent of maximum day demand; and
- Fire Storage: Largest fire flow.

The City's existing storage was evaluated to determine whether the City's existing water system has sufficient capacity to provide the required system storage. Currently, the City has a water storage capacity surplus in both the North and Core Zones and the South Zone as summarized in Table 7-4.

Table 7-4. Comparison of Available and Required Storage Capacity

Available Storage Capacity, MG[a]	Required Storage Capacity, MG			Storage Surplus[c], MG
	Operational[b]	Fire Flow	Total	
North and Core Zone				
1.80	0.55	0.72	1.27	0.53
South Zone				
1.80	0.14	0.63	0.77	1.03

(a) Available storage is calculated using the useable storage within the tanks. Useable storage is defined as the volume between the tank overflow level and the "dead" or unusable storage, based on the tank outlet.
(b) Operational Storage equals 20 percent of Maximum Day Demand in each zone.
(c) Equal to required storage minus available storage.

7.3 EXISTING WATER SYSTEM PERFORMANCE EVALUATION

Hydraulic analyses, using the developed model, were conducted to identify areas of the existing water system that do not meet the recommended system performance criteria as presented previously in Chapter 5. The results of the evaluation of the existing water system are presented below for the following demand scenarios:

- Maximum Day Demand including Peak Hour (Normal Operations) - A peak hour flow condition was simulated for the existing distribution facilities to evaluate their capability to meet a peak hour demand scenario. Peak hour demands are met by the combined flows from the groundwater (firm groundwater pumping capacity) and booster pump stations.
- Maximum Day Demand plus Fire Flow (Emergency Operations) - To evaluate the existing water system under the maximum day demand plus fire flow scenario, InfoWater's "*Available Fire Flow Analysis*" tool was used to determine the available fire flow while meeting the maximum day demand plus fire flow performance criteria within the existing water system. Maximum day plus fire flow demands are met by the combined flows from the groundwater (firm groundwater pumping capacity) and storage tanks.

The performance criteria and results of the City's existing water distribution system evaluation for these two demand scenarios are discussed below.

7.3.1 Normal Operations – Maximum Day Demand including Peak Hour

7.3.1.1 Evaluation Criteria

The maximum day demand for the existing City service area was calculated to be 2,420 gpm (3.48 mgd). This maximum day demand represents a peaking factor of 2.2 times the average day demand. During a maximum day demand scenario, the City's design standards require a minimum pressure of 35 psi be maintained throughout the water system.

The peak hour demand for the existing City service area was calculated to be 3,630 gpm (5.21 mgd). This peak hour demand represents a peaking factor of 3.3 times the average day demand. During a peak hour demand scenario, the City's design standards require a minimum pressure of 30 psi be maintained throughout the water system.

In addition, during normal operations, maximum velocities should not exceed 6 ft/s. Details of the system minimum pressures as simulated in the model under the maximum day and peak hour demand scenario are discussed below.

7.3.1.2 Evaluation Results

During a maximum day demand scenario (including a peak hour demand), results indicate that the existing water system could adequately deliver peak hour demands to meet the City's minimum pressure criterion of 30 psi as illustrated on Figure 7-1. Under this scenario, system pressures ranged from 48 to 62 psi. The City's criteria of using VFDs for pumping directly into the distribution system results in fairly stable pressures for all conditions.

7.3.2 Emergency Operations – Maximum Day Demand Plus Fire Flow

7.3.2.1 Evaluation Criteria

To evaluate the existing water system under the maximum day demand plus fire flow scenario, InfoWater's "*Available Fire Flow Analysis"* tool was used to determine the available fire flow at each of the simulated fire flow locations with a minimum residual system pressure of 20 psi within the pressure zone.

The City's potable water distribution system includes fire hydrants that are installed throughout the City to provide water supply during a fire flow condition. To simulate fire flows in the hydraulic model, selected junctions located near actual hydrants were assigned fire flow requirements based on their adjacent land use. Where multiple land uses are in the vicinity of a simulated fire flow junction, the highest fire flow requirement was assigned. Because the hydraulic model simulates a steady state condition, the time component of the fire flow requirement is not simulated, but is factored into the storage capacity evaluation presented above. The hydraulic model only evaluates the hydraulic capacity of the City's existing water system to supply the required fire flow during a maximum day demand condition.

The City's water system performance standards recommend pipeline velocities be less than 12 ft/s during a maximum day demand plus fire flow condition. However, as described in *Chapter 5 Planning and Design Criteria*, the City's existing pipelines will be evaluated on a case-by-case basis as system pressure is the primary criterion. In locations where new or replacement pipelines were proposed, the pipeline velocity criterion was used to determine the appropriate sizing.

7.3.2.2 Evaluation Results

The results of the maximum day demand plus fire flow evaluation for the City's existing water system are presented on Figure 7-2. Available fire flows are compared to the fire flow requirements assigned to each simulated fire flow location according to land use. Junctions shown in red represent locations where the City's water distribution system was not capable of supplying the required fire flow while maintaining a minimum residual pressure of 20 psi within the entire pressure zone. The locations that were not able to meet the fire flow requirements were locations with a commercial or industrial fire flow requirement. Two main areas that did not meet fire flow requirements are discussed below and shown on Figure 7-2.

- Ary Lane – The existing commercial area along Ary and Market Lane is served by 8-inch diameter pipelines. The hydraulic model results for this location show existing fire flow between 3,140 gpm and 3,270 gpm, which is below the current planning requirement of 3,500 gpm. The planning criteria is meant to apply to new buildings and may not be applicable to existing buildings. Performing fire flow evaluations on the actual fire flow requirements for the specific buildings along Ary and Market Lane is beyond the scope of the WSMP. No improvement recommendations have been made for the existing system at this location.

- Gateway Drive – The existing commercial area along Gateway Drive is located at the southeastern-most edge of the City's system. This area is served by a single 10-inch diameter pipeline in West A Street from Evans Road to Gateway Drive. The hydraulic model results for this location show existing fire flow between 2,055 gpm to 3,340 gpm, which is below the planning requirement of 3,500 gpm. As the Southwest Specific Plan area develops, additional distribution system looping will be added to this area of the City's system which will help to address the fire flow deficiency. Therefore, no recommendations are made for the existing system for this location.

As discussed in Chapter 5, the fire flow requirements used for the hydraulic model are based on general land use assumptions and may not be reflective of actual fire flow requirements for specific buildings. Areas within the existing City are assumed to meet the fire flow standards that were in place at the time of development. Therefore, no recommendations for improvements are made based on the fire flow results of the existing system.

7.4 SUMMARY OF FINDINGS AND RECOMMENDATIONS FROM EXISTING SYSTEM EVALUATION

The hydraulic model developed for the WSMP and discussed in Chapter 6 was used to perform the system evaluations. Based on the results from the hydraulic evaluation discussed above, the existing system is able to meet demands within the City's criteria standards for normal operations. Recommendations for existing system improvements are made for the North/Core Zones pumping capacity deficit. The following provides a list of the recommended improvements and conditions which should be monitored for future evaluation:

- Add an additional 1,000 gpm capacity pump at the Fitzgerald Drive booster pump station to address the existing pumping capacity deficit in the North and Core Zones provided space is available at the existing station. This recommendation is based on the appearance that there is adequate space at the existing structure to accommodate the addition of a new pump. Review of actual as-built conditions is recommended to confirm the available space exists at the booster pump station.
- As discussed in Section 7.2.1, the existing firm groundwater supply for the North/Core Zones is nearly at capacity to meet existing maximum day demands. In the future, the City will need to add new supply capacity into the system or hydraulically connect the South Zone to the North/Core Zones to access the surplus capacity available in the South Zone (see further discussion in Chapter 8).
- The commercial area located in the southwest area of the Core Zone indicates available fire flow is below the recommended fire flow for commercial land use assuming one flowing hydrant for the fire flow. However, no recommendations for improvements to address the fire flow are made for the existing system to address fire flow deficiencies since multiple hydrants could be used to improve available fire flows.

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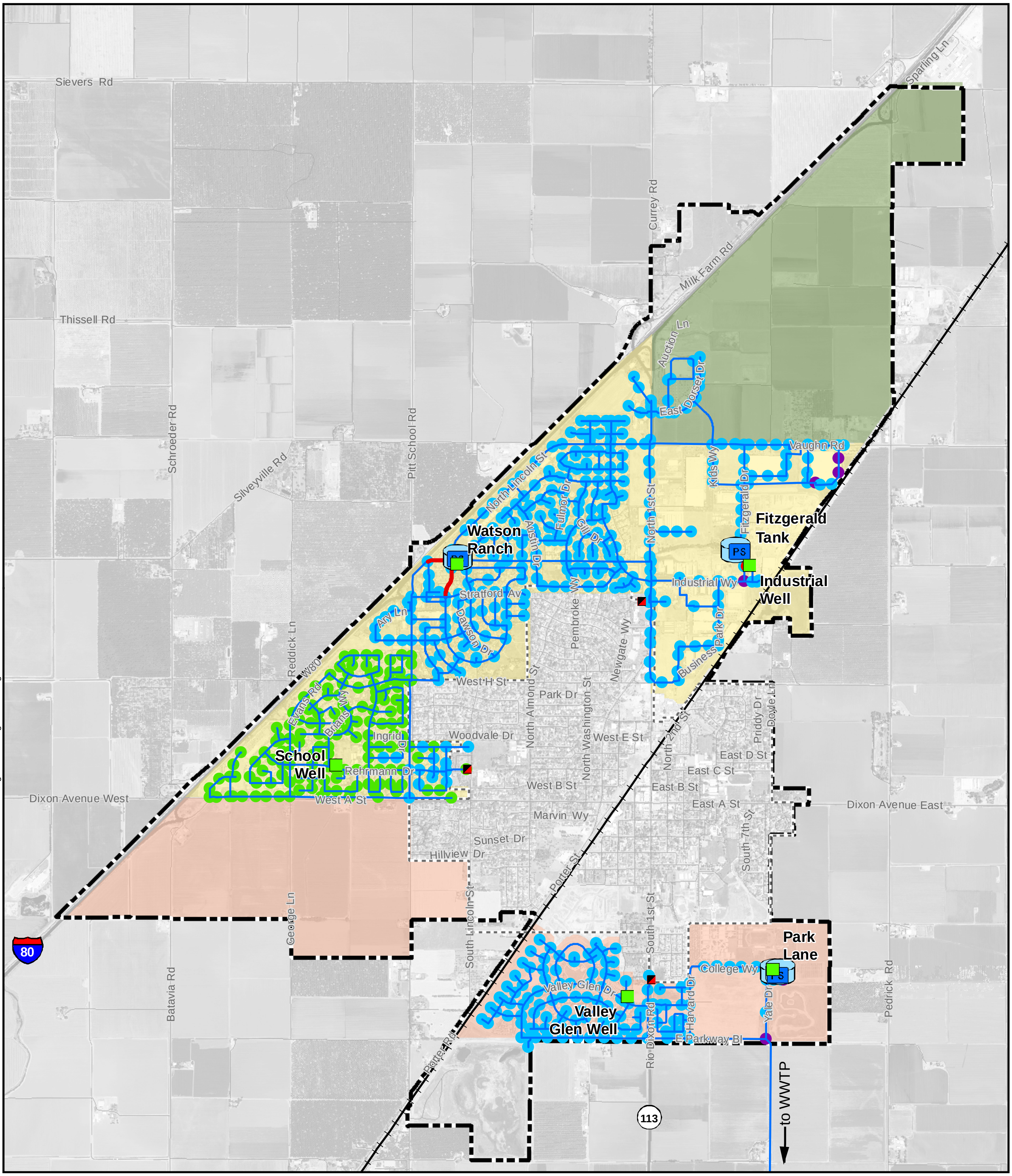

Symbology

- Emergency Intertie

System Pressures

- Less than 30 psi
- 30 to 40 psi
- 40 to 50 psi
- 50 to 60 psi
- Greater than 60 psi

Pipeline Velocities

- 4 ft/sec or less
- Greater than 4 ft/sec

City Water Service Area

- Core Zone
- North Zone
- South Zone

N

0 1,500 3,000

Scale in Feet

Figure 7-1

Existing Water System Minimum Pressure and Maximum Velocity

City of Dixon
Water System Master Plan and Hydraulic Model Update

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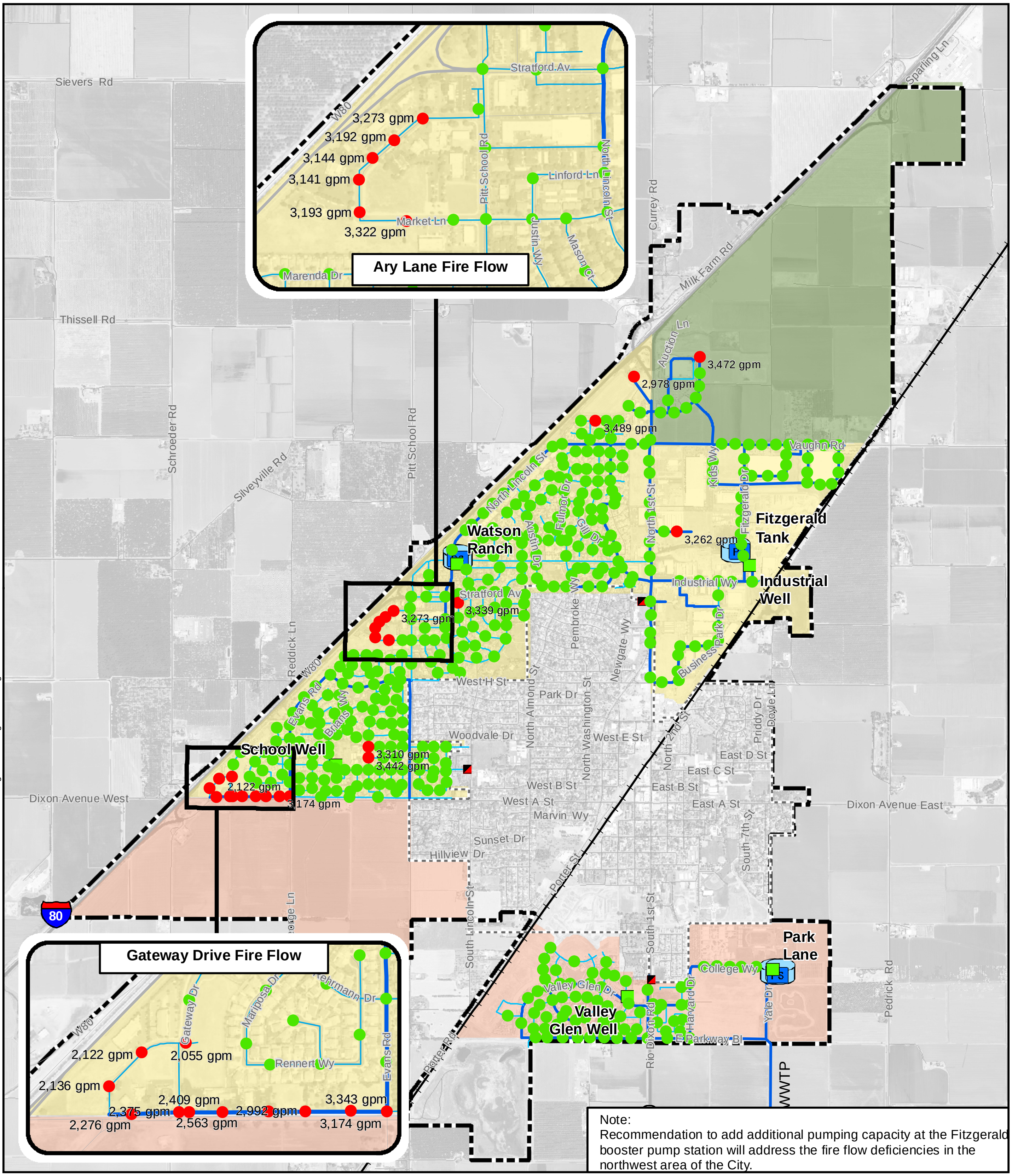

Note:
Recommendation to add additional pumping capacity at the Fitzgerald booster pump station will address the fire flow deficiencies in the northwest area of the City.

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Symbology

Fire Flow Criteria

- Pass
- Fail

Pipeline Diameter

- Less than 10-inch
- 10-inch and Greater

- Emergency Intertie
- Union Pacific Railroad

City Water Service Area

- Core Zone
- North Zone
- South Zone

N

0 1,500 3,000
Scale in Feet

DIXON CALIFORNIA

WEST YOST ASSOCIATES

Figure 7-2

Existing Water System Available Fire Flow

City of Dixon
Water System Master Plan and Hydraulic Model Update

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CHAPTER 8
Future Water System Evaluation

This chapter presents the evaluations of the City's planned 2030 and buildout water distribution system and their ability to meet the City's recommended performance and planning criteria under future demand conditions. This future water system evaluation includes both facility capacity and hydraulic performance evaluations. The evaluation includes an analysis of future supply capacity, pumping capacity, water storage capacity and the planned 2030 and buildout system's ability to meet recommended operational and design criteria under future maximum day demand plus fire flow and peak hour demand scenarios. Infrastructure improvements including pipelines, storage tanks and pumping facilities required to meet projected future demands are shown on Figure 8-1.

The hydraulic model developed by West Yost, and described in Chapter 6, was used to conduct a hydraulic evaluation of the future City water system and identify any water distribution system deficiencies under future conditions. Recommendations have been made to address any future system deficiencies, and these recommendations were then used to develop a prioritized CIP, including an estimate of probable construction costs (see Chapter 10).

8.1 FUTURE SYSTEM SCENARIOS

The WSMP evaluates two future demand conditions based on the City's adopted General Plan land use information: 2030 (near-term) and buildout.

8.1.1 2030 System Assumptions

The future 2030 conditions assume planned development occurs within the City's existing City limits boundary. No development outside of the existing City limits is assumed to occur for the 2030 conditions.

The Southwest Dixon Specific Plan and Northeast Quadrant Specific Plan make up a majority of the planned 2030 development along with infill locations. As part of the Southwest Dixon Specific Plan, a recommendation for hydraulically connecting the South Zone to the Core Zone is made. Hydraulically connecting the zones allows the City water system to be evaluated as a single system rather than two independent systems.

8.1.2 Buildout System Assumptions

The buildout conditions assume the City's existing SOI, as identified in the adopted General Plan, has been developed, including the areas located north of Interstate 80 (I-80). The major development for the buildout system occurs within the SOI on the east side of the existing City limits. As part of the development on the east side, it is recommended to include a transmission pipeline to hydraulically connect the South Zone to the North Zone. The hydraulic connection between the North and South Zones will complete a redundant backbone loop around the City's overall water system. The backbone loop improves the reliability of the City's water system to meet demands.

8.2 FUTURE SYSTEM DEMANDS

Future demand conditions used in the hydraulic model evaluation are based on the City's projected General Plan land uses. The projected demand assumptions are discussed in detail in Chapter 3. The City's projected demands were allocated in the hydraulic model using the spatially located land use parcels and the calculated demands using the demand factors presented in Chapter 3.

The projected demands for 2030 totaled 5,743 AF, for an average day demand of 5.1 mgd (3,560 gpm). The projected demands for buildout totaled 7,995 AF, for an average day demand of 7.1 mgd (4,956 gpm). The projected demands for 2030 and buildout conditions are shown by zone in Table 8-1. For the future water system evaluations, it is assumed the zones are hydraulically interconnected and, therefore, storage and pumping capacity are evaluated as a total system. As shown in Table 8-1, the Core Zone has relatively small growth as it is mostly built out currently. The South Zone and North Zone both show large increases in demands.

The Southwest Dixon Specific Plan accounts for a significant amount of the growth in the South Zone, while the Northeast Quadrant Specific Plan accounts for a significant amount of growth in the North Zone. West Yost reviewed the information in the specific plans for both locations to compare with the demand projections using the recommended demand factors in this WSMP.

- The Southwest Dixon Specific Plan projected approximately 1,146 ac-ft/yr for the average annual demand, while using the proposed demand factors from this WSMP and the 14 percent UAFW the demands are projected to be approximately 1,184 ac-ft/yr. Thus, the projected demands in the Southwest Dixon Specific Plan and the WSMP are similar.
- The Northeast Quadrant Specific Plan projected approximately 1,370 ac-ft/yr for the average annual demand, while using the proposed demand factors from this WSMP and the 14 percent UAFW the demands are projected to be approximately 872 ac-ft/yr. The difference in the projected demands for the Northeast Quadrant Specific Plan are most likely due to the recommended demand factors in this WSMP taking into account increased conservation due to the recent drought. The reduced demand projection for the Northeast Quadrant Specific Plan will impact future improvement requirements.

Table 8-1. Projected 2030 and Buildout System Demands			
Zone	Average Day Demand, gpm	Maximum Day Demand, gpm[(a)]	Peak Hour Demand, gpm[(b)]
2030 Conditions			
North Zone	570	1,254	1,881
Core Zone	1,566	3,445	5,168
South Zone	1,424	3,133	4,699
Total	3,560	7,832	11,748
Buildout Conditions			
North Zone	709	1,561	2,342
Core Zone	2,006	4,413	6,620
South Zone	2,241	4,930	7,395
Total	4,956	10,904	16,357

(a) Maximum Day Demand = 2.2 times Average Day Demand
(b) Peak Hour Demand = 3.3 times Average Day Demand

8.3 FUTURE WATER SYSTEM FACILITY CAPACITY EVALUATION

To evaluate the 2030 and buildout water system, analyses addressing the following system facilities were conducted:

- Maximum Supply Capacity,
- Pumping Capacity, and
- Storage Capacity.

The results of the 2030 and buildout water system facility analyses are discussed below.

8.3.1 Maximum Supply Capacity

The City's existing system is supplied by five groundwater wells with a total available supply capacity of approximately 12.2 mgd. The WSMP assumes the existing groundwater supply capacity will be maintained and continue to be available in the future. Additional supply is needed to meet the projected maximum day demands of 2030 and buildout.

Table 8-2 shows the recommended supply for the future demand scenarios. To meet the projected 2030 and buildout demands, new groundwater wells are recommended. The future well capacity has been assumed to be 1,500 gpm per well. This assumption is less than the average existing well capacity of 1,700 gpm; however, the 1,500 gpm per well capacity is a conservative planning approach and actual well production may vary. The recommended well locations are preliminary and future well siting evaluations will need to be performed.

The supply recommendations in the Southwest Dixon Specific Plan and Northeast Quadrant Specific Plan were also reviewed. The Southwest Dixon Specific Plan included recommendations for a 1,500 gpm well added to the southwest area of the Specific Plan. This WSMP makes the same recommendation for the Southwest Dixon Specific Plan. The Northeast Quadrant Specific Plan recommends two wells. Based on the system hydraulics and buildout demands two wells are recommended for the Northeast Quadrant Specific Plan Area.

Table 8-2. Summary of Existing and Future Water Supply Capacities

Groundwater Supply Source	System Operation	Supply Capacity[a], gpm
Existing System		
Watson Ranch	Tank and BPS	1,500
Industrial Well/Fitzgerald BPS	Tank and BPS	800
School Well	Distribution	1,800
Valley Glen	Distribution	1,900
Parklane	Tank and BPS	2,500
	Existing Total Supply	**8,500**
	Existing Firm Supply	**6,000**
2030 System[b]		
Southwest SP Well	Distribution	1,500
Northwest Quadrant Specific Plan Well #1	Distribution	1,500
	2030 Total Supply	**11,500**
	2030 Firm Supply	**9,000**
Buildout System[c]		
East Development Area Well	Distribution	1,500
Northwest Quadrant Specific Plan Well #2	Tank and BPS	1,500
	Buildout Total Supply	**14,500**
	Buildout Firm Supply	**12,000**

(a) Future wells are assumed to produce 1,500 gpm (2.2 mgd).
(b) The existing total and firm supply are included in the 2030 supply calculations. Maximum day demand for 2030 is 7,832 gpm.
(c) The existing and 2030 total and firm supply are included in the buildout supply calculations. Maximum day demand for buildout is 10,904 gpm.
BPS = Booster Pump Station

8.3.2 Pumping Capacity

The City's pumping capacity was evaluated to assess its ability to deliver a reliable firm capacity to the City's future service area. Firm capacity assumes a reduction in total pumping capacity to account for pumps that are out of service at any given time due to mechanical breakdowns, maintenance, water quality, or other operational issues. For the City's booster pump stations, the criteria for firm pumping capacity assumes the largest pump is a stand-by pump. For the future 2030 and buildout systems, the City's service area is evaluated as a single system as recommendations have been made to hydraulically connect the South Zone to the North and Core Zones.

The pumping capacity criterion for the City, described in additional detail in Chapter 5, requires the City's future water system to have sufficient pumping capacity to meet the greater demand scenario of a peak hour demand or a maximum day demand concurrent with a maximum fire flow event. For the City's 2030 system, the maximum day demand with a concurrent fire flow is the greater demand scenario and for the buildout system, the peak hour demands are the controlling demand scenario. The results of the pumping capacity evaluation are summarized in Table 8-3.

Table 8-3. Evaluation of Existing Firm Pumping Capacity

Future Scenario	Firm Pumping Capacity[(a)], gpm	Peak Hour Demand[(b)], gpm	Maximum Day Demand plus Fire Flow[(c),] gpm	Pumping Surplus/(Deficit), gpm
2030	13,350[(d)]	11,748	11,832	1,518
Buildout	16,510[(e)]	16,357	14,904	153

(a) Firm pumping capacity includes booster pump stations (with largest pump assumed for standby and not included in the capacity calculations) and any wells which pump directly into the distribution system.
(b) Future peak hour demand based on General Plan land use demand calculations (see Table 8-1).
(c) Future maximum day demand based on General Plan land use demand calculations (see Table 8-1). Fire flow included is 4,000 gpm which is based on the development of the Northeast Quadrant SP area requirements.
(d) Includes firm pumping capacity of Fitzgerald Drive Booster Pump Station with improvements (2,330 gpm), Watson Ranch 2 Booster Pump Station (1,660 gpm), Parklane Booster Pump Station (2,660 gpm), and existing and future wells that pump directly into the distribution system (School Well (1,800 gpm), Valley Glen Well (1,900 gpm) new Southwest Dixon SP Well (1,500 gpm), and new Northeast Quadrant SP Well #1.
(e) Buildout pumping capacity includes one new Northeast Quadrant SP booster pump station (1,660 gpm) and East Development Area Well (1,500 gpm).

The pumping capacity analysis indicates that the City's future firm pumping capacity meets the pumping capacity criterion with the improvements recommended in this WSMP. As shown in Table 8-3, the City has a pumping capacity surplus of 1,518 gpm for the 2030 demand conditions and 153 gpm for the buildout conditions. The following improvements are recommended to meet the pumping capacity criterion and shown on Figure 8-1:

- 2030 Demand Conditions (11,832 gpm pumping capacity requirement)
  - — Existing system recommendation to increase Fitzgerald Drive booster pump station from 1,330 gpm firm capacity to 2,330 gpm firm capacity.
  - — New groundwater well in Southwest Dixon Specific Plan area at 1,500 gpm capacity which pumps directly into the distribution system.
  - — New groundwater well in Northeast Quadrant Specific Plan area at 1,500 gpm capacity which pumps directly into the distribution system.

- Buildout Demand Conditions (16,357 gpm pumping capacity requirement)
  - Recommendations for existing and 2030 system improvements.
  - New groundwater well in the East Development Area at 1,500 gpm capacity which pumps directly into the distribution system.
  - New groundwater well in the Northeast Quadrant Specific Plan area at 1,500 gpm which pumps directly into a tank and then through a booster pump station into the distribution system with a firm booster pump station capacity of 1,660 gpm.

8.3.3 Storage Capacity

As discussed in Chapters 3 and 7, the principal advantages that storage provides for the water system are the ability to equalize demands on supply sources, production facilities, and transmission mains; to provide emergency storage in case of supply failure; and to provide water to fight fires.

The City has available storage in the City's tanks and the groundwater basin. Together, these sources of storage must be sufficient to meet the City's storage criteria for the City's existing water system. The volume required for each storage component is detailed below:

- Operational Storage: 20 percent of maximum day demand; and
- Fire Storage: Largest fire flow.

The City's future storage was evaluated to determine whether the City's existing storage capacity is sufficient to provide the required storage for future demands and make recommendations for future tank capacity as needed. The storage evaluation results are summarized in Table 8-4.

Table 8-4. Comparison of Future Available and Required Storage Capacity

Available Storage Capacity[a,b], MG	Required Storage Capacity, MG			Storage Surplus (Deficit)[e], MG
	Operational[c]	Fire Flow[d]	Total	
2030 Demand Conditions				
3.6	2.26	0.72	2.98	0.62
Buildout Demand Conditions				
3.6	3.14	0.72	3.86	(0.26)

[a] Because the North and Core Zones and South Zone are assumed to be hydraulically connected in the future, the existing available storage in the City's zones has been combined for the future analysis.
[b] Available storage is calculated using the useable storage within the tanks. Useable storage is defined as the volume between the tank overflow level and the "dead" or unusable storage, based on the tank outlet.
[c] Operational Storage equals 20 percent of Maximum Day Demand in each zone.
[d] Calculations for required fire flow storage based on a fire flow demand of 4,000 gpm for a 3-hour duration.
[e] Equal to required storage minus available storage. Amount shown is the required useable storage.

The storage recommendations in the Southwest Dixon Specific Plan and Northeast Quadrant Specific Plan were also reviewed. The Southwest Dixon Specific Plan included recommendations for two 1.0 MG tanks added to the southwest area of the Specific Plan. Based on the storage calculations in this WSMP, and the existing storage in the City's system (including the "new" Parklane tanks), no new storage is being recommended for the Southwest Dixon Specific Plan Area. The Northeast Quadrant Specific Plan recommends two 1.0 MG tanks be added to the specific plan area. As described below, based on the demands calculated for this WSMP, and existing storage, a smaller tank is now recommended.

The storage capacity analysis indicates that the City's future storage capacity meets the storage capacity criterion for the 2030 conditions, but has a storage deficit for the buildout conditions. As shown in Table 8-4, the City has a storage capacity surplus of 0.62 MG for the 2030 demand conditions and a storage deficit of 0.26 MG for the buildout conditions. The following improvements are recommended to meet the storage capacity criterion:

- Buildout system requires an additional 0.26 MG of usable storage to be constructed. This WSMP recommends the construction of the future tank to be located in the Northeast Quadrant Specific Plan area. The storage requirement is less than the recommended storage in the Northeast Quadrant Specific Plan document due to reduced system wide demand projections.

8.4 FUTURE SYSTEM PERFORMANCE EVALUATION

Hydraulic analyses, using the developed model, were conducted to identify improvement requirements for future development areas within the City's water service area. The recommended improvements meet the system performance criteria as presented previously in Chapter 5. The results of the evaluation of the 2030 and buildout water system are presented below for the following demand scenarios:

- Maximum Day Demand including Peak Hour (Normal Operations)—A peak hour flow condition was simulated for the existing distribution facilities to evaluate their capability to meet a peak hour demand scenario. Peak hour demands are met by the combined flows from the groundwater (firm groundwater pumping capacity) and booster pump stations.
- Maximum Day Demand plus Fire Flow (Emergency Operations)—To evaluate the existing water system under the maximum day demand plus fire flow scenario, InfoWater's "Available Fire Flow Analysis" tool was used to determine the available fire flow while meeting the maximum day demand plus fire flow performance criteria within the existing water system. Maximum day plus fire flow demands are met by the combined flows from the groundwater (firm groundwater pumping capacity) and storage tanks.

The performance criteria and results of the City's future water distribution system evaluation and recommendations are discussed below.

8.4.1 System Normal Operations – Maximum Day Demand including Peak Hour

8.4.1.1 Evaluation Criteria

The maximum day demand for the City's future water system service area was calculated to be 7,832 gpm (11.3 mgd) for the 2030 system and 10,904 gpm (15.7 mgd) for the buildout system. These maximum day demands represent a peaking factor of 2.2 times the average day demand. During a maximum day demand scenario, a minimum pressure of 35 psi must be maintained throughout the water system.

The peak hour demand for the City's future water system service area was calculated to be 11,748 gpm for the 2030 system and 16,357 gpm for the buildout system. These peak hour demands represent a peaking factor of 3.3 times the average day demand. During a peak hour demand scenario, a minimum pressure of 30 psi must be maintained throughout the water system.

In addition, during normal operations, maximum velocities should not exceed 6 ft/s. Details of the system minimum pressures as simulated in the model under the maximum day and peak hour demand scenario are discussed below.

8.4.1.2 2030 Evaluation Results

The 2030 service area includes development in areas to the northeast and southwest of the City's existing system. The City does not have any existing water infrastructure within these locations. Recommendations for these locations include a distribution backbone system to provide supply to the proposed locations. The backbone pipeline recommendations shown in the Southwest Dixon Specific Plan and Northeast Quadrant Specific Plan were also reviewed and added into the hydraulic model. The pipeline alignments shown in these areas are based on providing supply to the proposed development areas and actual alignments will be determined during the design process. As part of the development in the southwest part of the City, it is recommended to make a connection between the existing South Zone and the Core Zone which is consistent with recommendations in the Southwest Dixon Specific Plan. This connection requires a crossing of the Union Pacific Railroad (UPRR) tracks. Connecting the South Zone and Core Zone will improve the reliability of the overall system by combining the available supply, pumping capacity, and storage capacity of the City's entire service area. As part of the evaluation, recommended diameters from the specific plans were reviewed to confirm if the City's design standards, discussed in Chapter 5, could be maintained. Adjustments were made to a few pipeline recommendations in the Southwest Dixon Specific Plan to upsize pipelines to ensure adequate fire flow and improved system reliability.

Within the City's Core Zone, the Watson Ranch facility is connected to the southwest part of the system from the facility site to West H Street with 8-inch and 10-inch diameter pipelines, a significant amount of which is ACP. From West H Street to West A Street, the distribution system is a 12-inch diameter pipeline. To improve the ability to convey water between the South area of the City to the north, it is recommended to replace the existing 8-inch and 10-inch diameter pipelines with a 12-inch diameter pipeline. Replacement of this pipeline is consistent with the City's renewal and replacement program discussed in Chapter 9. Costs for replacement of this pipeline are included in the system improvement cost estimates and have been removed from the distribution system ACP replacement program costs shown in Chapter 9.

According to the supply analysis, the 2030 projected maximum day demands exceed the existing firm supply available. Two new wells, with a capacity of 1,500 gpm each, are recommended for the 2030 system to provide an adequate firm supply. The well locations used in the WSMP are a new well within the Southwest Dixon Specific Plan and a new well within the Northeast Quadrant Specific Plan, consistent with those specific plans. The actual location of the future wells will require evaluation of the sites to determine where new wells will actually be located.

The 2030 system has adequate storage capacity and no new storage facilities are recommended. The Northeast Quadrant Specific Plan included recommendations for additional storage. However, the storage recommendations in this WSMP are based on the system demand calculations using the updated recommended demand factors which take into account recent water use trends and conservation efforts. The projected demands in this WSMP show a decrease in the overall demands which results in no new storage required for the 2030 system.

During a 2030 maximum day demand scenario (including a peak hour demand), results indicate that the recommended improvements could adequately deliver peak hour demands to meet the City's minimum pressure criterion of 30 psi as illustrated on Figure 8-2. Under this scenario, system pressures ranged from 49 to 66 psi. The City's criteria of using VFDs for pumping directly into the distribution system results in fairly stable pressures for all conditions.

8.4.1.3 Buildout Evaluation Results

The buildout service area includes development outside of the existing City limits and within the City's SOI. The buildout development areas are located east of the existing City limits and the area north of I-80. The City does not have any existing water infrastructure within these locations. Recommendations for these locations include a distribution backbone system to provide supply to the proposed locations. The pipeline alignments shown in these areas are based on providing supply to the developments and actual alignments will be determined during the design process. As part of the development in the area located east of the City's existing City limits, it is recommended to make a connection between the existing South Zone and the North Zone. This connection requires a crossing of the UPRR tracks. Connecting the South Zone and North Zone will complete a backbone distribution system around the City's service area and improve the system reliability.

The development of the area north of I-80 provides special challenges to the City as no supply or system infrastructure currently exists to supply this area and proposed development areas are small. The existing SOI shows four locations north of I-80 which are not connected to each other. The proposed development for these areas is commercial. To serve the areas north of I-80, pipeline connections from the existing City water system crossing I-80 to each of the development areas is recommended. Actual alignment to connect the development areas will be determined during design of the developments.

According to the supply analysis, the buildout projected maximum day demands exceed the firm supply available assuming the 2030 improvements. Two new wells, at a capacity of 1,500 gpm each, are recommended for the buildout system to provide an adequate firm supply. The well locations used in the WSMP are a new well within the East development area and a new well located north of I-80. The actual location of the future wells will require evaluation of the sites to determine where new wells will actually be located.

The buildout system has a useable storage deficit of 0.26 MG. Therefore, the buildout system requires an additional 0.26 MG of usable storage to be constructed. This WSMP recommends the construction of the future tank to be located in the Northeast Quadrant Specific Plan area at the proposed new well site recommended for the 2030 water system. The new well would be reconfigured to pump directly into the tank rather than into the distribution system once the tank is constructed.

During a buildout maximum day demand scenario (including a peak hour demand), results indicate that the recommended improvements could adequately deliver peak hour demands to meet the City's minimum pressure criterion of 30 psi as illustrated on Figure 8-3. Under this scenario, system pressures ranged from 49 to 66 psi. The City's criteria of using VFDs for pumping directly into the distribution system results in fairly stable pressures for all conditions.

8.4.2 Emergency Operations – Maximum Day Demand Plus Fire Flow

8.4.2.1 Evaluation Criteria

To evaluate the future water system under the maximum day demand plus fire flow scenario, InfoWater's "*Available Fire Flow Analysis*" tool was used to determine the available fire flow at each of the simulated fire flow locations with a minimum residual system pressure of 20 psi within the service area.

The junctions in the model used to represent hydrants for the existing system evaluation were included in the future fire flow evaluation. To simulate fire flows in the hydraulic model for the future development locations, selected junctions located along proposed distribution backbone pipelines were assigned fire flow requirements based on their adjacent land use. Where multiple land uses are in the vicinity of a simulated fire flow junction, the highest fire flow requirement was assigned. Because the hydraulic model simulates a steady state condition, the time component of the fire flow requirement is not simulated, but is factored into the storage capacity evaluation presented above. The hydraulic model only evaluates the hydraulic capacity of the City's future water system to supply the required fire flow during a maximum day demand condition within proposed distribution system backbone pipelines.

The City's water system performance standards recommend pipeline velocities be less than 12 ft/s during a maximum day demand plus fire flow condition. However, as described in *Chapter 5 Planning and Design Criteria*, the City's existing pipelines were evaluated on a case-by-case basis as system pressure is the primary criterion. In locations where new or replacement pipelines were proposed, the pipeline velocity criterion was used to determine the appropriate sizing.

8.4.2.2 2030 Fire Flow Evaluation Results

The results of the maximum day demand plus fire flow evaluation for the City's recommended 2030 water system are presented on Figure 8-4. Available fire flows are compared to the fire flow requirements assigned to each simulated fire flow location according to land use. Junctions shown in red represent locations where the City's water distribution system was not capable of supplying the required fire flow while maintaining a minimum residual pressure of 20 psi within the entire zone. The locations that were not able to meet the fire flow requirements were locations with a commercial or industrial fire flow requirement or at locations where the fire flow is located at the end of a dead-end pipeline. The hydraulic model evaluation assumes that only one hydrant is flowing. As shown on Figure 8-4, the available flows, although below the required 3,500 gpm fire flow for commercial or industrial and below 4,000 gpm in the Northeast Quadrant, would be adequate if two or more hydrants were used to fight the fire. Also, as discussed in Chapter 5, the fire flow requirements used for the hydraulic model are based on general land use assumptions and may not be reflective of actual fire flow requirements for specific buildings.

8.4.2.3 Buildout Fire Flow Evaluation Results

The results of the maximum day demand plus fire flow evaluation for the City's recommended buildout water system are presented on Figure 8-5. Available fire flows are compared to the fire flow requirements assigned to each simulated fire flow location according to land use. Junctions shown in red represent locations where the City's water distribution system was not capable of supplying the required fire flow while maintaining a minimum residual pressure of 20 psi within the entire zone. The locations that were not able to meet the fire flow requirements were locations with a commercial or industrial fire flow requirement located in the new development areas north of I-80 or at locations where the fire flow is located at the end of a dead-end pipeline. The hydraulic model evaluation assumes that only one hydrant is flowing. As shown on Figure 8-5, the available flows, although below the required 3,500 gpm fire flow for commercial or industrial, as the areas north of I-80 develop, design of the system should give consideration to providing a looped system to improve fire flow and avoid long dead-end segments of pipeline. Also, as discussed in Chapter 5, the fire flow requirements used for the hydraulic model are based on general land use assumptions and may not be reflective of actual fire flow requirements for specific buildings.

8.5 SUMMARY OF FINDINGS AND RECOMMENDATIONS FROM FUTURE SYSTEM EVALUATION

Based on the results from the hydraulic evaluation discussed above, the recommendations to serve the future 2030 and buildout system are listed below:

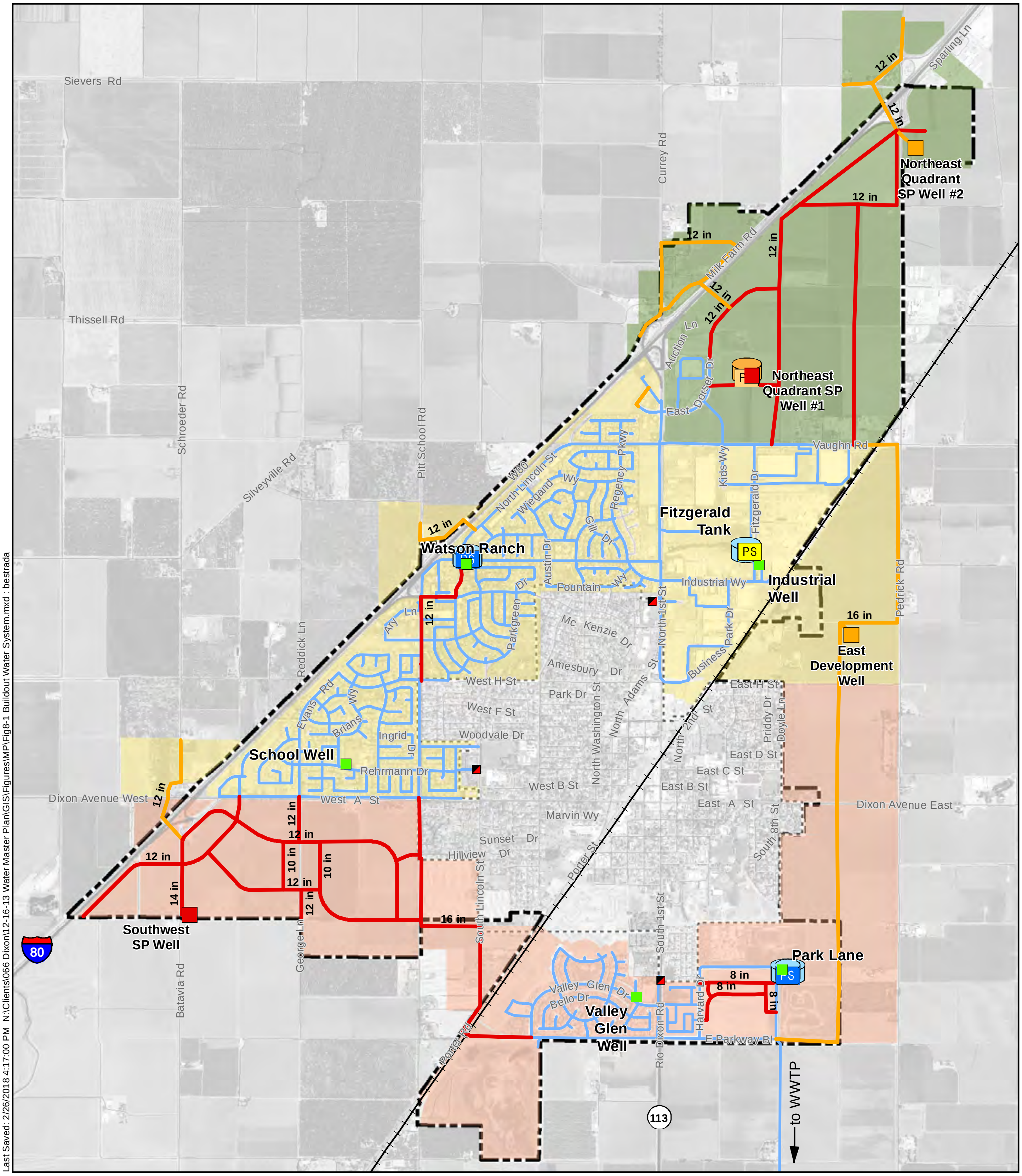
2030 System Recommendations

- Construct 2 new wells at 1,500 gpm each
  - — Southwest Dixon Development Area
  - — Northeast Quadrant #1 Well site
- Pipelines from Watson Ranch Facilities to West H Street
  - — 12-inch diameter pipeline: 3,500 feet

- Pipelines within the Southwest Dixon Specific Plan area
  - 10-inch diameter pipeline: 2,200 feet
  - 12-inch diameter pipeline: 19,600 feet
  - 14-inch diameter pipeline: 1,100 feet
  - 16-inch diameter pipeline: 4,200 feet
- Pipelines within the Northeast Quadrant Specific Plan area
  - 12-inch diameter pipeline: 16,600 feet
  - 16-inch diameter pipeline: 5,200 feet
- Pipelines within South Zone development
  - 8-inch diameter pipeline: 1,900 feet
  - 12-inch diameter pipeline: 2,500 feet
- Connection between South and Core Zone
  - 16-inch diameter pipeline: 4,000 feet
  - 16-inch diameter UPRR crossing

Buildout System Recommendations

- Construct two (2) new wells at 1,500 gpm each
  - East development area
  - Northeast Quadrant #2 Well site
- Construct 0.26 MG of usable storage in Northeast Quadrant Specific Plan area
- Construct 1,660 gpm firm capacity booster pump station at new tank in Northeast Quadrant Specific Plan area
- Pipelines east of the existing City limits
  - 16-inch diameter pipeline: 16,800 feet
- Pipelines north of I-80
  - 12-inch diameter pipeline: 15,500 feet
  - Two (2) 12-inch diameter crossings of I-80



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Symbology

Existing Facilities

- Well
- Booster Pump Station
- Tank
- Emergency Intertie
- Existing Pipelines
- Proposed Existing System Pump

Proposed Future Facilities

- New Well 2030
- New Well Buildout
- Proposed Buildout BPS
- Proposed Buildout Tank
- 2030 New Pipeline
- Buildout New Pipeline

0 1,500 3,000
Scale in Feet

N

DIXON CALIFORNIA

WEST YOST ASSOCIATES

Figure 8-1

Buildout Water System

City of Dixon
Water System Master Plan and Hydraulic Model Update

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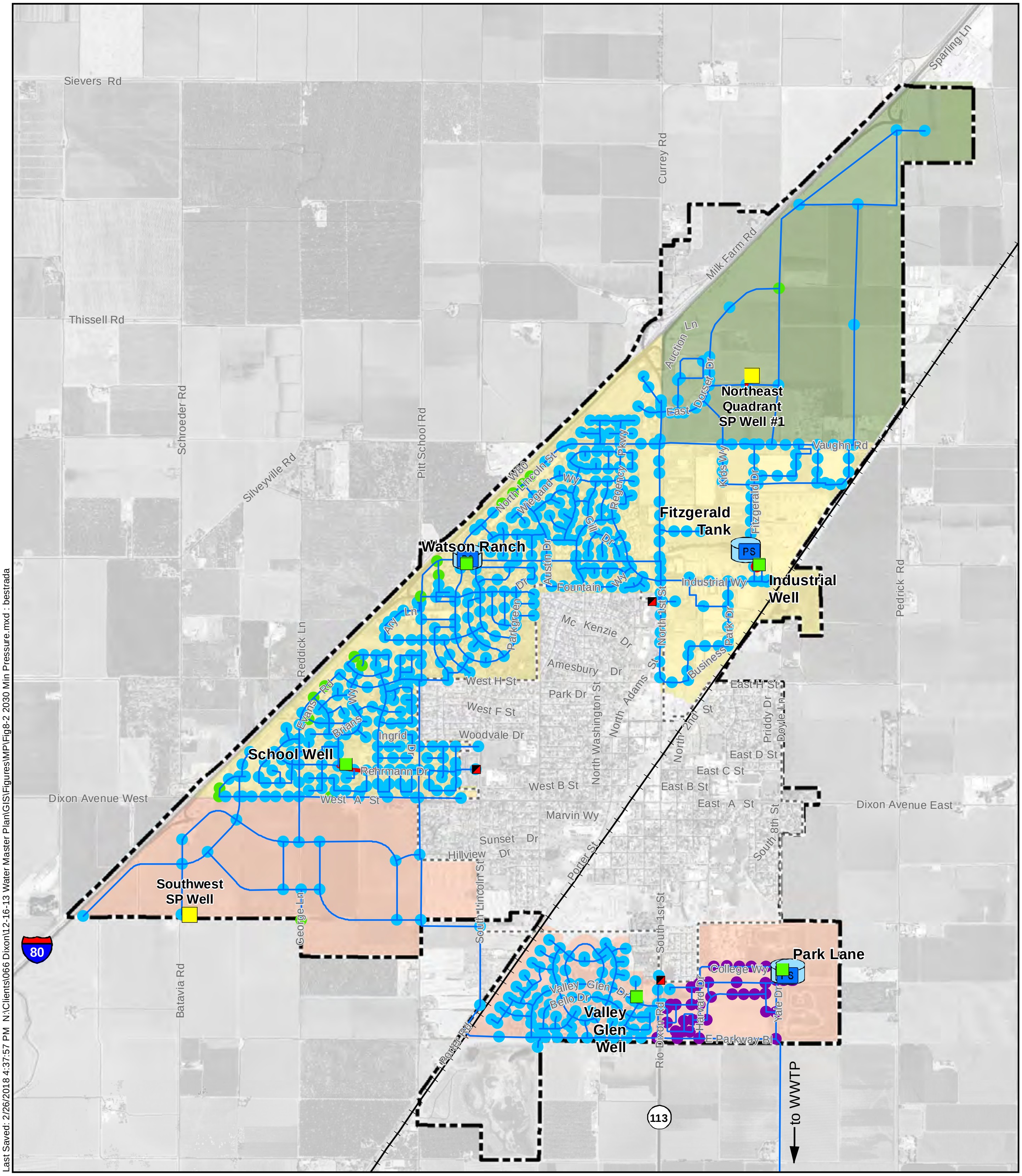

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Symbology

System Pressures

- Less than 30 psi
- 30 to 40 psi
- 40 to 50 psi
- 50 to 60 psi
- Greater than 60 psi

- Proposed Well
- PS Proposed Pump
- Emergency Intertie

Pipeline Velocity

- 4 ft/sec or less
- Greater than 4 ft/sec

N

0 1,500 3,000

Scale in Feet

DIXON CALIFORNIA

WEST YOST ASSOCIATES

Figure 8-2

2030 Water System Minimum Pressure and Maximum Velocity

City of Dixon
Water System Master Plan and Hydraulic Model Update

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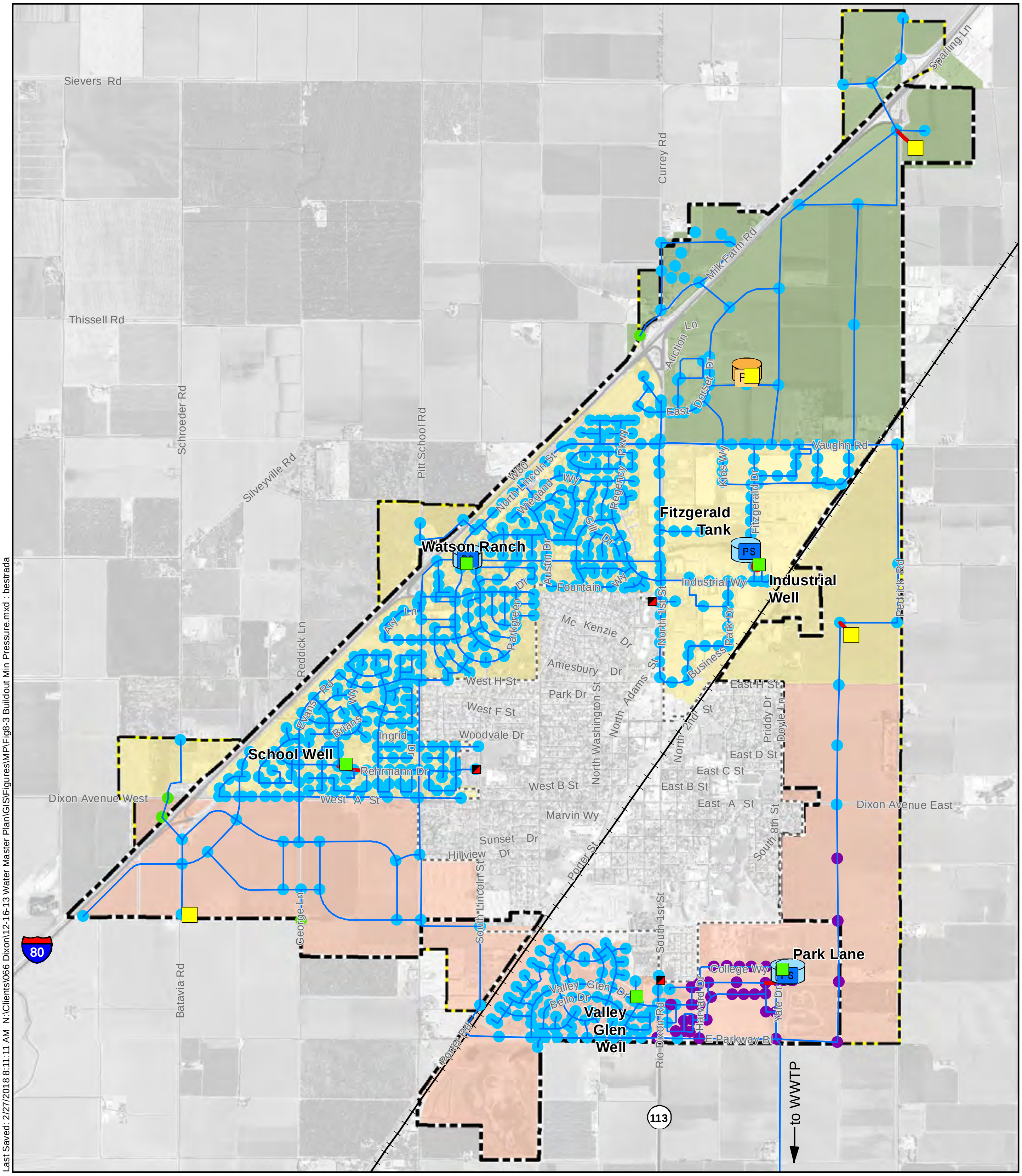

Symbology

System Pressures

- Less than 30 psi
- 30 to 40 psi
- 40 to 50 psi
- 50 to 60 psi
- Greater than 60 psi
- Proposed Well

PS Proposed Pump

Proposed Tank

Emergency Intertie

Pipeline Velocity

- 4 ft/sec or less
- Greater than 4 ft/sec

0 1,500 3,000

Scale in Feet

Figure 8-3

Buildout Water System Minimum Pressure and Maximum Velocity

City of Dixon
Water System Master Plan and Hydraulic Model Update

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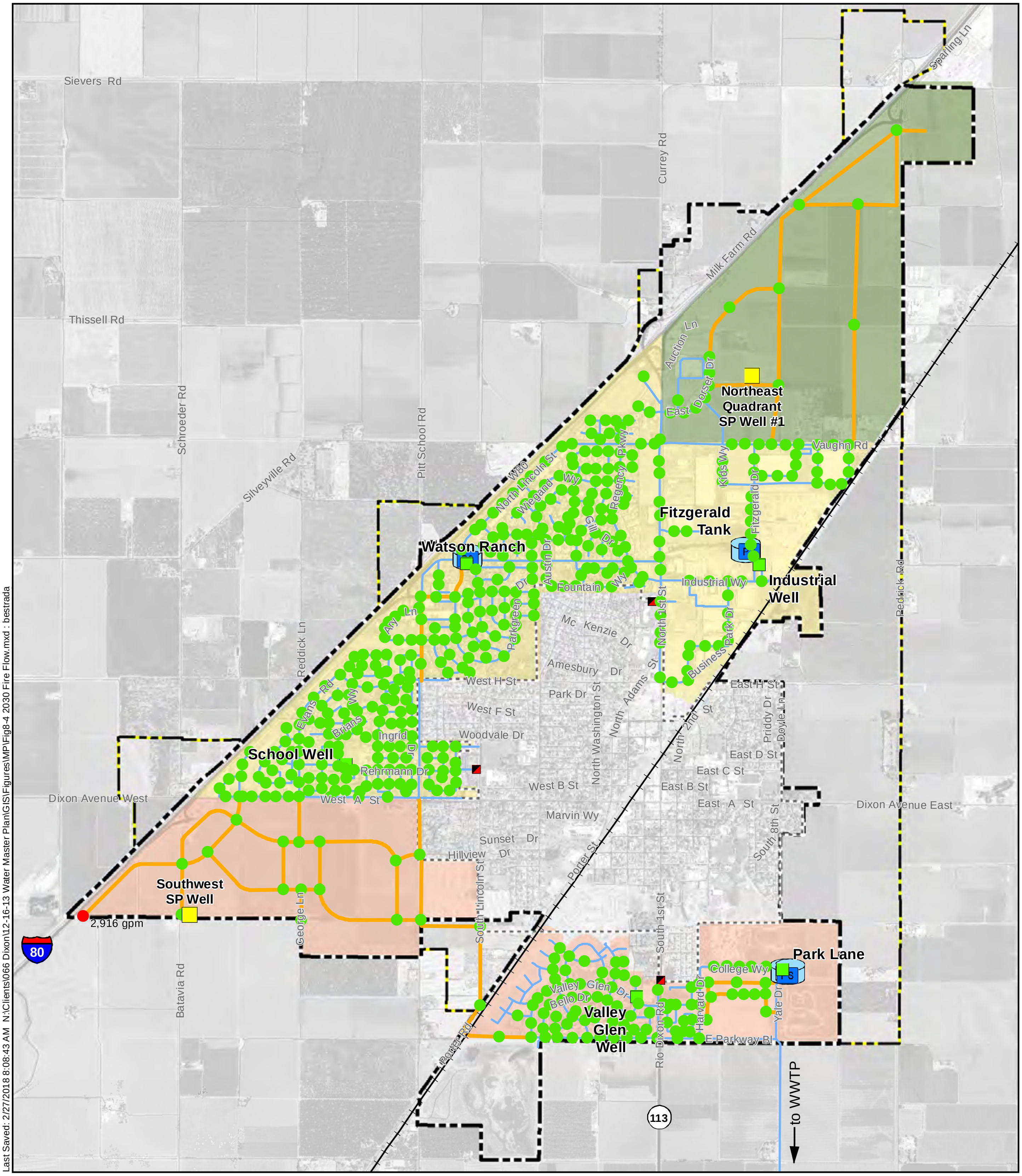

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Symbology

Fire Flow Criteria

- Pass
- Fail

- Future Tank
- Future Pump
- Future Well
- Emergency Intertie

- Existing Pipeline
- 2030 Pipeline

N

0 1,500 3,000

Scale in Feet

WEST YOST ASSOCIATES

Figure 8-4

2030 Water System Available Fire Flow

City of Dixon
Water System Master Plan and Hydraulic Model Update

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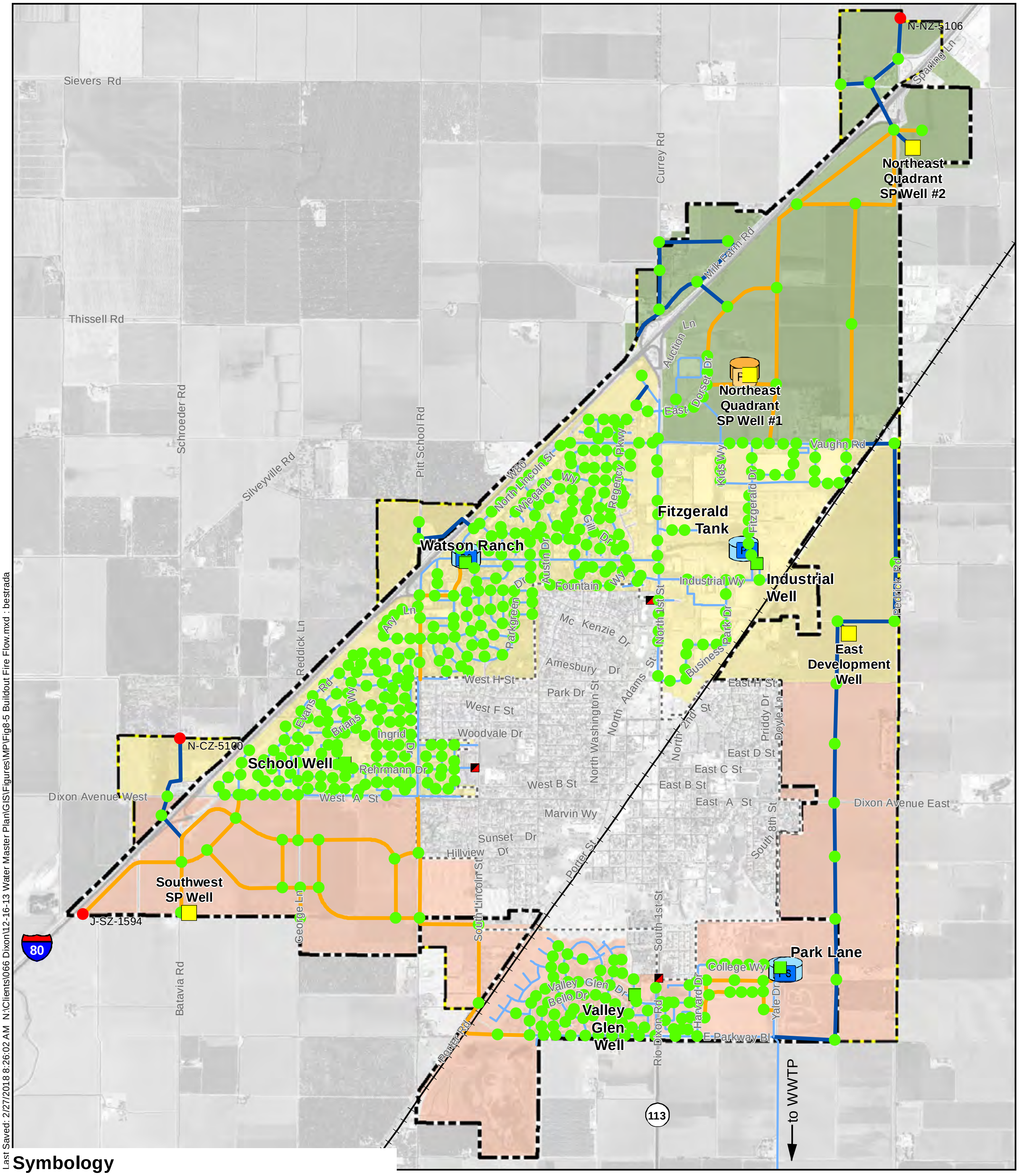

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Symbology

Results

- Fail
- Pass

System Pipelines

- Existing Pipeline
- 2030 New Pipeline
- Buildout New Pipeline

- Future Tank
- PS Future Pump
- Future Well
- Emergency Intertie
- Core Zone
- North Zone
- South Zone

N

0 1,500 3,000

Scale in Feet

DIXON CALIFORNIA

WEST YOST ASSOCIATES

Figure 8-5

Buildout Water System Available Fire Flow

City of Dixon
Water System Master Plan and
Hydraulic Model Update

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CHAPTER 9
Strategic Asset Management Plan

This chapter presents a Strategic Asset Management Plan (SAMP) for the City's existing water system facilities. As described below, like municipalities everywhere, the City is facing important challenges in managing aging water system infrastructure and balancing utility services and costs. The decision between maintaining individual water system assets versus overhauling or replacing a facility will involve many factors such as operational efficiency, capital and long-term costs, and the consequence of potential failure.

9.1 INTRODUCTION

This SAMP attempts to establish a baseline condition of the water system assets (where possible) and determines when, and to what extent, improvements should be implemented. This SAMP begins with a condition assessment of the City's well, booster pump, and storage facility assets to determine their functionality and estimate the remaining life of the facilities' individual components. These components include all significant assets within each facility from mechanical pumps to electrical instrumentation and controls. This SAMP then develops a risk-based system for prioritizing the most urgent capital and maintenance program improvements.

9.1.1 Asset Management Plan Overview

The goal of the SAMP is to establish a consistent, repeatable process for City staff to follow to manage (maintain, improve, and expand) its water system assets at the lowest lifecycle cost, while meeting the desired level of service. This chapter is organized into the following sections:

- Introduction
- Levels of Service
- Asset Inventory
- Condition Assessment
- Risk Assessment
- Preventative Maintenance Program
- Rehabilitation and Replacement Program

9.1.2 Available Information

The following background information was provided by the City and was used for this analysis:

- Division of Drinking Water, Water Supply Permit No. 02-04-14P-4810009 Issued to City of Dixon, September 2014
- City of Dixon Water System Operations and Maintenance Manual (draft)
- Asset Purchase Records, workbook "DSMWS Assets_022414.xlsx"
- Asset Inventory Records, workbook "DSMWS System Inventory (2003).xls"

- Severn Trent Services (Severn Trent), Monthly Potable Water Facilities Monitoring Reports, January 2015 through July 2016
- Preventative Maintenance Schedule and Records, 2015/2016
- Water System Operations and Maintenance Agreement between the City of Dixon and Severn Trent Services, May 2014

9.2 LEVEL OF SERVICE

West Yost worked with City staff to define the levels of service and associated performance metrics as listed in Table 9-1. These levels of service allow the City to focus its efforts and resources, communicate service expectations and choices, and evaluate risk levels.

Table 9-1. Levels of Service

Maximized Efficiency and Useful Life	Increased Reliability and Customer Satisfaction
Goals: • Continue to proactively maintain the wells, booster pumps, storage tanks, and distribution facilities • Proactively replace infrastructure	Goals: • Maintain optimal pressure in system • Perform all required monitoring and reporting by mandated schedule • Develop system redundancies in case of unexpected failures
Metrics: • Conduct annual valve exercise program • Breaks per 100 miles (proposed target < 10 breaks per year) • Unaccounted for water (proposed target < 5 percent)	Metrics: • Customer service complaints per 1,000 customers (proposed target < 1 call) • Emergency response time (proposed target < 1 hour) • Time to resolution for emergencies (proposed target < 24 hours)

9.3 ASSET INVENTORY

The water system facilities are shown on Figure 2-3 in Chapter 2 of this report. This section includes a detailed description of assets that comprise the City's water system and describes the process used to manage the City's asset inventory.

9.3.1 Existing Inventory

The City tracks major facilities (e.g., wells, booster pump stations, and storage tanks) for purposes of estimating equipment value depreciation, but does not include the components such as pumps, motors, gauges, etc. Distribution system pipes, valves, hydrants, and other appurtenances are tracked by quantity within each subdivision.

Severn Trent Services (Severn Trent), the City's contract operator of the water system, will be importing the inventory developed as part of this project into the NEXGEN Computerized Maintenance Management System (CMMS). Severn Trent will use this new CMMS for inventory tracking and work order functions. The CMMS is expected to be implemented by mid-2017.[1] Currently, work orders for the water system are recorded by Severn Trent and transmitted to the City as a portable document file (PDF) report each month.

9.3.2 Inventory Database

West Yost developed a Microsoft (MS) Access asset registry database for the City's water system, which stores asset inventory information in the following locational hierarchy:

Location
↳Facility
↳Component

The *Location* refers to the subdivision in which the asset is geographically situated. *Facility* indicates which well, booster pump, storage tank, or distribution system the asset is a part of. *Component* refers to the individual asset. In order to create this asset registry, a unique identifier [AssetID] was created for each component and a unique identifier [FacilityID] was created for each facility. These identifiers help track individual components as they relate to the system as a whole. The asset registry also assigns each asset to an asset classification system. This three-tiered system includes an asset category (e.g., Mechanical Systems), asset class (e.g., Valves) and asset subclass (e.g., Air Release Valve).

Asset Category
↳Asset Class
↳Asset Subclass

Through the classification system, the model assigns values that are expected to be similar for all assets of a specific subclass, such as standard useful life, unit cost, replacement difficulty, and functionality. These factors are used to assess the risk of a component failure, and are discussed in more detail in Section 9.5. The asset classification system developed for the City's water system is shown in Table 9-2.

[1] City of Dixon Water System O&M Manual (Draft).

Table 9-2. Asset Classification and Unit Costs[a]

Asset Class	Asset Subclass	Reference Units	Unit Cost, dollars	Industry Standard Life, years	Replacement Difficulty	Functionality
Actuator	Actuator	Diameter (in)	$7,250*(D/6)^{0.6}$	30	Difficult	Lack of Redundancy/Potential Reduced Efficiency
Air Compressor	Air Compressor/Receiver	Horsepower (HP)	$11,200*(HP/40)^{0.6}$	20	Easy	Reduced Capacity/Pressure
Building	Structure	Area (sq ft)	200*Area	50	Difficult	Lack of Redundancy/Potential Reduced Efficiency
Chlorine Injector	Chlorine Injector	Each	1300	7	Easy	Station Cannot Operate Without
Electrical	Auto Transfer Switch	Amps	15*Amps	20	Off-line	Station Cannot Operate Without
Electrical	Control Panel	Each	45000	20	Off-line	Station Cannot Operate Without
Electrical	Main Switchboard	Amps	25*Amps+26,000	20	Off-line	Station Cannot Operate Without
Electrical	Motor Control Center	Lump Sum	70,000 - 200,000	20	Off-line	Station Cannot Operate Without
Electrical	PLC/SCADA/Telemetry	Each	25,000	20	Off-line	Reduced Efficiency
Electrical	Surge Protector	Each	1,000	20	Off-line	Lack of Redundancy/Potential Reduced Efficiency
Electrical	Utility Meter	Each	2,500	20	Off-line	Lack of Redundancy/Potential Reduced Efficiency
Electrical	Variable Frequency Drive	Lump Sum	9,000 - 30,000	15	Easy	Reduced Efficiency
Generator	On-site Generator	Lump Sum	75,000 - 285,000	25	Difficult	Lack of Redundancy/Potential Reduced Efficiency
Instrumentation	Chlorine Analyzer	Each	10,000	15	Easy	Station Operates Normally Without
Instrumentation	Flow Element	Diameter (in)	$1,750*(D)^{0.5}$	15	Off-line	Station Operates Normally Without
Instrumentation	Level Element	Each	3,350	15	Easy	Reduced Efficiency
Instrumentation	Transmitter	Each	1,800	15	Easy	Station Operates Normally Without
Instrumentation	Water Meter	Each	200	30	Easy	-
Motor	Motor	Horsepower (HP)	200*HP	30	Difficult	Lack of Redundancy/Potential Reduced Efficiency
Piping	Distribution Piping - ACP[b]	Diameter (in) & Length (LF)	20*D*length	50	Difficult	Station Cannot Operate Without
Piping	Distribution Piping - DIP	Diameter (in) & Length (LF)	20*D*length	100	Difficult	Station Cannot Operate Without
Piping	Distribution Piping - PVC	Diameter (in) & Length (LF)	20*D*length	100	Difficult	Station Cannot Operate Without
Pump	Booster Pump	Horsepower (HP)	970*HP	30	Difficult	Lack of Redundancy/Potential Reduced Efficiency
Pump	Metering Pump	Each	600	10	Easy	Station Cannot Operate Without
Pump	Well Pump	Horsepower (HP)	680*HP	30	Difficult	Station Cannot Operate Without
Sand Separator	Centrifugal Sand Separator	Each	7,733	30	Off-line	Station Operates Normally Without
System Appurtenance	Fire Hydrant	Each	8,000	50	Difficult	-
System Appurtenance	Intertie	Each	10,000	50	Difficult	-
System Appurtenance	Sampling Station	Each	1,500	30	Difficult	-
Tanks	Hydropneumatic Tank	Volume (gal)	19*(V+70)	30	Difficult	Reduced Capacity/Pressure
Tanks	Storage Tank - Plastic/Fiberglass	Volume (gal)	$225*(V)^{0.5}$	30	Difficult	Station Cannot Operate Without
Tanks	Storage Tank - Steel	Volume (gal)	$140*(V)^{2/3}$	40	Difficult	Reduced Capacity/Pressure
Valves	Blowoff Valve	Each	200	30	Easy	Reduced Efficiency
Valves	Check Valve	Diameter (in)	$223*(D)^{1.125}$	25	Easy	Reduced Efficiency
Valves	Gate Valve	Diameter (in)	$4,900*(D/16)^{1.6}$	30	Easy	Reduced Efficiency
Valves	Isolation Valve	Diameter (in)	$4,900*(D/16)^{1.6}$	30	Easy	Lack of Redundancy/Potential Reduced Efficiency
Well	Groundwater Well	Lump Sum	1,000,000 - 2,000,000	30	Difficult	Station Cannot Operate Without

[a] Acronyms and Abbreviations *(in alphabetical order)*: asbestos cement pipe (ACP), diameter (D), ductile iron pipe (DIP), gallon (gal), horsepower (hp), inch (in), linear feet (LF), polyvinyl chloride (PVC), programmable logic controller (PLC), square feet (sq ft), supervisory control and data acquisition (SCADA), and volume (V).

[b] AC pipe replacement costs assume the existing pipe will be abandoned in place.

Assets for the well, booster pump, storage tank, and distribution system were added to the MS Access database along with identifying information such as: manufacturer, model, serial number, size, installation year, etc. The asset registry is located in Appendix C.

9.3.3 Replacement Values

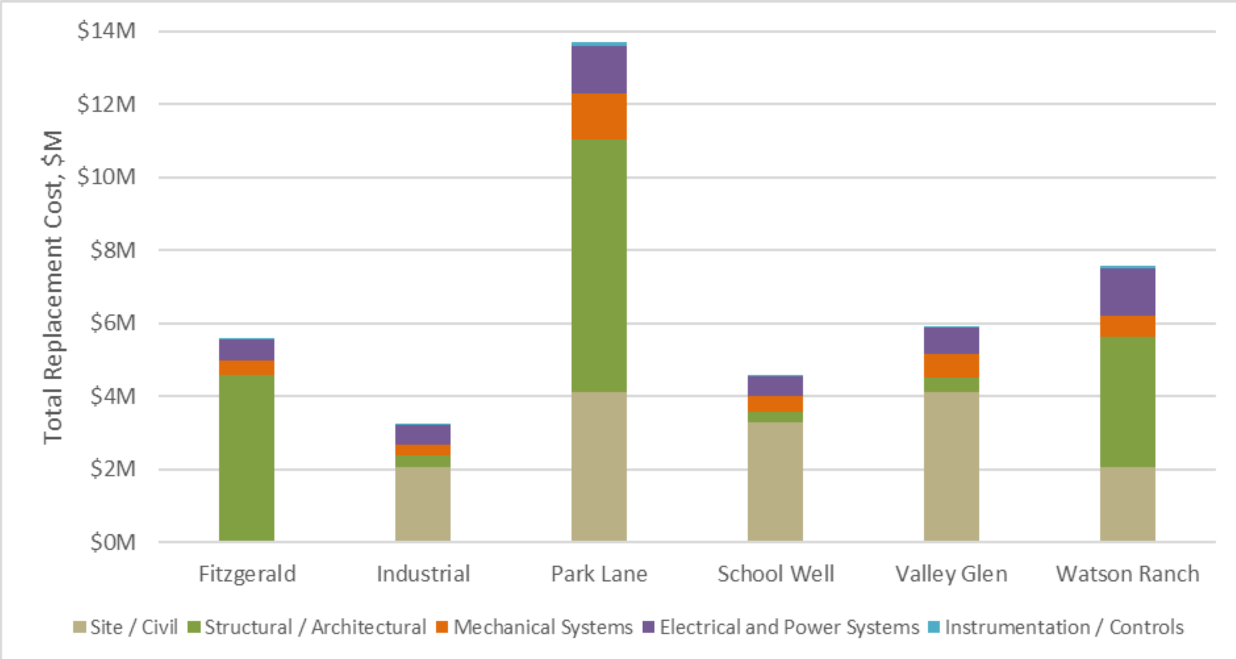
West Yost developed planning-level cost estimates for the replacement of water system facility assets. Replacement costs were developed on a unit-cost basis (defined in Table 9-2), which were developed using the City's purchase records, manufacturers' estimates, RS Means published costs, and West Yost experience from similar projects. The total replacement costs include markups of 25 percent for administrative, legal, engineering, and construction management; 50 percent for construction and installation; and 30 percent for construction contingency.

The total replacement value of the City's water system is approximately $135.3 million ($M), as shown in Table 9-3. The estimated replacement value of the City's water system well, booster pump, and storage tank facilities is $40.6M, as shown by facility and component category on Figure 9-1. Additionally, the City's distribution system valves, piping, and other appurtenances have an estimated replacement value of $94.6M.

Table 9-3. Water System Replacement Costs

Location/Category	Replacement Cost, $M
Well, Booster Pump, and Storage Tank Facilities	
Fitzgerald	$5.6
Industrial	$3.2
Park Lane	$13.7
School Well	$4.6
Valley Glen	$5.9
Watson Ranch	$7.6
Facility Total	$40.6
Distribution System	
Valves	$6.4
Pipes	$80.2
Water Meters	$0.9
Hydrants and Sampling Stations	$7.2
Distribution System Total	$94.6
Water System Total	$135.3

Figure 9-1. Facility Replacement Costs



9.4 CONDITION ASSESSMENT

West Yost conducted site visits of each well, booster pump, and storage tank facility on August 23, 2016 in order to verify and gather equipment information and to assess the condition of the facilities. The site visits were conducted by a team that included City water distribution system operators from Severn Trent Services, civil engineers, and an electrical/controls engineer. The assessment team conducted a visual condition assessment of the civil, structural, mechanical, electrical, and controls systems. The assessment team did not conduct confined space entries, access structures or assets below grade, or conduct destructive testing. The team took photos of components and noted visible information (e.g., model number, serial number, size, etc.) on the Facility Inspection Forms for transfer into the MS Access asset registry database.

The assessment team used the ranking index described in Table 9-4 to rate the condition and performance of the facilities' components based on external observations.

Table 9-4. Condition and Performance Ranking Index		
Score	Condition Ranking Index	Performance Ranking Index
1	Excellent	Component functioning as intended
2	Slight visible degradation	In service, but higher than expected O&M costs
3	Visible degradation	In service, but function is impaired
4	Integrity of component moderately compromised	In service, but function is highly impaired
5	Integrity of component severely compromised	Component is not functioning as intended

The results of the condition assessment for each facility are included in detail in the Facility Inspection Forms, which are located in Appendix D.

9.5 RISK ASSESSMENT

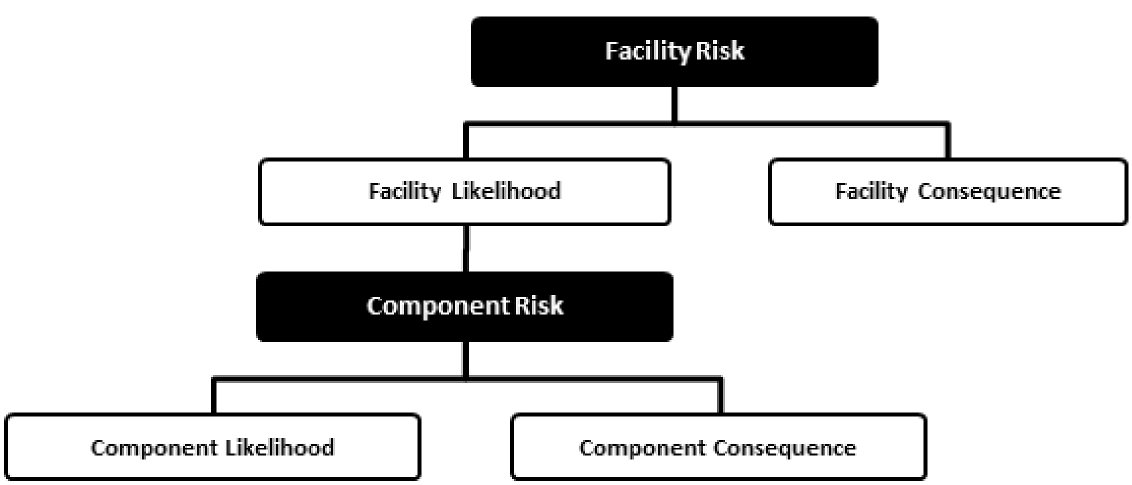
This section discusses the methodology used to assess the risk of the City's water system assets and summarizes the risk assessment results.

9.5.1 Methodology

This risk assessment considers the likelihood of failure along with the consequence of failure of each individual asset. The *likelihood of failure* assesses the probability that a failure will occur and the *consequence of failure* considers the impact an asset's failure may have on the level of service provided by the system.

Each component is assigned a rating on both metrics as shown on Figure 9-2 to determine the component's risk. The aggregate risk of these individual components determines the likelihood of failure for each facility. Combined with the consequence of failure for each facility, a final facility risk is calculated, which represents the facility's criticality within the water system.

Figure 9-2. Facility Risk Assessment Methodology



9.5.2 Failure Modes

For this analysis, a failure is defined by the asset's inability to work as intended or as needed in its application. Failure modes include physical mortality and level of service failure:

- Physical mortality failure was considered the primary failure mode for all assets. Each asset has an expected useful life, based on industry standards, which is documented for each asset subclass in Table 9-2.
- Level of service failure refers to the component's impact on the facility's overall ability to deliver water, as well as its ability to do so in a fiscally responsible manner.

9.5.3 Component Risk Levels

This section describes the individual component failure analyses and the resulting risk levels.

9.5.3.1 Likelihood of Failure Analysis

The likelihood of failure analysis considers the probability that a failure will occur in a given component based on the two modes of physical mortality and level of service. Table 9-5 describes the factors considered in determining the potential likelihood of a failure.

Table 9-5. Likelihood of Component Failure Criteria

Failure Mode	Description	Criteria/Factor
Physical Mortality	The percent of useful life remaining considers that older assets are more likely to fail than newer ones due to the age of materials and wear from repeated use. The percent of useful life remaining was determined by comparing the number of remaining years estimated during the field assessments to the industry standard lifetime for each asset.	Percent of Useful Life Remaining
	An asset with visible degradation is more likely to fail. While condition and age are often dependent, newer components may be in poor condition due to environmental conditions or improper maintenance.	Condition Rating
Level of Service	Impaired function of assets can cause higher O&M costs or reduced ability of the facility to meet system demands. An asset's performance may affect the level of service provided by the facility, depending on the asset's role in day-to-day operations.	Performance Rating

Likelihood of failure is rated on a zero to five scale with five indicating the highest likelihood. The factors for each rating are summarized in Table 9-6.

Table 9-6. Likelihood of Component Failure Rating Factors

Failure Mode	Factor	Rating (0 being the lowest, 5 being the highest)						Scoring Logic
		0	1	2	3	4	5	
Physical Mortality	Percent of Useful Life Remaining	Unknown	≥ 70%	40% to 70%	10% to 40%	5% to 10%	≤ 5%	Assigned the highest rating of all factors
	Condition Rating	Unknown	(1) Excellent	(2) Slight Visible Degradation	(3) Visible Degradation	(4) Integrity Moderately Compromised	(5) Integrity Severely Compromised	
Level of Service	Performance Rating	Unknown	(1) Functioning as Intended	(2) In Service, but Higher than Expected O&M Costs	(3) In Service, but Function is Impaired	(4) In Service, but Function is Highly Impaired	(5) Not Functioning as Intended	Single Rating

9.5.3.2 Consequence of Failure Analysis

The consequence of failure analysis considers the impact that a component failure may have on operating the respective facility. Table 9-7. Consequence of Component Failure CriteriaTable 9-7 describes the criteria evaluated in considering a consequence of failure rating.

Table 9-7. Consequence of Component Failure Criteria

Category	Description	Criteria/Factor
Operating Ability	Operating ability considers the functionality of the facility if a component fails. Component failure will have a varying degree of impact on the ability of the facility to deliver water depending on the role of the component and the configuration of the facility. Component failure may lead to reduced power efficiency, increased personnel hours, or decreased ability to meet service demands.	Functionality of Facility
Service Reliability	Reliability of service decreases as the time and/or resources required to repair or replace a component increase. An easy repair or replacement is defined as taking one person no more than one day to complete the task. A difficult repair or replacement would take more than one person and/or more than one day to complete. If the repair or replacement requires the facility to be taken offline, even for a short amount of time, this is an even greater service impact. If the component is obsolete, it is assumed that a partial redesign or programming of the controls would need to occur.	Repair/Replacement Difficulty

The consequences of failure described above were translated into numeric rankings of one to five, with five indicating the highest or worst consequence. Each component at each of the City's facilities was evaluated for the categories described above, and an overall consequence of failure score was calculated for each component. The factors and their potential ratings for each consequence are listed in Table 9-8.

Table 9-8. Consequence of Component Failure Rating Factors							
Consequence	Factor	Rating (1 being the lowest, 5 being the highest) 1	2	3	4	5	Scoring Logic
Operating Ability	Functionality of Facility	Operates Normally Without	Lack of Redundancy/ Potential Reduced Efficiency	Reduced Efficiency	Reduced Capacity/ Pressure	Cannot Operate Without	Single Factor
Service Reliability	Repair/ Replacement Difficulty	Easy	Difficult	—	Offline	Obsolete	Single Factor

9.5.3.3 Component Risk Assessment Results

A database model was developed to perform the risk assessment calculations. As noted above, the aggregate score for likelihood of failure ranges from 1 to 10, while the aggregate score for consequence of failure ranges from 2 to 10. The model applies a series of algorithms to calculate total consequence and likelihood of failure scores for each component asset.

By plotting the consequence of failure and the likelihood of failure scores against each other, an overall risk level was assigned to each component. Table 9-9 shows the total number of components that fall into each likelihood and consequence of failure category. Risk levels are prioritized into one of five risk levels: Low Risk, Medium-Low Risk, Medium Risk, Medium-High Risk, or High Risk, each of which is color-coded in Table 9-9. The severity of each risk level are assigned to each potential rating using engineering judgment to determine which combinations of scores warrant the highest levels of concern.

Table 9-9. Component Risk Levels

Number of Components		Consequence of Failure: A (2-3)	B (4)	C (5)	D (6-7)	E (8-10)	Total
Likelihood of Failure	A (0-2)	0	4	0	5	0	9
	B (3)	50	61	7	25	12	155
	C (4)	4	12	2	6	4	28
	D (5)	3	7	1	1	0	12
	E (6-7)	4	7	2	9	1	23
	F (8-10)	0	3	2	6	7	18
	Total	61	94	14	52	24	245

Risk: **Red** = High, **Orange** = Med-High, **Yellow** = Medium, **Light Green** = Med-Low, **Dark Green** = Low

The risk assessment results are summarized in Table 9-10, which lists the total number of components that fall in each risk level.

Table 9-10. Summary of Component Risk Assessment Results

Risk Level	No. of Components	% of Total
Low	50	20%
Medium-Low	69	28%
Medium	31	13%
Medium-High	51	21%
High	44	18%
Total	245	100%

9.5.4 Facility Risk Levels

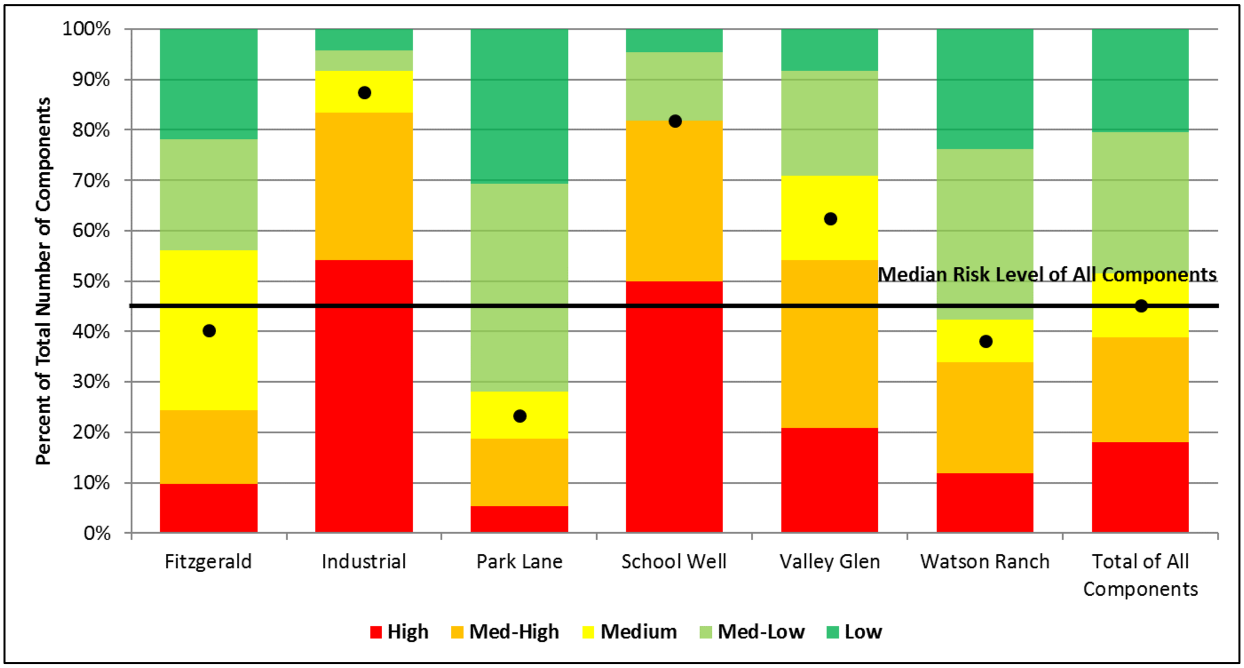
The risk for each facility was evaluated based on the likelihood and consequence of failure of the facility, as well as the combined risk level of the component assets within the facility. For this analysis, a failure is defined by the facility's inability to meet service demands. This section summarizes the analysis, which used available information to assign a risk level for each facility.

9.5.4.1 Likelihood of Failure Analysis

The likelihood of failure analysis considers the probability that a failure will occur in a given facility. Since the risk assessment for each component within each facility considers the likelihood that a failure will occur and its overall effect on the facility as a whole, the likelihood of a facility failure increases as the risk level of the components within it increase. For example, if a motor control center at Facility A received a high risk rating (see Section 9.5.3) because it is in poor condition and Facility A cannot operate without the motor control center, Facility A would have a higher likelihood of failure than Facility B, which does not have any high risk components.

The example given above is a simplified one. In this analysis, each facility has components that have high risk levels. Therefore, it is necessary to develop a statistical method to evaluate the risk levels of the components in each facility in order to compare them against each other. shows the percentage of components in each facility at each risk level. The median risk level of each facility was compared to the median risk level of the total of all components in this evaluation. Facilities whose median risk level (shown as a black dot on Figure 9-3) falls above the line (which is equal to the median risk level of all of the components evaluated) are considered to be more likely to fail than those below the line since a greater percentage of the components in that facility are considered to be higher risk.

Figure 9-3. Risk Levels of Assets, Percent of Total



Each facility is evaluated by calculating the deviation of the midpoint of the median risk level from the midpoint of the median risk level when all of the components evaluated are combined (shown on Figure 9-3 as "Total of All Components"). Likelihood of failure is rated on a one to five scale with five indicating the highest likelihood, with the level of deviation scored as shown in Table 9-11.

Table 9-11. Facility Likelihood of Failure Rating Factors

Failure Mode	Factor	Rating (1 being the lowest, 5 being the highest)					Scoring Logic
		1	2	3	4	5	
Component Failure	Deviation of Median Risk Level from the Median Risk Level of the Total of All Components	> 13% below	6% to 13% below	Within 6%	6 to 13% above	> 13% above	Single Factor

9.5.4.2 Consequence of Failure Analysis

The consequence of failure considers the impact a facility's failure may have on the level of service provided by the City's water system. This section describes the specific criteria and associated rating factors used in assigning consequence of failure scores to each facility.

Table 9-12 presents a summary of the factors used to assess each facility's consequence of failure.

Table 9-12. Facility Consequence of Failure Criteria

Category	Description	Criteria/Factor
Ability to Meet Demand Scenarios	Depending on the redundancy built into the system, some zones may be able to meet service demands with one facility offline, while other zones have limited redundancy and would be able to meet maximum day demands, but not peak demands.	Zone Storage and Pumping Excess Capacity
	The higher the facility's capacity is, the more negative the impact of an outage will be on the zone.	Facility Contribution to Total Zone Capacity

The ability of each facility to meet demand scenarios depends on the capacity of the facilities and the volume of reservoirs that serve each zone. In order to assess the ability of each facility to meet demand scenarios, the total capacity of each facility was estimated by the results of the existing system hydraulic modeling described in Chapter 7 of this report. The actual flow rates from each facility may vary depending on system conditions; however, the design flow rates are considered to be representative of current facility conditions and general operating conditions.

The rating method and scoring logic for each factor of the consequence of failure analysis are shown in Table 9-13. Each factor is rated on a scale of 1 to 5, with 5 having the most severe (highest) consequence.

Table 9-13. Consequence of Failure Rating Factors

Consequence	Factor	Rating (1 being the lowest, 5 being the highest)					Scoring Logic
		1	2	3	4	5	
Ability to Meet Demand Scenarios	Zone Storage and Pumping Excess Capacity	> 75 %	51 – 75%	26 – 50%	1 - 25%	≤ 0%	Total Rating
	Facility Contribution to Total Zone Capacity	> 50 %	41 – 50%	31 – 40%	21 - 30%	≤ 20%	

9.5.4.3 Facility Risk Assessment Results

A database model was developed to perform the risk assessment calculations. The model applies a series of algorithms to calculate total consequence and likelihood of failure scores for each facility. By plotting the consequence of failure and the likelihood of failure scores against each other, an overall risk level was assigned to each facility. Risk levels increase as likelihood and consequence increase. The facilities were then ranked from highest risk to lowest risk, as shown in Table 9-14.

Table 9-14. Summary of Facility Risk Assessment Results

Facility Name	Risk
School Well	High
Valley Glen	Medium-High
Industrial Well	Medium-High
Watson Ranch	Medium-High
Park Lane	Medium
Fitzgerald	Medium

9.6 PREVENTATIVE MAINTENANCE PROGRAM

This section describes the City's existing water system preventative maintenance program, and presents an optimized program based on the risk levels determined in Section 9.5.

9.6.1 Routine Preventative Maintenance and Inspection Schedule

Severn Trent operates the City's water system under a service contract and runs a preventative maintenance program that is developed as problems occur or as defects are encountered. A summary of this program is provided in Table 9-15 and includes maintenance schedules for water system facilities and components.

The inspection and maintenance activities listed in Table 9-15 are conducted in compliance with the following policies and procedures:

- Interior cleaning is performed in accordance with AWWA Standard C652-11.
- System backflow assembly testing is performed by an AWWA certified tester or Cross-Connection Control Specialist and are tested immediately after the backflow assemblies are installed, relocated, or repaired and placed into service.
- Annual inspection of the fire extinguishers is conducted by a person licensed by the State Fire Marshal, in accordance with the California Health and Safety Code, Division 12, Part 2, Chapter 1.5, Articles 2, 3, and 6. Monthly inspections are conducted by Severn Trent staff to verify that the fire extinguisher is in its designated place, that it has not been actuated or tampered with, and that there is no obvious or physical damage or condition to prevent operation, in accordance with the California Code of Regulations, Subchapter 4, Article 36, §1922.
- Per ANSI Z358.1, paragraph 7.5: Weekly testing of eye wash stations is required to verify water flow. Annual inspection assures compliance with performance requirements such as water volume, temperature, and leakage, among others.

Table 9-15. Preventative Maintenance Schedule

Water System Asset	Existing Preventative Maintenance Activities			Recommended Preventative Maintenance Activities	
	Action	Frequency	Source[a]	Action	Frequency
Gauges and Flow Meters	Visual Inspection	Daily	WSP	No Change	
	-			Calibrate	Annually
Facility Lighting and Security	Visual Inspection	Daily	WSP	No Change	
Booster Pumps	Visual Inspection	Daily	PMR	Visual and Audio Inspection	Daily
	Change Grease	Annually	PMR	Change Grease and Lube Oil (if applicable)	Monthly
Wells	Visual Inspection	Daily	PMR	No Change	
	Change Motor Oil	Annually	PMR	No Change	
	-			Monitor Oil	Quarterly
Water Storage Reservoirs	Visual Inspection	Daily	WSP	No Change	
	Exterior Inspection[b]	Biannually	WSP	No Change	
	Interior Inspection[b]	Every 5 Years	WSP	Interior Inspection and Recoat	Every 5 Years
Backflow Assemblies	Test	Annually	WSP	No Change	
Distribution System Piping	Flush Distribution Mains[c]	Biennially (Every 2 Years)	WSP	No Change	
	Flush Dead-End Distribution Mains[c]	Annually	WSP	No Change	
Distribution System Valves	Exercise and Inspection[d]	Biannually	WSP	Exercise and Inspect	Annually
Chemical Metering Pumps, Disinfectant Reservoirs	Visual Inspection	Daily	WSP	No Change	
	-			Calibrate	Daily
Chlorine Analyzers	Service and Calibrate[e]	Annually	PMR	Service	Monthly
				Calibrate	Weekly
Hydrants	Exercise and Flow Test[c]	Annually	O&M	No Change	
Generators	Test	Monthly	PMR	No Change	
	Service and Inspection[e]	Annually	PMR	No Change	
Distribution/Well Flow Meters	Calibrate[e]	Annually	PMR	No Change	
	-			Visually Inspect	Daily
Fire Extinguishers	Inspect and Sign Tag	Monthly	PMR	No Change	
	Service[e]	Annually	PMR	No Change	
Eye Wash Stations	Inspect, Test, Flush, and Clean Eye Ports	Monthly	PMR	Test to Verify Flow	Weekly
	-			Performance Inspection	Annually

(a) Sources: Division of Drinking Water Water Supply Permit (WSP); City Operations and Maintenance Manual (O&M); Severn Trent Preventative Maintenance Records (PMR).
(b) Reservoir inspection procedures are documented in the report below.
(c) Distribution system flushing and hydrant exercising programs have been put on hold since 2014 to conserve water due to drought conditions. If there are water quality complaints or degradation on dead-end mains, these mains can be flushed as needed.
(d) Severn Trent has developed a schedule to perform valve exercising and inspection biannually. This schedule is currently under City review before implementation.
(e) Preventative maintenance provided by third-party: Cummins Pacific (generators), Calcon Systems (flow meters and chlorine analyzers), and Code Three (fire extinguishers)

Severn Trent's reservoir exterior and interior inspections involve visual inspection of the following:

Exterior Reservoir Inspections

- protective coatings and paint
- vents, overflow pipes, and drain pipe covers and screening
- facility security, condition of access ladder and tank entries
- condition of staff gauges
- floating surface water material

Interior Reservoir Inspections

- protective coatings and paint
- interior ladder
- overflow pipes
- cathodic protection system
- support columns
- flow-to-wall seams
- overall condition of the facility

9.6.2 Increased Preventative Maintenance and Corrective Maintenance Recommendations

In addition to the Existing Preventative Maintenance Schedule shown above, West Yost recommends the additional preventative maintenance and corrective maintenance activities listed in Table 9-16.

9.7 REHABILITATION AND REPLACEMENT PROGRAM

This section describes the City's existing program for rehabilitation and replacement of water system components and presents an optimized program based on the risk levels determined in Section 9.5.

9.7.1 Existing Rehabilitation and Replacement Program

The City is currently rehabilitating or replacing water system components on an as-needed basis as individual problems arise. The City recently rehabilitated the Watson Ranch storage tank in a proactive manner.

9.7.2 Optimized Rehabilitation and Replacement Program

Any pump station assets that require rehabilitation or replacement in the near- or long-term were developed into improvement projects by facility. The City expressed interest in packaging improvements by facility (rather than by type of improvement such as SCADA upgrades that would be completed at all pump stations under one contract) because it provides the City with the most operational flexibility with only a single facility out of service at one time.

Table 9-16. Recommendations for More Frequent Maintenance Observations

Facility Name	Asset	Component Risk	Recommended Preventative/Corrective Maintenance Action
School Well	WT-SW-CHT-01, Sodium Hypochlorite Storage Tank	High	Replace leaking chlorine (hypochlorite) transmission tubing material with hypochlorite-compatible material.
	WT-SW-FIT-01, Well Flow Meter	High	Replace with new unit to improve both accuracy and reliability.
	WT-SW-GNR-01, Backup Generator	Med-High	Replace with National Electric Code-compliant unit.
Industrial	WT-FZ-FIT-01, Well Flow Meter	High	Replace with new unit to improve both accuracy and reliability.
	WT-FZ-GNR-01, Backup Generator	High	Replace with National Electric Code-compliant unit.
	WY-WT-ID-BLD-02, Chlorine Pump Building	Medium	Replace existing structure with code-compliant enclosure.
Watson Ranch	WT-WR-WLP-01, Well Pump	High	Repair broken pump anchor bolt. Replace pump as soon as possible.
	WY-WT-WR-CLR-01, Chlorine Injector	High	Replace chlorine (hypochlorite) delivery pipeline and injector when other chlorine system improvements are scheduled.
	WT-WR-DBP-23, Booster Pump 2-3	Medium	Check pump-motor joint gasket. Repair protective coating system at damaged areas on pump and motor
Fitzgerald	WY-WT-FZ-BPM-02, Booster Pump 2 Motor	Medium	Repair protective coating system at damaged areas on pump and motor.
	WT-FZ-DBP-02, Booster Pump 2	Medium	Identify leak pathway, and repair both corrosion damage and coating system at damaged areas on pump and motor.
	WT-FZ-DBP-03, Booster Pump 3	Medium	Repair protective coating system at damaged areas on pump and motor.
	WY-WT-FZ-BPM-03, Booster Pump 3 Motor	Medium	Repair protective coating system at damaged areas on pump and motor.
Park Lane	WT-PL-DBP-05, Booster Pump 5	Medium	Repair protective coating system at damaged areas on pump and motor.
	WY-WT-PL-WLM-01, Well Pump Motor	Medium	Clean pump motor and enclosure; monitor motor for oil leakage; and repair leaking seals, gaskets, or other oil leaks, if applicable.
All Facilities	Floor drains in chlorine storage tank rooms and chlorine analyzer rooms	N/A	Determine the location of drainage. Perform corrective action, if applicable, to direct drainage to sanitary sewer.
	Booster Pumps	varies	Vertical orientation of the horizontal split-case booster pumps may lead to increased wear on the bearings - monitor and replace as needed.

Pipeline rehabilitation and replacement is typically identified in an on-going manner based on pipe age, material, history of leaks or a failure of a pipeline. The City's water system is fairly young with most of the system constructed since the 1970s with pipeline materials of ACP and polyvinylchloride PVC making up the majority of pipeline materials. AC pipeline makes up a small portion of the City's pipelines and has a useful life range between 50 to 80 years. PVC pipeline makes up a majority of the City's pipelines and has a useful life expectancy of up to 100 years, according to some studies. The City pipelines are in relatively good condition, as determined from the infrequent incidence of leaks. However, replacement of the AC pipelines is considered the main focus for the City's distribution pipeline rehabilitation and replacement program. The City has approximately 30,500 linear feet of AC pipeline in the system ranging from 4-inch to 12-inch diameter. It is assumed pipelines less than 8-inch diameter will be replaced with an 8-inch diameter pipeline. Replacement of all AC pipeline in the system is $5,238,000 assuming a cost of $20 per diameter-inch and that the existing AC pipeline is abandoned in place. These costs are spread out evenly for the first 10 years of the proposed CIP.

Distribution system valves are expected to wear faster than the PVC distribution piping, and will need to be replaced prior to the full pipe replacement. It is estimated that valves have a useful life expectancy of up to 30 years. Valves requiring replacement will be identified through the valve exercise program. The standard useful life has been used to project the capital improvement needs for distribution system valves.

Individual improvement projects have been developed for the next 10 years and are prioritized by facility criticality. Beyond 10 years, it is difficult to anticipate specific system needs. Capital projections for the 2028 to 2047 capital improvement programs used industry standard useful life estimates for each asset to develop a planning-level estimate of potential improvements.

The resulting 30-year rehabilitation and replacement program costs are shown in Table 9-17.

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Table 9-17. Recommended Rehabilitation and Replacement Program

Project Name	Cost (2016 Dollars)	Rehabilitation and Replacement Program (costs include 3% annual inflation) FY[a] 2017/18	FY 2018/19	FY 2019/20	FY 2020/21	FY 2021/22	FY 2022/23	FY 2023/24	FY 2024/25	FY 2025/26	FY 2026/27	FY 27/28 - FY 31/32	FY 32/33 - FY 36/37	FY 37/38 - FY 41/42	FY 42/43 - FY 46/47
10-Year Rehabilitation and Replacement Program															
Storage Tank Piping Seismic Upgrades	$180,000	$191,000	-	-	-	-	-	-	-	-	-	-	-	-	-
Arc Flash Study and Labeling	$31,500	$33,500	-	-	-	-	-	-	-	-	-	-	-	-	-
School Well Immediate Improvements	$409,200	$434,200	-	-	-	-	-	-	-	-	-	-	-	-	-
Industrial Electrical Upgrades	$547,200	$580,600	-	-	-	-	-	-	-	-	-	-	-	-	-
Fitzgerald VFD and Instrumentation Upgrades	$122,100	-	$133,500	-	-	-	-	-	-	-	-	-	-	-	-
Watson Ranch Well Improvements	$213,300	-	$233,100	-	-	-	-	-	-	-	-	-	-	-	-
Watson Ranch Well Replacement	$2,050,000	-	$2,240,100	-	-	-	-	-	-	-	-	-	-	-	-
Valley Glen Well Instrumentation Upgrades	$24,800	-	-	$28,000	-	-	-	-	-	-	-	-	-	-	-
Industrial Well and Hydropneumatic Tank Improvements	$490,700	-	-	$552,300	-	-	-	-	-	-	-	-	-	-	-
Industrial Well Replacement	$2,050,000	-	-	$2,307,300	-	-	-	-	-	-	-	-	-	-	-
School Well Site Upgrades	$518,200	-	-	-	$600,800	-	-	-	-	-	-	-	-	-	-
School Well Replacement	$3,280,000	-	-	-	$3,802,500	-	-	-	-	-	-	-	-	-	-
Park Lane VFD and Instrumentation Upgrades	$318,700	-	-	-	-	$380,600	-	-	-	-	-	-	-	-	-
Fitzgerald Electrical Upgrades	$346,700	-	-	-	-	-	$426,400	-	-	-	-	-	-	-	-
Valley Glen Electrical Upgrades	$507,500	-	-	-	-	-	-	$642,900	-	-	-	-	-	-	-
School Generator Replacements	$177,000	-	-	-	-	-	-	-	$231,000	-	-	-	-	-	-
Watson Ranch Miscellaneous Improvements	$226,500	-	-	-	-	-	-	-	$295,600	-	-	-	-	-	-
Park Lane Electrical Upgrades	$500,100	-	-	-	-	-	-	-	-	$672,100	-	-	-	-	-
Industrial Building Replacements	$131,000	-	-	-	-	-	-	-	-	-	$181,400	-	-	-	-
Fitzgerald Mechanical Replacements	$185,700	-	-	-	-	-	-	-	-	-	$257,100	-	-	-	-
Distribution System Asbestos Cement Pipe Replacement[b]	$4,805,240	$509,800	$525,100	$540,900	$557,100	$573,800	$591,000	$608,800	$627,000	$645,800	$665,200	-	-	-	-
Distribution System Appurtenance Replacements[c]	$56,214,600	$627,300	$1,104,900	$261,500	$754,300	$376,700	$429,000	$99,100	$418,100	$70,716,400	$65,000	-	-	-	-
30-year Rehabilitation and Replacement Program															
Well, Booster Pump, and Storage Facility Improvements	-	-	-	-	-	-	-	-	-	-	-	$4,820,000	$19,848,600	$9,536,000	$15,380,200
Distribution System Appurtenance Replacements[b]	-	-	-	-	-	-	-	-	-	-	-	$287,600	$2,687,300	$6,630,200	$4,687,700
Total		**$2,376,400**	**$4,236,700**	**$3,690,000**	**$5,714,700**	**$1,331,100**	**$1,446,400**	**$1,350,800**	**$1,571,700**	**$72,034,300**	**$1,168,700**	**$5,107,600**	**$22,535,900**	**$16,166,200**	**$20,067,900**

[a] Dates for rehabilitation and replacement program are represented as fiscal year (FY).

[b] AC pipe replacement costs assume the existing pipe will be abandoned in place. This replacement estimate includes all of the distribution system asbestos cement pipe except for 1,641 feet of 8-inch and 851 feet of 10-inch diameter pipe that will be upsized as part of CIP-320.

[c] Distribution system appurtenance replacements are projected based solely upon the expected useful life of the components. The actual replacement needs will be identified through the valve exercise program.

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CHAPTER 10
Capital Improvement Program

This chapter presents the recommended CIP for the City's existing and future water system. Recommendations for improvements to the existing and future water system were described previously in Chapters 7 and 8, respectively. This chapter provides a summary of the recommended improvement projects, along with estimates of probable construction costs. It should be noted that the recommended CIP only identifies improvements at a master plan level and does not constitute a design of such improvements. Subsequent detailed design is required to determine the exact sizes and locations of these proposed improvements.

Costs are presented in December 2016 dollars based on an Engineering News Record Construction Cost Index (ENR CCI) of 11,609 (San Francisco). Total CIP costs include the following design and construction contingency and project cost allowances:

- Design and Construction Contingency: 30 percent
- Project Cost Allowances:
  - Engineering, Administrative, and Legal: 25 percent
  - Environmental: 10 percent

A complete description of the assumptions used in developing the estimates of probable construction cost is provided in Appendix E.

10.1 RECOMMENDED EXISTING WATER SYSTEM IMPROVEMENTS

Chapter 7 provided a summary of the evaluation of the City's existing water system and its ability to meet the recommended operational and design criteria described in Chapter 5. Based on these results, the existing water system in the North/Core Zones is deficient in pumping capacity. Also, while not currently deficient in firm supply capacity, the City's North/Core Zone existing demands are close to the existing firm supply capacity. Therefore, it is recommended that the City begin evaluations of new supply alternatives, which would include an evaluation of how the new supply would be integrated into Cr(VI) treatment for groundwater and/or the feasibility of obtaining surface water supply through the North Bay Aqueduct Alternate Intake Project.

10.1.1 Existing Water System Improvements

The recommended CIP projects for the existing water system include the following:

- Pump Station
  - Add one new 1,000 gpm pump to the existing Fitzgerald Drive booster pump station to increase firm pumping capacity in the North/Core Zones. Review of actual as-built conditions is recommended to confirm that adequate space exists at the booster pump station.

The locations of the recommended existing water system improvements are shown on Figure 10-1.

10.1.2 Recommended Existing Water System CIP Costs

The recommended existing system projects are presented in Table 10-1, along with their probable construction costs. As shown, the existing system CIP cost is estimated to be approximately $93,000.

Table 10-1. Summary of Probable Construction Costs for Existing Water System CIP[a]

CIP ID	Reason for Improvement	Improvement Description	Estimated Construction Cost[b]	Capital Cost (includes mark-ups)[b,c]
Booster Pump Station Improvements				
CIP-100	Pumping Capacity Deficiency	1,000 gpm Pumping Capacity	$69,000	$93,000
			Subtotal	$93,000
			Total Existing System CIP	$93,000

(a) Costs shown are based on the December 2016 San Francisco ENR CCI of 11,609.
(b) Costs rounded to nearest $1,000. Costs include base construction costs plus 30 percent Design and Construction Contingency.
(c) Capital costs include mark-ups equal to 176 percent (Design and Construction contingency: 30 percent; Engineering, Administrative, and Legal: 25 percent; Environmental 10 percent).

10.2 RECOMMENDED FUTURE WATER SYSTEM IMPROVEMENTS

Chapter 8 provided a summary of the evaluation of the City's future water system for 2030 and buildout conditions and its ability to meet the recommended operational and design criteria described in Chapter 5. Based on these results, additional improvements to the future water system were recommended to maintain the City's criteria, as listed in the following section.

10.2.1 Improvements for 2030 Water System

The future system improvements for the 2030 system have been grouped into supply facility and new pipeline recommended CIP projects, and include the following:

- Supply Facility
  - New well in Southwest Dixon Specific Plan – 1,500 gpm
  - New well in Northeast Quadrant Specific Plan #1 – 1,500 gpm
- New Pipeline
  - 8-inch diameter pipeline – 1,900 feet
  - 10-inch diameter pipeline – 2,200 feet
  - 12-inch diameter pipeline – 42,200 feet
  - 14-inch diameter pipeline – 1,100 feet
  - 16-inch diameter pipeline – 13,400 feet

The locations of the recommended future 2030 water system improvements are shown on Figure 10-2 and detailed in Table 10-2.

10.2.2 Improvements for Buildout Water System

The future system improvements have been grouped into several recommended CIP projects, and include the following:

- Supply Facility
  - New well on eastside Sphere of Influence area – 1,500 gpm
  - New well Northeast Quadrant Specific Plan #2 – 1,500 gpm
- Storage Facility
  - New storage tank in Northeast Quadrant Specific Plan – 0.26 MG usable capacity (0.40 MG nominal)
- Pump Station
  - New pump station in Northeast Quadrant Specific Plan – 2,300 gpm total capacity (1,660 gpm firm capacity)
- New Pipeline
  - 12-inch diameter pipeline – 15,500 feet
  - 16-inch diameter pipeline – 16,800 feet

The locations of the recommended future buildout water system improvements are shown on Figure 10-3 and detailed in Table 10-3.

Table 10-2. Summary of Probable Construction Costs for 2030 Water System CIP[(a)]				
CIP ID	Reason for Improvement	Improvement Description	Estimated Construction Cost[(b)]	Capital Cost (includes mark-ups)[(b,c)]
Pipeline Improvements				
CIP-301	New Pipeline	2,100 feet of 12-inch pipe, 1,100 feet of 14-inch pipe	$501,000	$676,000
CIP-302	New Pipeline	4,700 feet of 12-inch pipe	$687,000	$928,000
CIP-303	New Pipeline	1,100 feet of 10-inch pipe, 3,500 feet of 12-inch pipe	$645,000	$871,000
CIP-304	New Pipeline	1,100 feet of 10-inch pipe, 3,000 feet of 12-inch pipe	$569,000	$768,000
CIP-305	New Pipeline	3,900 feet of 12-inch pipe	$575,000	$776,000
CIP-306	New Pipeline	2,400 feet of 12-inch pipe, 5,900 feet of 16-inch pipe	$1,478,000	$1,995,000
CIP-307	System Reliability	2,200 feet of 16-inch pipe	$936,000	$1,264,000
CIP-310	New Pipeline	4,500 feet of 12-inch pipe	$662,000	$894,000
CIP-311	New Pipeline	5,000 feet of 12-inch pipe	$733,000	$990,000
CIP-312	New Pipeline	5,300 feet of 16-inch pipe	$1,009,000	$1,362,000
CIP-313	New Pipeline	7,100 feet of 12-inch pipe	$1,046,000	$1,412,000
CIP-320	System Reliability	3,500 feet of 12-inch pipe	$514,000	$694,000
CIP-330	Development	1,900 feet of 8-inch pipe, 2,500 feet of 12-inch pipe	$564,000	$761,000
			Subtotal	$13,391,000
Groundwater Improvements[(d)]				
CIP-300	Supply Deficiency	1 new well, 1,500 gpm pumping capacity	$2,156,000	$2,910,000
CIP-325	Supply Deficiency	1 new well, 1,500 gpm pumping capacity	$2,156,000	$2,910,000
			Subtotal	$5,820,000
			Total 2030 Water System CIP	$19,211,000

(a) Costs shown are based on the December 2016 San Francisco ENR CCI of 11,609.
(b) Costs rounded to nearest $1,000. Costs include base construction costs plus 30 percent Design and Construction Contingency.
(c) Capital costs include mark-ups equal to 176 percent (Design and Construction Contingency: 30 percent; Engineering, Administrative, and Legal: 25 percent; Environmental 10 percent).
(d) Cost includes the installation of a backup generator for emergency conditions.

Table 10-3. Summary of Probable Construction Costs for Buildout Water System CIP[a]

CIP ID	Reason for Improvement	Improvement Description	Estimated Construction Cost[b]	Capital Cost (includes mark-ups)[b,c]
Pipeline Improvements				
CIP-500	New Pipeline	10,600 feet of 16-inch pipe	$2,019,000	$2,725,000
CIP-501	New Pipeline	5,200 feet of 16-inch pipe	$987,000	$1,332,000
CIP-503	New Pipeline	1,000 feet of 16-inch pipe	$884,000	$1,193,000
CIP-511	New Pipeline	2,600 feet of 12-inch pipe	$747,000	$1,008,000
CIP-512	New Pipeline	1,800 feet of 12-inch pipe	$456,000	$615,000
CIP-513	System Reliability	7,100 feet of 12-inch pipe	$1,378,000	$1,860,000
CIP-514	New Pipeline	3,500 feet of 12-inch pipe	$874,000	$1,180,000
CIP-520	New Pipeline	500 feet of 12-inch pipe	$77,000	$104,000
			Subtotal	$10,017,000
Booster Pump Station Improvements				
CIP-527	Pumping Capacity Deficiency	2,300 gpm total pumping capacity (1,660 gpm firm capacity)	$2,671,000	$3,606,000
			Subtotal	$3,606,000
Groundwater Improvements[d]				
CIP-505	Supply Deficiency	1 new well, 1,500 gpm pumping capacity	$2,156,000	$2,910,000
CIP-525	Supply Deficiency	1 new well, 1,500 gpm pumping capacity	$2,156,000	$2,910,000
			Subtotal	$5,820,000
Storage Improvements				
CIP-526	Storage Deficiency	1 new tank	$1,560,000	$2,106,000
			Subtotal	$2,106,000
			Total Buildout System CIP	$21,549,000

(e) Costs shown are based on the December 2016 San Francisco ENR CCI of 11,609.
(f) Costs rounded to nearest $1,000. Costs include base construction costs plus 30 percent Design and Construction Contingency.
(g) Capital costs include mark-ups equal to 176 percent (Design and Construction Contingency: 30 percent; Engineering, Administrative, and Legal: 25 percent; Environmental 10 percent).
(h) Cost includes the installation of a backup generator for emergency conditions.

10.2.3 Recommended Future Water System CIP Costs

The recommended 2030 and buildout water system projects are presented in Table 10-2 and Table 10-3, respectively, along with their probable construction costs. As shown, the CIP costs are estimated to be approximately $19.2 million for the 2030 water system improvements and $21.5 million for the buildout water system improvements.

10.3 RENEWAL AND REPLACEMENT PROGRAM IMPROVEMENTS

The strategic asset management plan, presented in Chapter 9, reviewed the condition of existing water system facilities and recommended a renewal and replacement program based on the existing condition and life expectancy of the City's existing water system facilities. The renewal and replacement projects are discussed in detail in Chapter 9. Table 9-17 provides the estimated cost for the recommended renewal and replacement program.

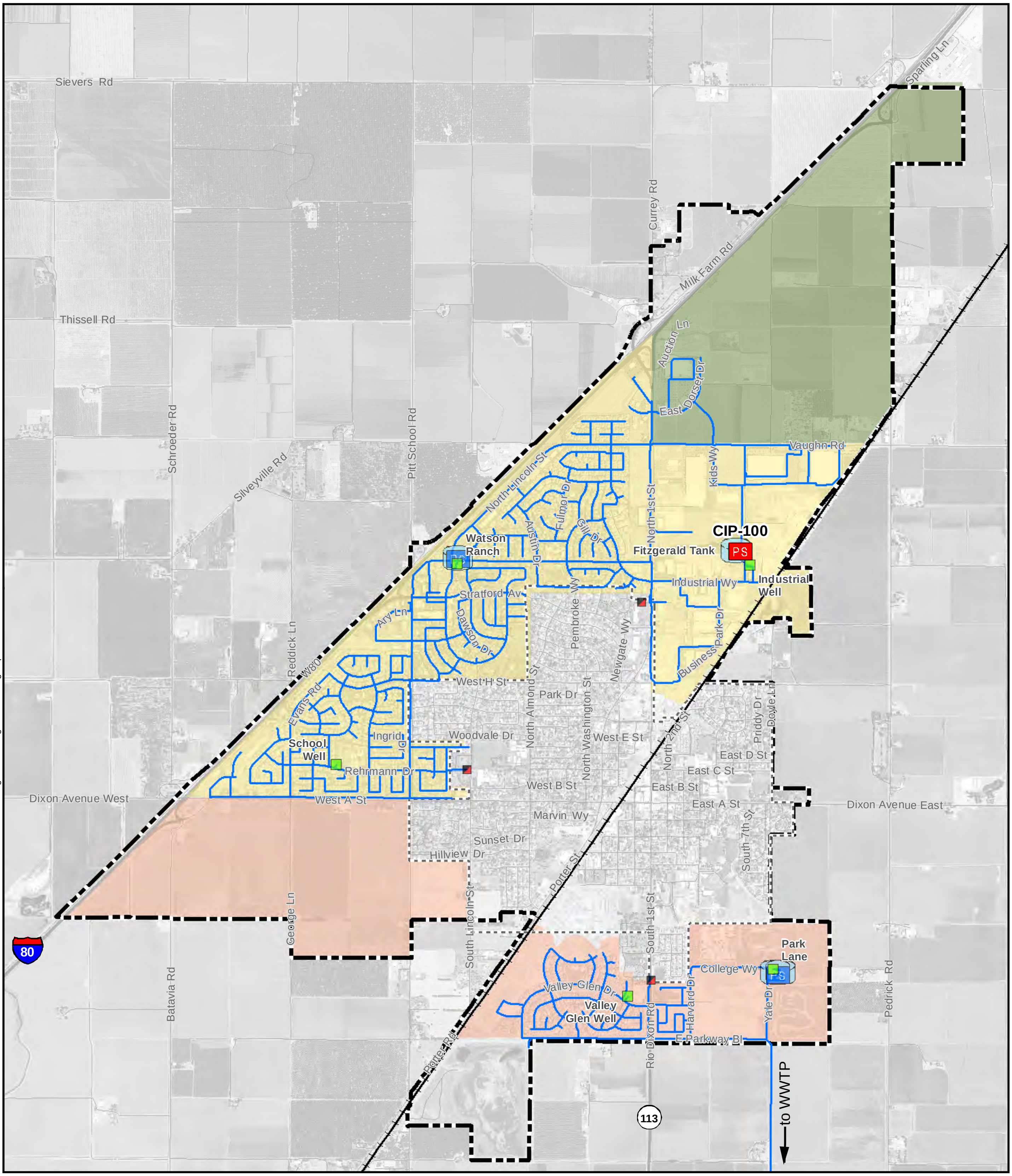
10.4 CAPITAL IMPROVEMENT PROGRAM IMPLEMENTATION

As shown in Table 10-4, several improvement projects have been recommended for the 2030 and buildout water system. The construction of the improvements for the future water system should be coordinated with the proposed schedules of future development to ensure that the required infrastructure will be in place to serve future customers.

Table 10-4. Summary of Recommended Water System CIP Cost[a,b]

Improvement Type	Existing System	2030 System	Buildout System	Total Capital Cost
Pipeline		$13,391,000	$10,017,000	$23,408,000
Booster Pump Station	$93,000		$3,606,000	$3,699,000
Supply		$5,820,000	$5,820,000	$11,640,000
Storage			$2,106,000	$2,106,000
Total	$93,000	$19,211,000	$21,549,000	$40,853,000

(a) Costs shown are based on the December 2016 San Francisco ENR CCI of 11,609.
(b) Capital costs include mark-ups equal to 176 percent (Design and Construction contingency: 30 percent; Engineering, Administrative, and Legal: 25 percent; Environmental 10 percent).



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Symbology

Existing Facilities

- Well
- PS Booster Pump Station
- Tank
- Emergency Intertie
- Existing Pipelines

Proposed Pump

- PS Proposed Pump

N

0 1,500 3,000

Scale in Feet

WEST YOST ASSOCIATES

Figure 10-1

Existing Water System Improvements

City of Dixon
Water System Master Plan and Hydraulic Model Update

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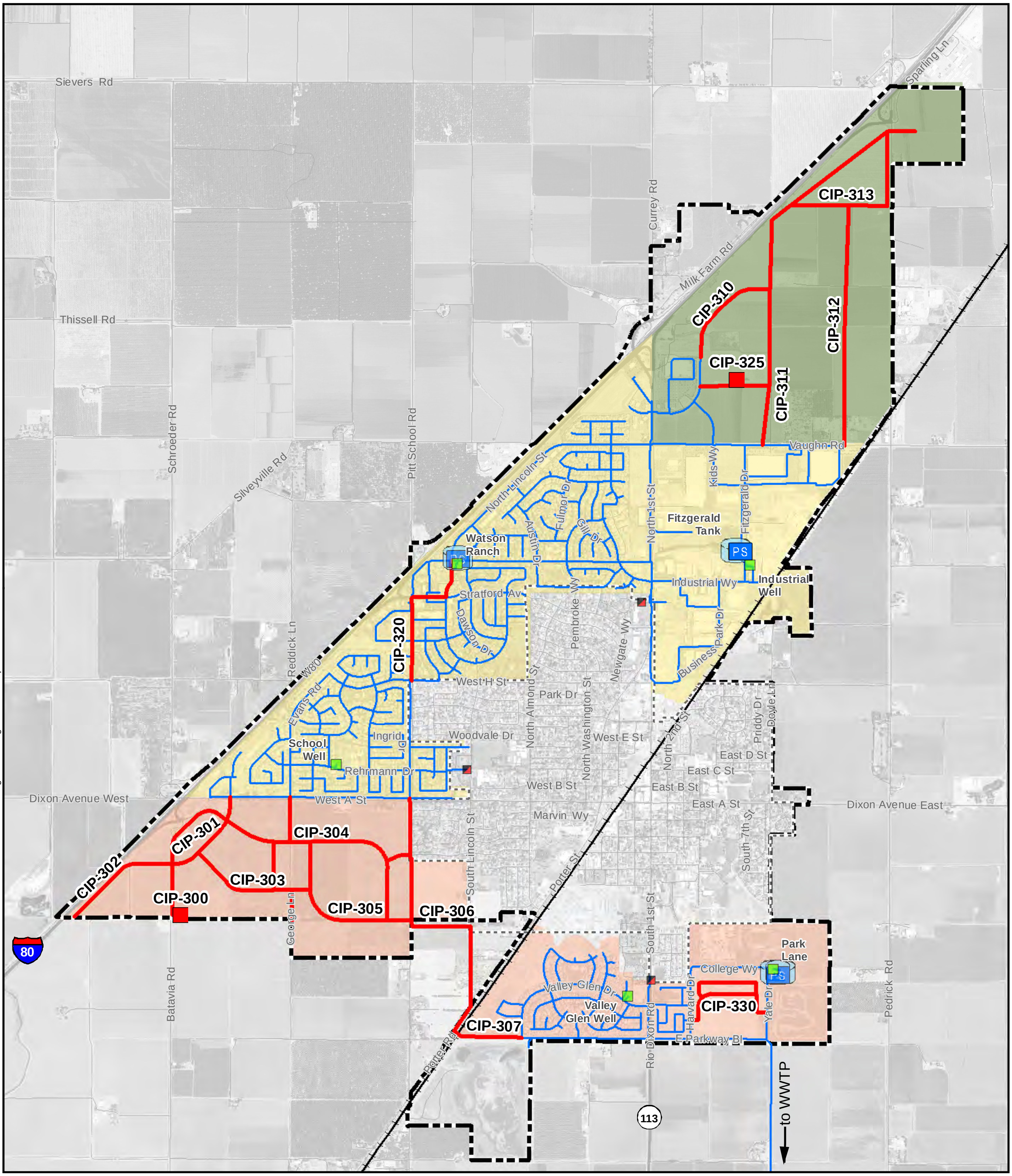

Symbology

Existing Facilities

- Well
- Booster Pump Station
- Tank
- Emergency Intertie
- Existing Pipelines

Proposed Facilities

- Proposed Well
- Proposed Pipeline

N

0 1,500 3,000

Scale in Feet

DIXON CALIFORNIA

WEST YOST ASSOCIATES

Figure 10-2

2030 Water System Improvements

City of Dixon
Water System Master Plan and
Hydraulic Model Update

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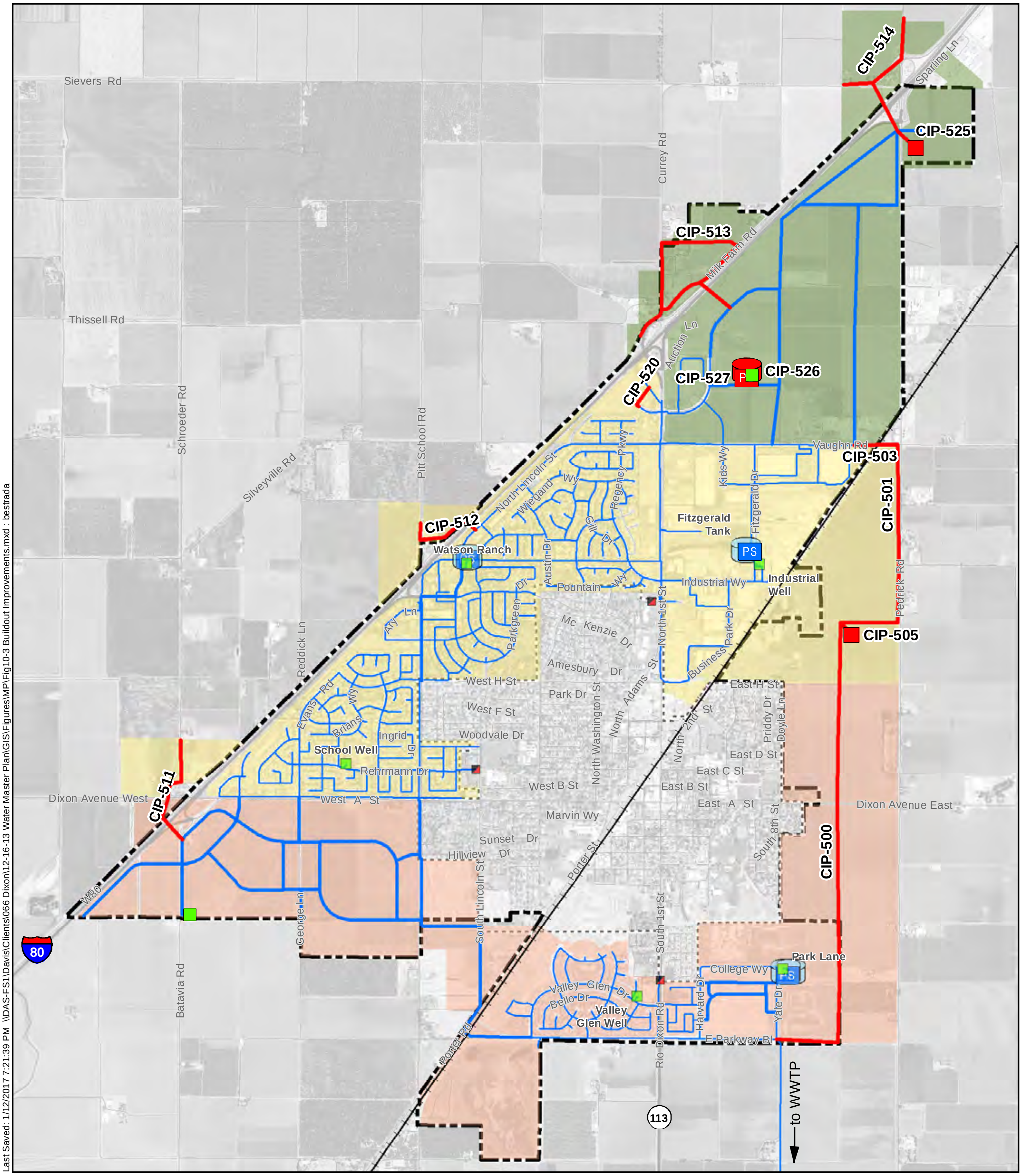

Symbology

Existing Facilities

- Well
- PS Booster Pump Station
- Tank
- Emergency Intertie
- Existing Pipelines

Proposed Facilities

- Proposed Well
- PS Proposed Pump Station
- Proposed Tank
- Proposed Pipeline

N

0 1,500 3,000

Scale in Feet

WEST YOST ASSOCIATES

Figure 10-3

Buildout Water System Improvements

City of Dixon
Water System Master Plan and
Hydraulic Model Update

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