WATER DISTRIBUTION SYSTEM EVALUATION

CITY OF SOLVANG
CALIFORNIA

FEBRUARY 22, 2008

STETSON ENGINEERS INC.

WATER RESOURCE PROFESSIONALS
SERVING CLIENTS SINCE 1957

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1.0 INTRODUCTION

The purpose of this evaluation study is to assess hydraulic capacity, system pressure and fire flow capabilities throughout the City of Solvang's (Solvang) water transmission and distribution system. Previously, Solvang had a water system model prepared using WaterCAD software. The WaterCAD model was last calibrated by Penfield and Smith in April 2004. The model and other calculations will be tools used to evaluate the water distribution system and identify system deficiencies. The model was developed to represent all water mains, groundwater and booster pumps, valves between pressure zones, storage reservoirs, groundwater wells, state project water supply, and water demands.

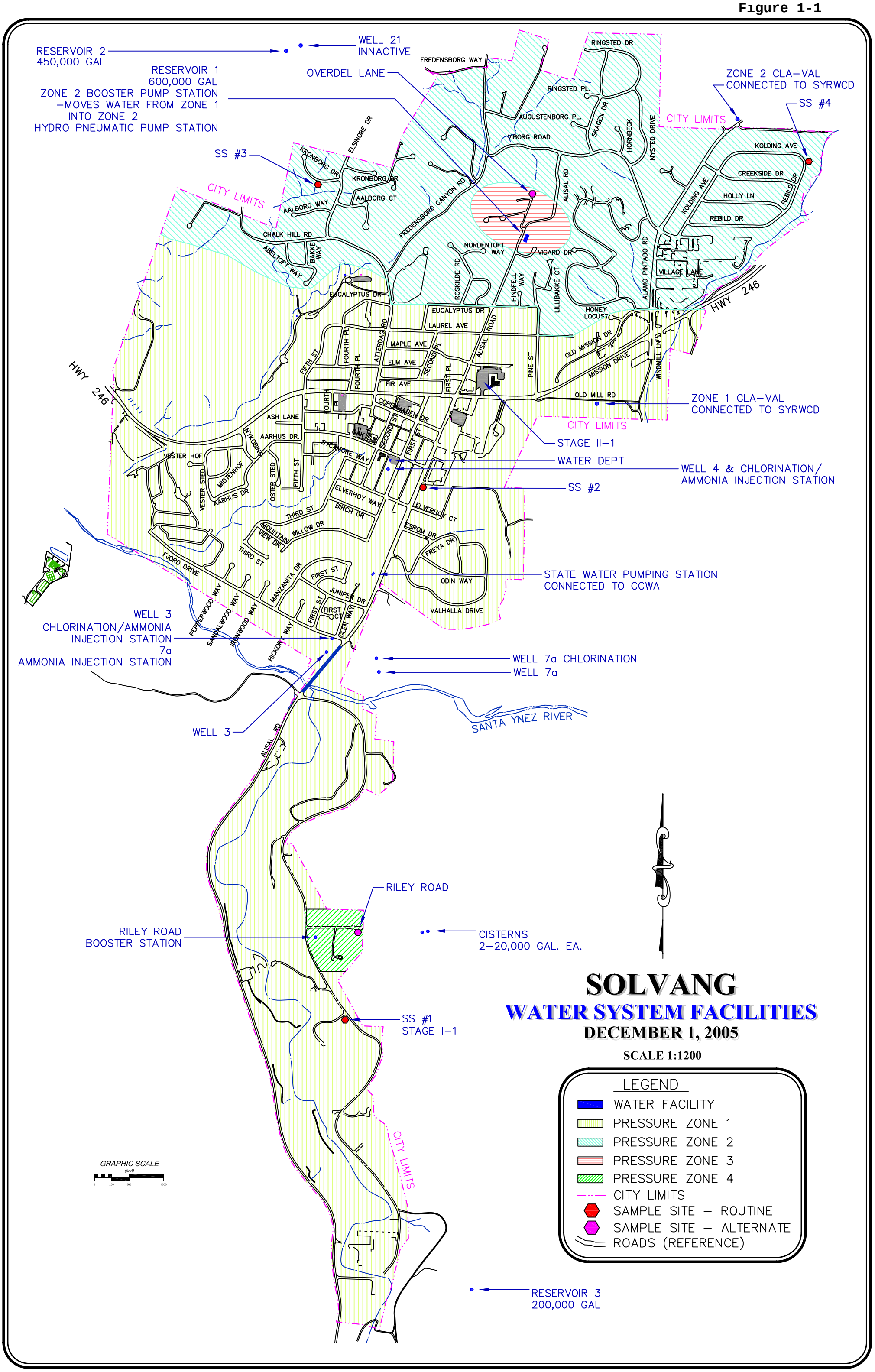
The following is a summary of the findings. With a few exceptions, the existing distribution system meets pressure and fire flow requirements during the worst case, no power, scenarios.

1.1 Description of Service Area

The City of Solvang covers approximately 2.5 square miles in the Santa Ynez Valley of Santa Barbara County. As of the end of 2007, the City's Water Department serves a population of approximately 5,434 through 1,948 service connections. The boundaries of the Solvang Water System are shown on Figure 1-1.

Solvang currently derives its water supply from 3 operable groundwater wells (3, 4, and 7A) and one State Water Project diversion, the Glen Way Pump Station. The water supply is produced from the Santa Ynez River uplands groundwater basin, Santa Ynez River alluvium groundwater and State Water Project water. Solvang receives well water and State Water Project water, or a combination of the two sources, at various points in Zone 1 of its water distribution system.

Figure 1-1


RESERVOIR 2
450,000 GAL
WELL 21
INNACTIVE
RESERVOIR 1
600,000 GAL
ZONE 2 BOOSTER PUMP STATION
–MOVES WATER FROM ZONE 1
INTO ZONE 2
HYDRO PNEUMATIC PUMP STATION
OVERDEL LANE
ZONE 2 CLA–VAL
CONNECTED TO SYRWCD
SS #4
SS #3
CITY LIMITS
HWY 246
ZONE 1 CLA–VAL
CONNECTED TO SYRWCD
STAGE II–1
WATER DEPT
WELL 4 & CHLORINATION/
AMMONIA INJECTION STATION
SS #2
STATE WATER PUMPING STATION
CONNECTED TO CCWA
WELL 3
CHLORINATION/AMMONIA
INJECTION STATION
7a
AMMONIA INJECTION STATION
WELL 7a CHLORINATION
WELL 7a
SANTA YNEZ RIVER
WELL 3
RILEY ROAD
RILEY ROAD
BOOSTER STATION
CISTERNS
2–20,000 GAL. EA.
SS #1
STAGE I–1
RESERVOIR 3
200,000 GAL
GRAPHIC SCALE
(feet)
SOLVANG
WATER SYSTEM FACILITIES
DECEMBER 1, 2005
SCALE 1:1200
LEGEND
WATER FACILITY
PRESSURE ZONE 1
PRESSURE ZONE 2
PRESSURE ZONE 3
PRESSURE ZONE 4
CITY LIMITS
SAMPLE SITE – ROUTINE
SAMPLE SITE – ALTERNATE
ROADS (REFERENCE)

There are four separate pressure zones currently in use in Solvang's service area; two main zones (1 and 2) and two sub-zones (3 and 4). The pressure zones are also noted on Figure 1-1. Solvang's Water System is shown schematically in Figure 1-2. Ground elevations within Solvang's service area range from about 390 feet to 760 feet above Mean Sea Level (MSL), with the highest elevations located in the northern portions of the service area. Pressure zone boundaries are established to maintain acceptable distribution system pressures.

Zone 1 pressure zone is the largest zone geographically and covers roughly the area south of Eucalyptus Drive. It receives water from the Glen Way State Water Project Pump Station and wells 3, 4, and 7A. The Zone 1 distribution area pressure is regulated by the water level in both Reservoirs 1 and 3.

Zone 2 is north of Zone 1 and receives water from Zone 1 via the Zone 2 booster pumps (Z2BP). Well 21, which is currently inactive, previously also fed water to Zone 2. The Zone 2 distribution area pressure is regulated by the water level in Zone 2 reservoir.

Zone 3 is a subzone of Zone 2. Zone 3 receives water from Zone 1 via the Zone 2 booster pumps and hydropneumatic tank. Zone 3 pressure is regulated by the 5,000 gallon hydropneumatic tank located adjacent to the Zone 2 Booster Pump Station.

Zone 4 is a subzone of Zone 1 and serves approximately 20 homes on Riley Road which are above Reservoir 3. Zone 4 receives water from Zone 1 via the Riley Road Pump Station. Zone 4 pressure is regulated by two 20,000 gallon cisterns located above the east end of Riley Road.

1.2 Description of Water Distribution Facilities

Water distribution facilities consist of water supply wells, storage reservoirs, pipelines and booster pumps.

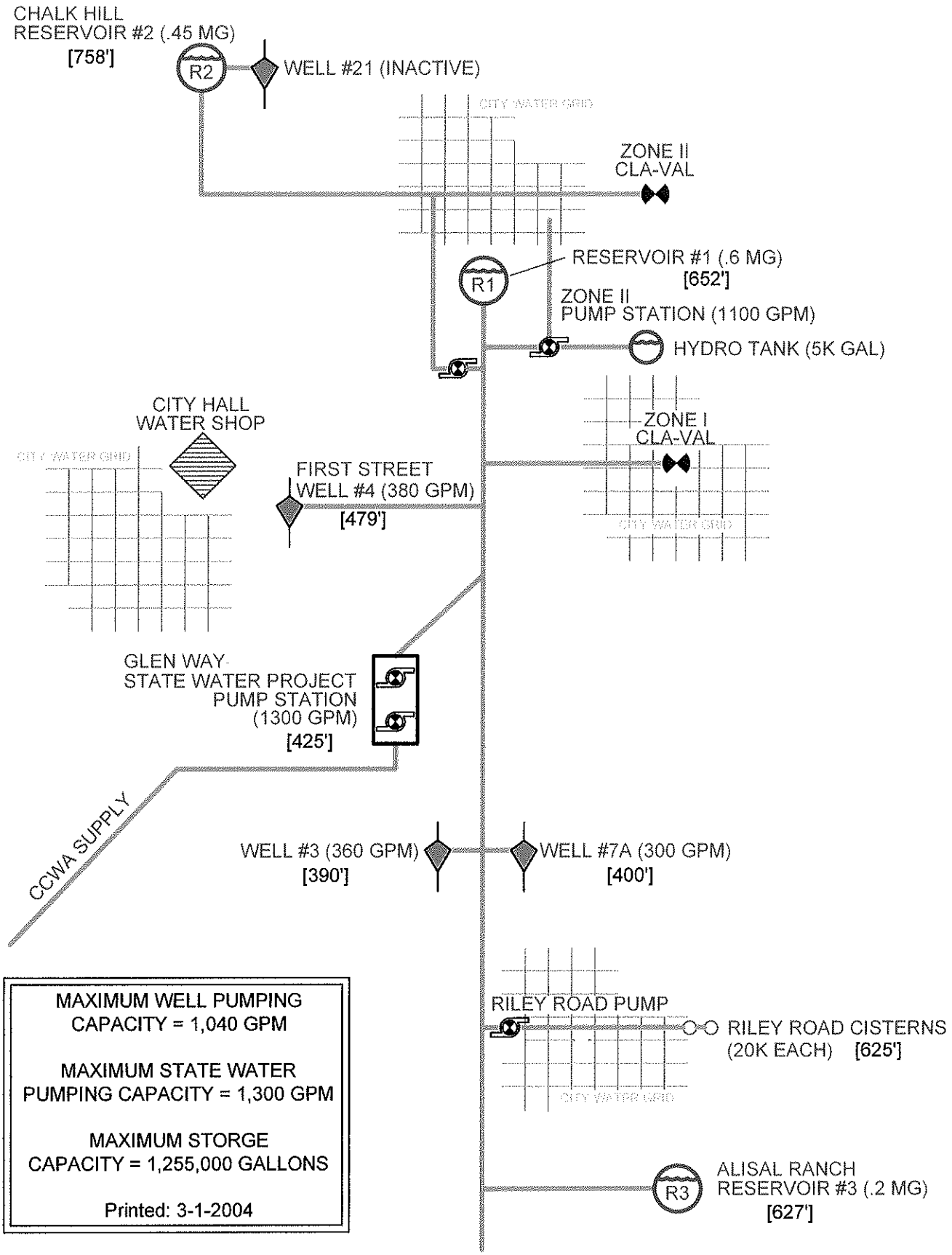
1.2.1 Water Supply

The Solvang Water System receives its potable water from three groundwater wells and a State Water Project Pump Station. The three wells operated by Solvang are Well 3 which currently produces 360 gallons per minute (gpm), Well 4 which currently produces 380 gpm, and Well 7A which currently produces 300 gpm. Solvang also has an inactive Well 21. Solvang's groundwater production capacity is 1,040 gpm.

Under the State Water Project Contract Solvang is allowed to take up to 125 acre-feet (AF) of water per month which is an average flow rate of 912 gpm. Currently Solvang uses up to 170 AF per month during the summer months. Once the project is at build-out Solvang will be held to the 125 AF per month limit.

Figure 1-2

Solvang
Water System Schematic



MAXIMUM WELL PUMPING CAPACITY = 1,040 GPM

MAXIMUM STATE WATER PUMPING CAPACITY = 1,300 GPM

MAXIMUM STORGE CAPACITY = 1,255,000 GALLONS

Printed: 3-1-2004

The maximum flow from the State Water Project Pump Station to the Solvang system is 1,300 gpm and the low flow is 150 gpm. Maximum flows cannot be achieved when Santa Ynez is using all of their pumps at the Mesa Verde Pump Station, and Central Coast Water Authority (CCWA) is pumping to the lake.

Flows from the State Water Project Pump Station to the Solvang system are constant for 24-hour periods. Flow changes require a 24 hour notice. Without having the ability to vary the flows through out the day, Solvang's operators have to allow storage space in the reservoirs to hold excess water during off peak times. This condition requires constant monitoring of the system to make the necessary changes to the system to keep up with demand or the lack of demand.

Pressure Zone 1 floats on flow from the State Water Project Pump Station. During times of high demand, if a reservoir level falls below the low level set point, the wells will be operated to help keep up with the demand. The wells continue operation until the reservoir reaches the high level set point.

1.2.2 Storage

The Solvang system has several reservoirs which provide storage and maintain pressure for each of the pressure zones. Pressure Zone 1 has two reservoirs. Reservoir 1 is located adjacent to Alisal Road and Vigard Drive and has a capacity of approximately 600,000 gallons. Reservoir 1 was completed in 1988. Reservoir 3 is located in the southern end of Pressure Zone 1 and has a capacity of approximately 200,000 gallons. Reservoir 3 was constructed in 1963 and recoated in 1996. Pressure Zone 2 has a single reservoir with a capacity of approximately 450,000 gallons; Reservoir 2 is located off of Chalk Hill Road. Reservoir 2 was installed in 1982. Pressure Zone 3, which is a sub zone of Zone 2, has a 5,000 gallon hydropneumatic tank that maintains the zone's pressure. The hydro tank was installed with the construction of Reservoir 1 in 1988. Pressure Zone 4 has two 20,000 gallon cisterns located east of Riley Road. These cisterns maintain system pressure for approximately 20 residences on Riley Road which are above the level of Reservoirs 1 and 3. The cisterns were installed in 1963.

The total storage capacity of the Solvang system is 1,295,000 gallons. The system operators maintain the reservoirs at approximately three - quarters full to provide storage for excess State Project water during off-peak times.

1.2.3 Pipelines

The majority of the pipelines within the Solvang system are made of asbestos-concrete (AC). Staff estimates that 90 percent of all pipelines within the system are AC pipelines. The

remaining pipelines are ductile iron (approximately 4 percent) and C-900 PVC (approximately 6 percent). The AC pipe is estimated to be 30 to 40 years old. The ductile iron pipe is approximately 20 years old and PVC was first installed in the system at least 20 years ago. Pipeline information from the WaterCAD model is summarized in Table 1-1.

Table 1-1
Pipelines

Material	Length (ft)	Percentage
Asbestos Cement [1)]	143,097	80%
Ductile iron	11,562	6%
Galvanized iron	1,333	1%
PVC	22,934	13%
Steel	161	0%
Total	179,086	100%

1) Penfield and Smith assumed asbestos cement pipe in situations where the pipe material was unknown.

The pipe sizes within the system vary from 4-inch to 16-inch. Solvang's system has a pressure limitation of 125 psi. A summary of the pipe sizes and lengths according to the WaterCAD model are summarized in Table 1-2.

Table 1-2
Pipe Size and Length

Diameter (in)	Length (ft)	Percentage
2	1,128	1%
4	2,926	2%
6	78,643	44%
8	69,065	39%
10	13,307	7%
12	13,130	7%
16	841	0%
48	47	0%
Total	179,086	100%

1.2.4 Booster Pumps

The Zone 2 Booster Pump Station lifts water from Zone 1 to Zone 2 at a flow rate of either 600 or 1,100 gpm. The Zone 2 Booster Pumps also convey water to the Zone 3 hydropneumatic tank. The Zone 2 Pump Station operation is tied to the level in Reservoir 2. When the level in

Reservoir 2 falls below the low level set point, the booster pumps begin operation. The pumps will shut down when the level in Reservoir 2 reaches the high level set point.

The two Riley Road cisterns are fed by a 5 horsepower pump. The pump is controlled by the level in the cisterns similar in operation to Reservoir 2.

1.3 Water Distribution System Evaluation Criteria

The performance of a finished water distribution system is judged by its ability to deliver the required flows while maintaining desirable pressures and water quality. Customer demands and fire-fighting needs must be met. Meeting these requirements depends upon the proper design and performance of distribution and transmission piping, storage reservoirs, booster pumps, and regulating valves.

Design guidelines for transmission and distribution vary from state to state and from utility to utility. The American Water Works Association (AWWA) provides some guidelines and many states regulate certain performance criteria. Also, the Insurance Service Office (ISO) sets standards for fire flow requirements for individual structures within a service area. However, design criteria are often left to the discretion of the water utility. It was assumed that Solvang uses the July 2003 published fire flow rates from the Santa Barbara County Fire Department and a commercial fire flow rate of 1,250 gpm used by ID1.

To evaluate the performance of the existing transmission and distribution system and to plan conservatively for future growth while maintaining system reliability, the guidelines presented in Table 1-3 were used as performance criteria for transmission and distribution mains for the water system evaluation.

Table 1-3
Design Guidelines for Transmission and Distribution Mains

Parameter	Criteria	Comment
Minimum Pressure	20 psi	Peak Hour Demand without Fire Flow
Pipe Velocity	< 5 feet per second	AWWA Standard
Fire Flow	500 gpm to 1,250 gpm	See Table 1-4

1.3.1 Fire Flow Requirements

The Santa Barbara County Fire Department requires that water systems be designed to provide certain fire flows for specific durations. Fire flows range from 500 to 1,250 gpm depending on the type of land use. Table 1-4 presents the typical fire flows and their durations for different types of land use.

Table 1-4
Fire Flow Requirements

Land Use	Hydrant Flow Rate (GPM)	Duration (HOURS)	Minimum Pressure (PSI)
Rural 5 to 10 Acres [1]	500	2	20
Urban & Rural Developed Neighborhood [1]	750	2	20
Rural Residential [2]	750	2	20
Residential [2]	750	2	20
Agricultural [2]	750	2	20
Extreme High Fire Hazard Area [1]	1,000	2	20
Commercial [3]	1,250	2	20

[1] *Santa Barbara County Fire Department, Fire Protection Division – 7/1/03 for Hydrant flow rates only for buildings less than 3,600 sf.*

[2] *Assumed the same building size as urban & rural developed neighborhood.*

[3] *Commercial fire flow rate used by ID1*

1.3.2 Fire Hydrants

Fire hydrants shall be provided for the protection of buildings constructed within the Solvang service area. Fire hydrants shall be located along required apparatus access roads and adjacent public streets. According to the Uniform Fire Code, the minimum number of fire hydrants shall be based on a 500-foot maximum spacing for residential and rural residential areas, 450-foot maximum spacing for commercial, and 350-foot maximum spacing for industrial areas (Uniform Fire Code, 1997). Determination of fire hydrant spacing was not performed as part of this study. Pipe intersections, also called model nodes, were used in the analysis to represent the closest fire hydrant. The WaterCAD model does not have fire hydrant locations identified.

2.0 WATER DEMAND

The purpose of this section is to present current water demands for Solvang's service area.

2.1 Water Requirements

Water utilities, including Solvang, must be able to supply water at rates that fluctuate over a wide range. Yearly, monthly, daily, and hourly variations in water use occur, with higher use during dry years and in hot months. Also, water use typically follows a diurnal pattern, being low at night and peaking in the early morning and late afternoon. Water demands most important to the hydraulic design and operation of the distribution system are average day demand, maximum day demand, and maximum hour demand.

Average day use is the total annual water use divided by the number of days in the year. The average day rate is used primarily as a basis for estimating maximum day and maximum hour demands. The average day rate is also used to estimate future revenues and operating costs.

Maximum day use is the maximum quantity of water used on any one day of the year. The maximum day rate is used to size water supply hydraulics, treatment facilities, and pumping stations. The water supply facilities must be adequate to supply water at the maximum day rate.

Maximum hour use is the peak rate at which water is required during any one hour of the year. Since minimum distribution system pressures are usually experienced during maximum hour, the sizes and locations of distribution facilities are generally determined on the basis of this condition. Maximum hour water requirements are partially met through the use of strategically located system storage. The use of system storage minimizes the required capacity of transmission mains and permits a more uniform and economical operation of the water supply, treatment, and pumping facilities.

2.2 Water Production and Use

The purpose of this subsection is to present historical water production, water use for each sector, water system losses, and climate characteristics.

2.2.1 Historical Water Production

Solvang currently derives its water supply from three active wells and one pump station from the State Water Project (SWP). The groundwater supply is produced from both the Santa Ynez River Uplands groundwater basin and the Santa Ynez River alluvium aquifer. Solvang receives

well water and SWP water or a combination of the two sources at various points within Pressure Zone 1 of its water distribution system.

Monthly water production data received from Solvang for the years 2000 through 2007 is compiled in Table 2-1. Table 2-1 summarizes monthly and annual water production for the years 2000 through 2007. The data indicate that historical annual water production for the 8 year period ranged from 1,454 to 1,677 acre-feet (AF). Average annual water production was 1,528 AF. The maximum monthly water production ranged from 176.2 AF to 202.5 AF and occurred in either July, August or September.

Table 2-1
Historical Water Production
(acre-feet)

	2007	2006	2005	2004	2003	2002	2001	2000
January	91.3	72.8	53.8	78.5	79.3	69.5	78.6	94.1
February	66.5	83.9	65.9	74.0	70.3	83.1	59.6	68.9
March	108.6	64.8	70.8	106.1	84.3	103.0	81.3	87.2
April	127.9	66.3	104.4	144.9	102.2	136.8	119.1	116.0
May	160.6	122.2	133.1	169.2	124.1	135.1	152.3	152.4
June	172.7	166.5	156.2	176.3	158.1	143.7	175.0	173.0
July	196.4	196.1	184.2	191.5	170.0	155.9	185.0	181.3
August	202.5	190.0	190.0	189.6	166.5	177.4	182.0	189.7
September	173.2	170.0	163.6	168.6	176.2	175.3	166.0	166.2
October	146.9	143.2	139.5	116.8	155.2	145.6	146.0	128.8
November	131.5	127.6	104.6	79.4	86.8	114.7	85.6	97.6
December	98.7	86.5	87.9	80.5	81.3	76.2	67.2	100.4
Annual Demand	1,676.8	1,490.5	1,454.0	1,576.0	1,454.8	1,517.0	1,497.7	1,555.8
Maximum Month	202.5	196.1	190.0	191.5	176.2	177.4	185.0	189.7
Average Day	4.6	4.1	4.0	4.3	4.0	4.2	4.1	4.3

Source: City of Solvang

Table 2-2 presents the monthly production quantities broken down into pumping from groundwater wells, and water deliveries from the SWP.

Table 2-2
Historical Monthly Water Production by Source [1)]
(acre-feet)

Month	Source	2007	2006	2005	2004	2003	2002	2001	2000
January	Wells	11.1	19.0	8.0	10.5	23.0	69.6	74.7	88.4
	Purchased	80.2	53.8	45.8	68.0	56.3	0.0	3.9	5.7
February	Wells	14.2	26.4	25.7	10.0	26.0	83.2	56.6	53.7
	Purchased	52.3	57.6	40.2	64.0	44.4	0.0	3.0	15.2
March	Wells	40.6	5.2	18.7	24.9	51.0	103.0	64.1	65.9
	Purchased	68.0	59.7	52.1	81.2	33.4	0.0	17.2	21.3
April	Wells	39.9	7.3	19.4	29.4	37.0	136.8	80.0	91
	Purchased	88.0	59.0	85.0	115.6	65.2	0.0	39.1	25
May	Wells	53.0	11.7	16.0	23.3	40.0	135.2	96.0	108.8
	Purchased	107.6	110.6	117.3	146.0	84.2	0.0	56.3	43.6
June	Wells	28.7	17.9	4.9	46.3	32.0	143.7	87.0	124.6
	Purchased	144.0	148.6	151.3	130.0	126.1	0.0	88.0	48.4
July	Wells	32.4	20.1	12.0	63.5	35.0	155.9	108.0	125
	Purchased	164.0	176.0	172.0	128.0	135.0	0.0	77.0	56.3
August	Wells	28.5	14.3	15.0	64.0	26.0	83.3	128.0	139.9
	Purchased	174.0	175.9	175.0	125.7	140.5	94.1	54.0	50.8
September	Wells	19.0	9.4	14.6	51.8	18.0	35.7	119.0	131.9
	Purchased	154.2	160.6	149.0	116.9	158.3	139.7	47.0	34.3
October	Wells	19.3	15.0	20.5	37.6	18.0	32.9	94.0	108.9
	Purchased	127.6	128.3	119.0	79.3	137.2	112.8	52.0	19.9
November	Wells	50.5	40.4	21.3	61.5	67.0	50.1	72.4	92.8
	Purchased	81.0	87.2	83.3	17.9	19.9	64.7	13.2	4.8
December	Wells	6.4	13.8	16.9	69.6	18.0	12.7	53.0	98.5
	Purchased	92.3	72.7	71.0	11.0	63.3	63.6	14.2	1.9
Annual Production		1,676.8	1,490.5	1,454.0	1,576.0	1,454.8	1,517.0	1,497.7	1,556.6

[1)] *The data in Table 2-2 confirms that the quantities of purchased water in summer months often times exceeds the 125 AF per month limitation that will be imposed by CCWA in the future.*

[2)] *Source: City of Solvang.*

3.0 USE OF SOLVANG'S HYDRAULIC NETWORK MODEL

As part of this study, Stetson Engineers reviewed and utilized Solvang's existing water distribution system model that was developed using WaterCAD software.

Computer hydraulic modeling analysis is a method of predicting the hydraulic gradient pattern, pressures, and flows across the water distribution network under a given set of conditions. The hydraulic gradient pattern depends upon the magnitude and location of system demands, the characteristics of the pipes in the distribution system, and the flows and gradients at network boundaries such as reservoirs and pumping stations. The head loss through each pipe is a function of flow rate, pipe diameter, length, and internal roughness, known as the "C" value. The available pressure, or head, at any point in the network is the difference between the hydraulic gradient and the ground surface elevation.

The physical characteristics of the water distribution system included in the computer model are ground topography, reservoir elevations, pump characteristics, and pipe diameter, length, and interior roughness. Historical water demands are also assigned to the computer model. The model contains gridded, or looped, mains of 4-inch diameter and greater. Closed valves between pressure zones are also included in the computer model.

The model was last calibrated by Penfield and Smith in 2004. With exceptions noted below, Stetson Engineers did not modify the basic model, but ran flow scenarios to analyze the system.

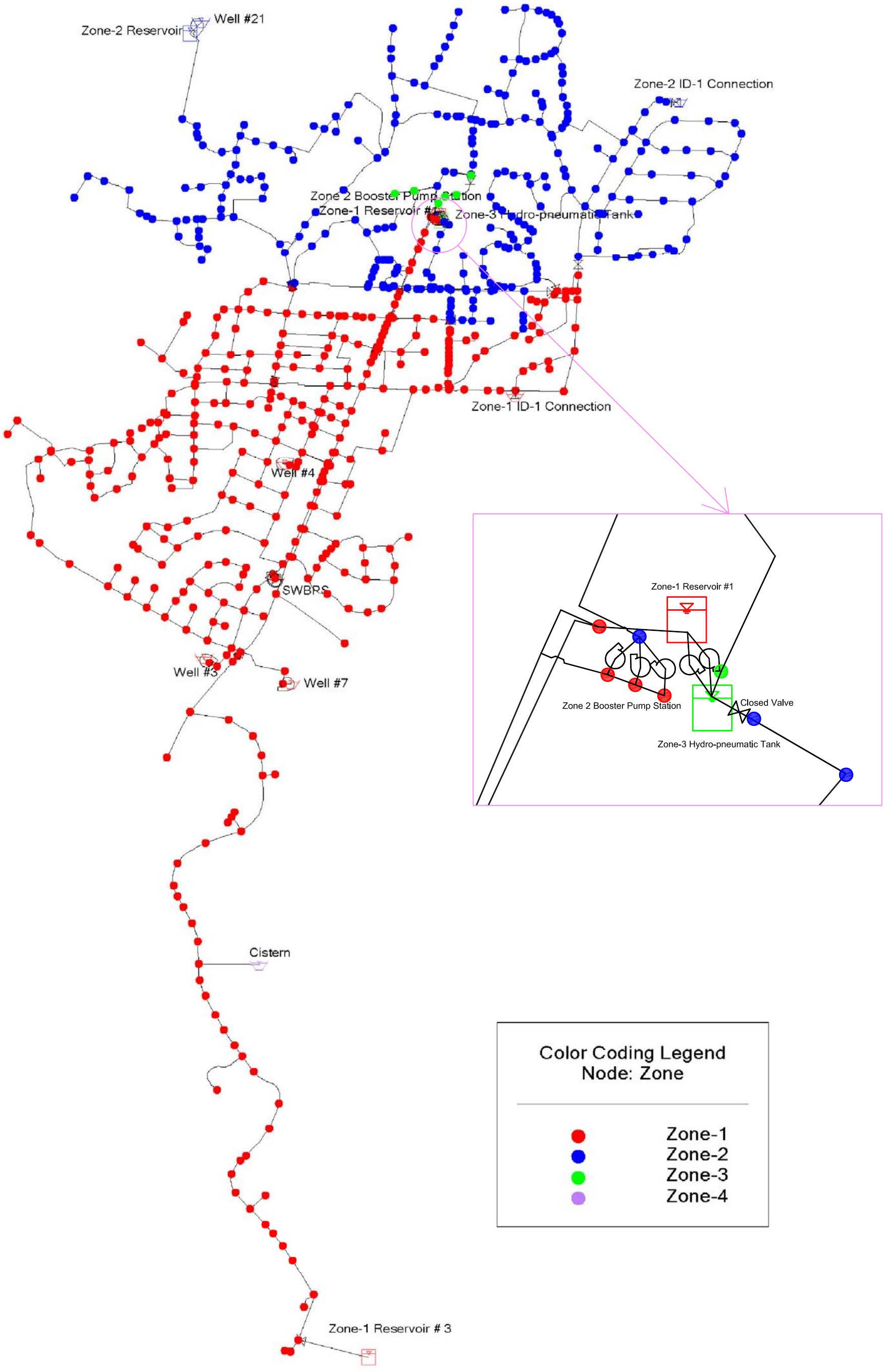
3.1 Review of Existing Computer Model

3.1.1 Network Components

The hydraulic model contains 784 pipe segments, 641 junction nodes, 4 storage tanks, 8 wells, 12 pumps (including groundwater pumps and booster pumps), and 16 valves

3.1.2 Pressure Zones and System Configuration

The model consists of three zones: Zone 1, Zone 2 and Zone 3. Pressure Zone 4 along Riley Road is not included in the model. See Figure 3-1 for pressure zone location. After the initial review it was apparent that the pressure zones were not correctly assigned into the model. Three pressure zones were mixed together in the northern portion of the system. The nodes were corrected so that all nodes were assigned to the correct pressure zone.



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CITY OF SOLVANG

WATER DISTRIBUTION SYSTEM EVALUATION

PRESSURE ZONES

Not In Scale

FIGURE 3-1

Two interconnections between the Solvang system and the adjacent Santa Ynez system were included in the model.

3.1.3 Model Scenarios and System Operations

The model consists of three scenarios

1. Base (All wells and booster pumps are off)
2. SWP2 & Z2BP-2 ON (State Water Pump #2 & Zone 2 Booster #2 on)
3. SWP2-ON (State Water Pump #2 on)

The Base Scenario represents a condition of power failure with all wells and boosters off. Scenario 2 has two pumps (SWP2 and Z2BP-2) on, with all other wells and booster pumps off.

Scenario 3 has one pump (SWP2) on, with all other wells and booster pumps off.

The model settings for the reservoirs for all scenarios are summarized in Table 3-1.

Table 3-1
Reservoirs

Label	Base Elevation (ft)	Total Volume (gal)	Tank Diameter (ft)	Initial Level (ft)
Res 1	638	600,030	N/A*	13.7
Res 2	760	449,452	60	10
Res 3	627	220,578	38	13.5
T-1 HYRDO	652	3,352	3.5	NA
Two (2) Cistern [1)]	NA	40,000	NA	NA
Total		1,313,412		

[1)] Not used in model

* Non-circular shape

The model settings for all the valves in all scenarios are summarized in Table 3-2.

Table 3-2
Valves

Label	Elevation (ft)	Valve Status
BDV-1	483	Closed
BDV-2	476	Closed
BDV-3	482	Closed
BDV-4	544	Closed
BDV-5	544	Closed
BDV-6	550	Closed
BDV-7	653	Closed
BDV-8	502	Closed
FCV-1	486	Inactive
FCV-3	537	Inactive
FCV-10	504	Inactive
SWV-1	427	Active [1)]
V-ID1-1	453	Closed
V-ID1-2	515	Closed
V-RES 3	0	Inactive
V-RS 3	501	Inactive

[1)] *Flow control valve, discharge rate is set as 420 gpm*

3.2 Water Demand Allocation

An average day demand of 1,012.14 gpm was assigned in all model run scenarios. This average day demand was provided with the model files received from Solvang. This average day demand is for all 3 pressure zones in the model. The average day demand is slightly higher than the average day production for the 8 years of data from 2000 through 2007 as previously shown in Table 2-1. The average day demand is broken into Zone demands as follows: for Zone 1 is 863.89 gpm (531 nodes), Zone 2 is 140.82 gpm (105 nodes) and Zone 3 is 7.43 gpm (5 nodes).

3.3 Distribution System Storage Requirements

Water is stored to provide water pressure, equalize pumping rates, equalize supply and demand over periods of high consumption, provide surge relief, and furnish water during fires and other emergencies. Storage may also serve as part of the treatment process, either by providing increased detention time or by blending water supplies to obtain a desired concentration.

Storage facilities must be sized to sufficiently provide for the following:

Equalization Storage:	Provide equalization to the daily fluctuation of water demand.
Fire Suppression Storage:	Meet the demands of fire fighting for a specified period of time within the service area.
Emergency Storage:	Provide water reserves for contingencies such as system failures, power outages and other emergencies.

The amount of equalization storage required is a function of the finished water pumping capacity, distribution piping capacity, and system demand characteristics. According to AWWA, equalization storage was recommended to be between 20 to 25 percent of the Average Day Demand (ADD).

Fire suppression storage requirements are typically dependent on the fire flow requirements and duration of flow.

Emergency storage is required to provide water during emergency situations such as pipeline failures, main breaks, equipment failures, raw water supply contamination, or natural disasters. The amount of emergency storage included within a particular water distribution system in an owner option based upon an assessment of risk and a capacity to pay for the standby provisions. Unlike equalization and fire storage, which should generally be available at all system storage sites, emergency storage may be included at only one or a limited number of storage sites.

3.3.1 Equalization Storage

The purpose of the equalization storage requirement is to make up the difference between the peak demands and the rate of supply produced at the water source. According to AWWA, equalization storage was recommended to be between 20 to 25 percent of the ADD.

The current ADD is approximately 1,012 gpm. The equation storage requirement is 364,300 gallons based on 25 percent of ADD.

3.3.2 Fire Suppression Storage

In general, each storage facility will need to provide fire suppression capacity for fire flows required of buildings in the storage facilities' area of influence. The fire suppression reserve for a residential area ranges from 500 gpm to 1,250 gpm. For the purpose of evaluating Solvang's

storage requirement for fire fighting, a flow of 1,250 gpm for a duration of two hours was used. Fire suppression storage requirement was calculated as 150,000 gallons.

3.3.3 Emergency Storage

The function of emergency water storage is to provide water for domestic consumption during emergency situations. Storage is provided for emergency situations such as:

- Power failure for an extended time
- Failure of raw water transmission facilities
- Failure of water treatment plant facilities
- Transmission or distribution main breaks

The most likely emergency is a power failure lasting several hours, a booster pump failure or a trunk main failure, any of which would limit distribution capacity in a localized area. To provide emergency storage for these circumstances, AWWA recommends that emergency storage equal to 20 to 25 percent of the ADD to be provided for each pressure zone. This emergency storage should meet customer demands for a period of six hours to allow for repair of main breaks, restoration of power, or repair equipment failures.

Assuming emergency storage is equal to 25 percent of the ADD, the total estimated emergency storage requirements for the Solvang service area is 364,300 gallons.

3.3.4 Reservoir Storage Requirement Summary

The total reservoir storage requirement for equalization, fire suppression and emergency is 878,600 gallons. The existing system reservoir storage capacity is 1,295,000 gallons therefore no additional storage facilities are required. A summary of required reservoir storage is shown on Table 3-3.

Table 3-3
Reservoirs Storage Requirements

Label	Gallons
Equalization Storage	364,320
Fire Suppression	150,000
Emergency Supply	364,320
Total	878,640

4.0 HYDRAULIC ANALYSIS OF EXISTING SYSTEM

The existing hydraulic model for the Solvang water system was created by Penfield and Smith using WaterCAD, version 6.5. We have performed a preliminary evaluation of the model using WaterCAD, version 7.0.

4.1 Evaluation Criteria

The system pressure was evaluated using the California Code of Regulation, Title 22 operation criteria. Title 22 states that all service connections maintain not less than 20 psi under maximum hour demand and average day demand plus design fire flow.

Maximum pipe velocity was limited to 5 feet per second using American Water Works Association Standards. Table 4-1 was used as performance criteria for transmission and distribution mains for system evaluation.

Table 4-1
Design Guidelines for Transmission and Distribution Mains

Parameter	Criteria	Comment
Minimum Pressure	20 psi	Peak Hour Demand without Fire Flow
Minimum Pressure	20 psi	Average Day Demand plus Fire Flow [1)]
Pipe Velocity	< 5 feet per second	AWWA Standard

1) Fire flow of 750 gpm was used for model runs

4.2 Existing Model Adjustments

4.2.1 Pressure Zone

The pressure zones in the model were separated and assigned based on the junction and the isolation valves locations. Pressure zones are previously shown on Figure 3-1.

4.2.2 Zone 4 System

Zone 4 has a pump that provides water to the cisterns and serves about 20 houses. However, the existing model configuration of Zone 4 system is missing a booster pump. Without using the booster pump, Zone 4 pressure would not be reliably evaluated. Therefore, zone 4 is modeled as a closed system and was not evaluated.

4.2.3 Demand

Using the model's existing average day demand (1,012 gpm), a peaking coefficient of 4 is used to adjust the average day demand to maximum hour demand (4,049 gpm). The peaking coefficient of 4 was chosen based on ID1's historical records for 2002, which is the year with highest water usages for ID1 for the period of 2002-2005. Based on Solvang's data, the use of a peaking factor of 4 is conservative.

Table 4-2 shows the demand distribution by zone and the demands used in the model.

Table 4-2
Average Day, Maximum Hour Demand and the Zone Demand Proportion

Zone	Number of Nodes	Average Day Demand (gpm)	Max Hour Demand (gpm)	Demand Distribution
Zone-1	359	656	2,625	65%
Zone-2	274	344	1,376	34%
Zone-3	8	12	48	1%
Zone-4	0	0	0	0%
Total	641	1,012	4,049	100%

The peaking factors for the analyses are as follow: Maximum Day = 2.6 x Average Day; Maximum Hour = 4.0 x Average Day

4.2.4 C-Values

The existing pipe friction coefficients, Hazen-Williams C-values, were adjusted to calibrated C-values as shown in Table 4-3.

Table 4-3
Pipe Friction Coefficient

Material	Calibrated C
Cement Asbestos	142.5
Iron, Cement Lined	127.5
Plastic	142.5

C-values were calibrated by Penfield & Smith in 2004

4.3 Hydraulic Analysis of Existing Model

4.3.1 Model Scenarios

Three scenarios as shown in Table 4-4 were used to analyze the existing system. Scenario 1 has the State Water Pump Station booster pump # 2 and Zone 2 Booster Pump Station booster pump #2 on and maximum hour demand. Scenario 2 has only the State Water Pump Station booster pump #2 on and maximum hour demand. Scenario 3 has no pumps running with average day demands plus a residential fire flow of 750 gpm. Scenario 3 is the no power scenario. None of the wells are operating in any of the scenarios.

Table 4-4
Existing System Scenarios

Scenario	Description
1	Max Hour, SWP2 & Z2BP-2 On
2	Max Hour, SWP2-ON
3	Ave Day + Fire, No Power

4.3.2 Evaluation of Results

It was assumed the existing model was calibrated to plus or minus 5 psi, therefore, nodal pressures less than 25 psi were considered below design criteria.

Scenario 1 Maximum Hour, SWP2 & Z2BP-2 On

Eight model nodes show pressures less than 25 psi, three of them are demand nodes. As shown in Figure 4-1, the low pressure nodes are all in northern portion of Zone 1, near the Zone 2 booster station.

Two pipes have velocities greater than 5 feet per second (fps) as shown in Figure 4-2. Both of the high velocity pipelines in Zone 1 are located on the mainline of the Zone 2 booster pump station and downstream of Zone 1 reservoir.

Table 4-5 shows the system inflow and outflow for the steady state analysis during scenario 1 operation.

Table 4-5
Scenario 1: System Flow
(gpm)

	Maximum Hour Demand	Inflow to the System			Outflow to Other Zone/System				Balance
		Well Production	Tank Discharge	CCWA or Other System/Zone	Z1	Z2	Z3	Z4	
Z1	2,625	0	2,943	420	0	738	0	0	0
Z2	1,376	0	638	738	0	0	0	0	0
Z3	48	0	48	0	0	0	0	0	0
Z4	0	0	0	0	0	0	0	0	0

Scenario 2 Maximum Hour, SWP2 On

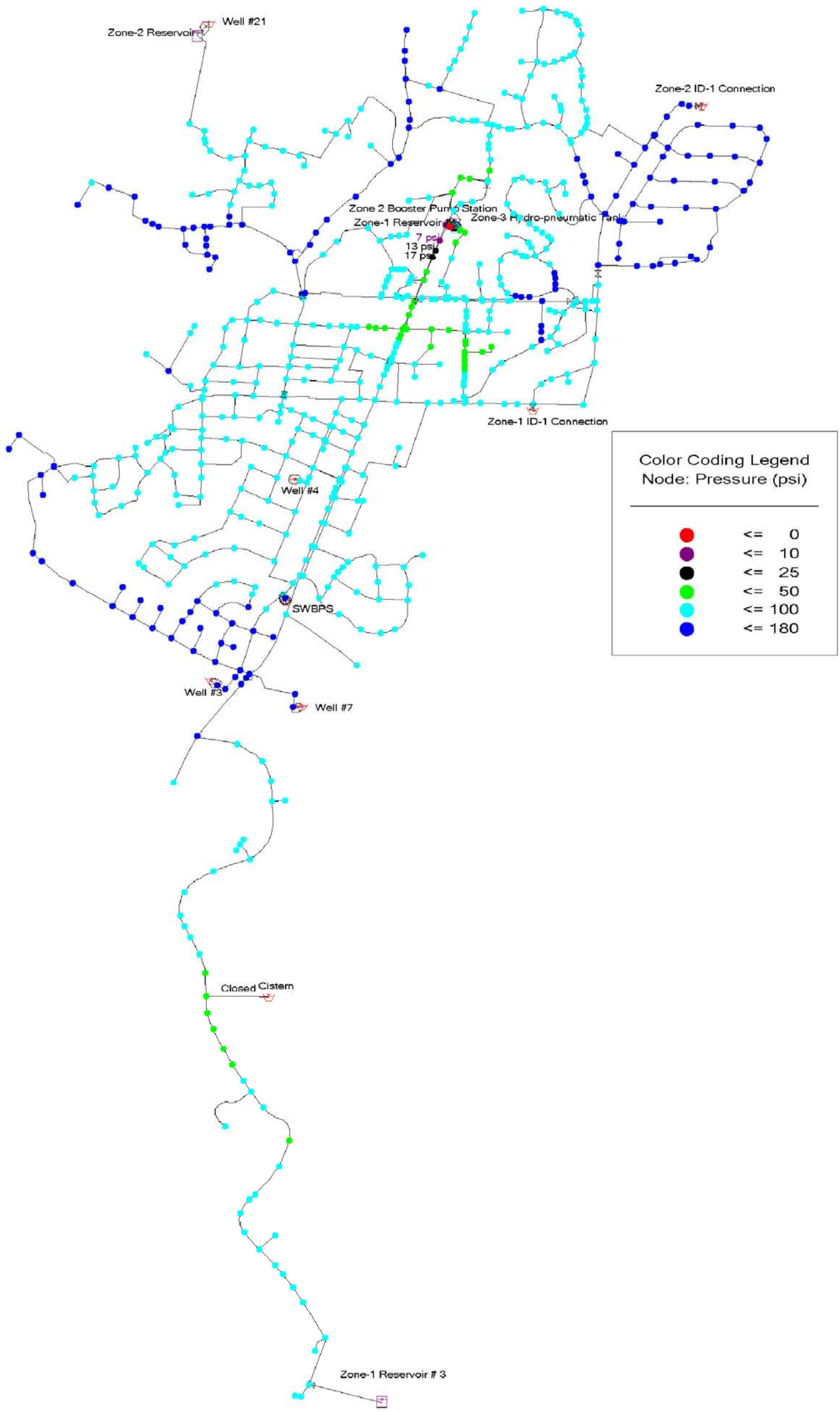
Fourteen model nodes show pressures less than 25 psi, eight of them are demand nodes, as shown in Figure 4-3. Zone 1 has eight low pressure nodes, three of them are demand nodes and located near the Zone 2 booster station. Zone 2 has six low pressure nodes, five of them are demand nodes and located near Zone 2 booster station and Zone 3 Hydro-pneumatic tank.

Eight pipes have velocities greater than 5 feet per second (fps), as shown in Figure 4-4. Seven of them are located in Zone 2 and are mainly located on the downstream of Zone-2 reservoir. One pipe has high velocities in Zone 1 and is located on the mainline of Zone 2 booster pump station and downstream of Zone 1 reservoir.

Table 4-6 shows the system inflow and outflow for the steady state analysis during Scenario 2 operation.

Annotation showing demand nodes with pressure less than 25psi

Scenario: Max Hour - SWP-2 & Z2BP-2 ON



STETSON ENGINEERS INC.

CITY OF SOLVANG

WATER DISTRIBUTION SYSTEM EVALUATION

SCENARIO 1: MAX HOUR, SWP2 & Z2BP-2 ON, PRESSURES <25 PSI

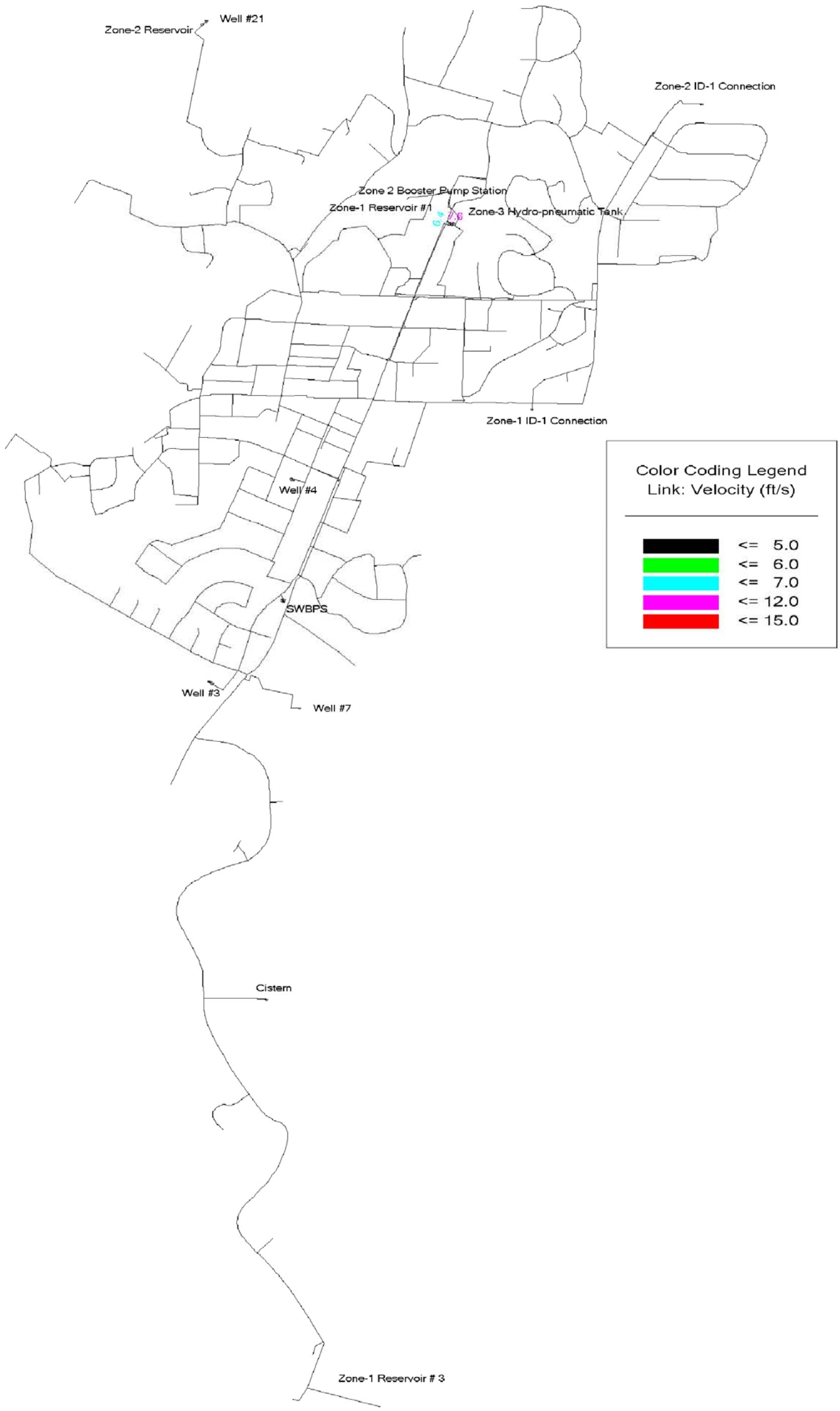
Not In Scale

FIGURE

4-1

Annotation showing pipes with velocities greater than 5 fps

Scenario: Max Hour - SWP-2 & Z2BP-2 ON



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WATER DISTRIBUTION SYSTEM EVALUATION

SCENARIO 1: MAX HOUR, SWP2 & Z2BP-2 ON, PIPELINES WITH VELOCITIES > 5 FPS

N

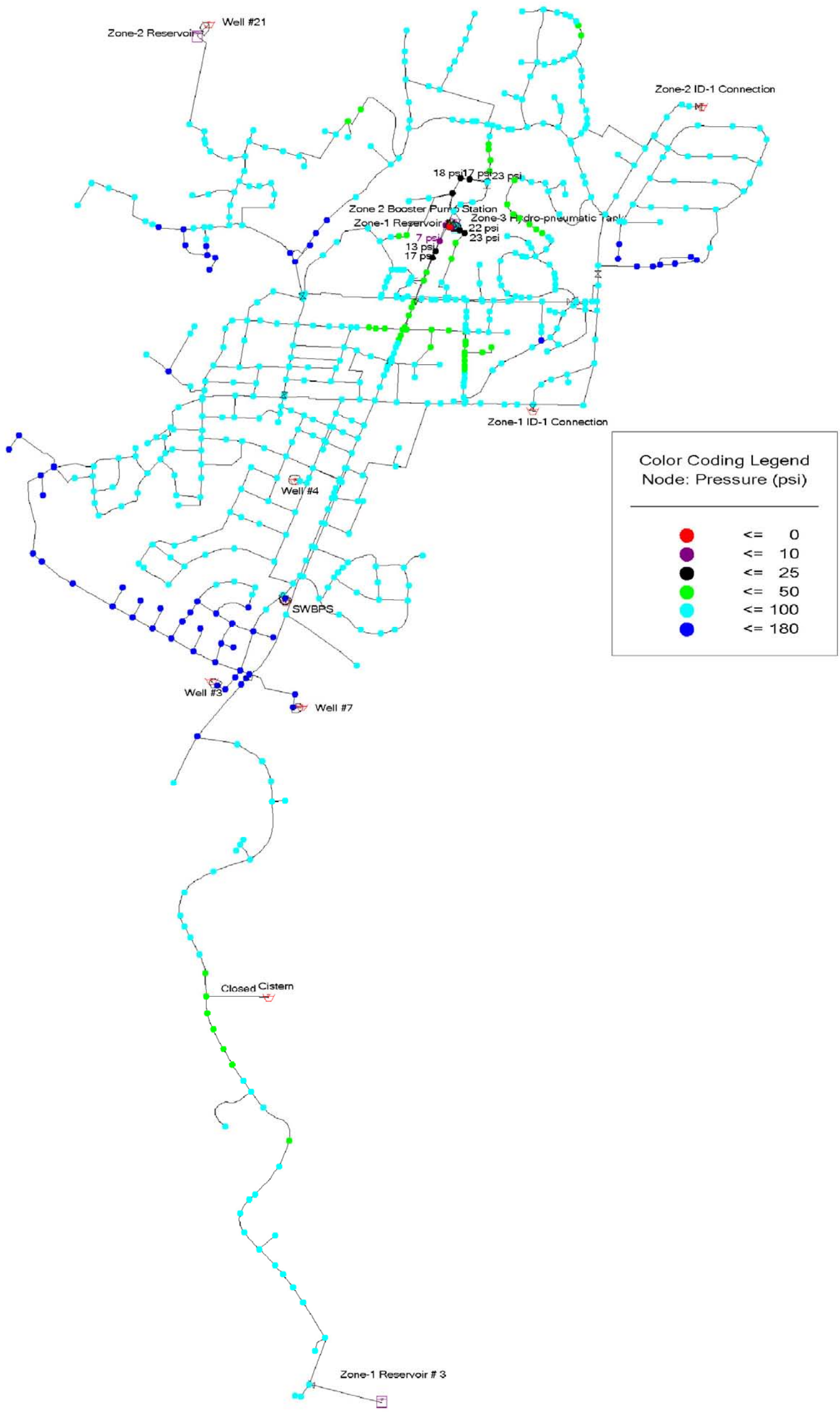
Not In Scale

FIGURE

4-2

Annotation showing demand nodes with pressure less than 25psi

Scenario: Max Hour - SWP -2 ON



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WATER DISTRIBUTION SYSTEM EVALUATION

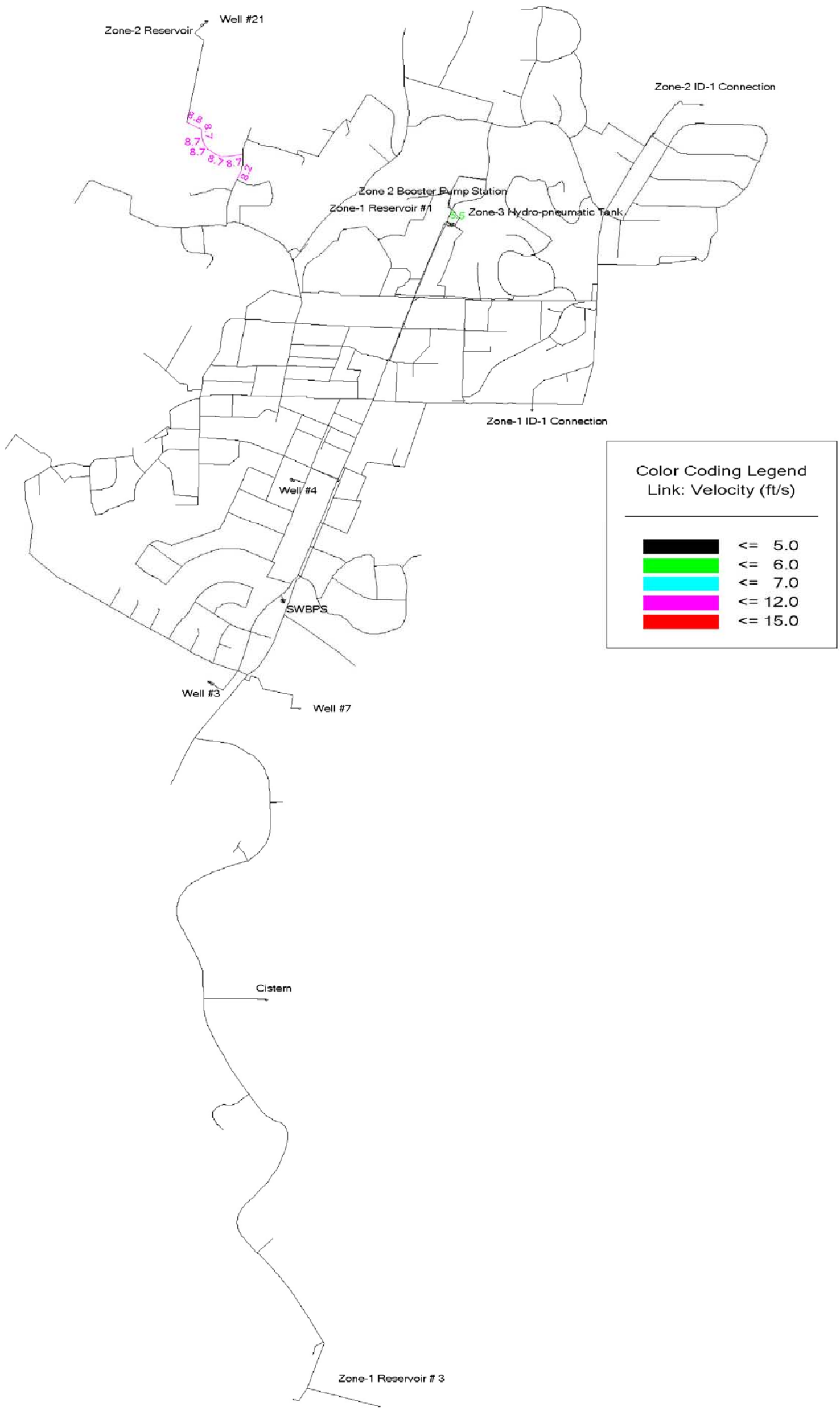
SCENARIO 2: MAX HOUR, SWP2 ON, PRESSURES <25 PSI

Not In Scale

FIGURE 4-3

Annotation showing pipes with velocities greater than 5 fps

Scenario: Max Hour - SWP -2 ON



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CITY OF SOLVANG

WATER DISTRIBUTION SYSTEM EVALUATION

SCENARIO 2: MAX HOUR, SWP2 ON, PIPELINES WITH VELOCITIES > 5 FPS

N

Not In Scale

FIGURE

4-4

Table 4-6
Scenario 2: System Flow
(gpm)

	Maximum Hour Demand	Inflow to the System			Outflow to Other Zone/System				Balance
		Well Production	Tank Discharge	CCWA or Other System/Zone	Z1	Z2	Z3	Z4	
Z1	2,625	0	2,205	420	0	0	0	0	0
Z2	1,376	0	1,376	0	0	0	0	0	0
Z3	48	0	48	0	0	0	0	0	0
Z4	0	0	0	0	0	0	0	0	0

Scenario 3 Average Day Demand + Fire Flow, No Power

The purpose of this scenario is to show the system capability to meet fire flow requirement during power failure.

Fire flow of 750 gpm was analyzed under average day demand when there is no water production from the wells, no water supply from the State Water Project Pump Station and all booster pumps are off (all zones isolated).

Eighteen model nodes have residual pressure less than 25 psi when flowing at 750 gpm, as shown in the Figure 4-5. Zone 1 has eight low residual points. Most of them are located near the Zone 2 booster station and downstream of Zone 1 Reservoir #1. The remaining three low pressure nodes are located at a dead end on a 2-inch pipe.

Zone 2 has ten low pressure nodes. All of them are located near Zone 2 booster station and Zone 3 Hydro-pneumatic tank.

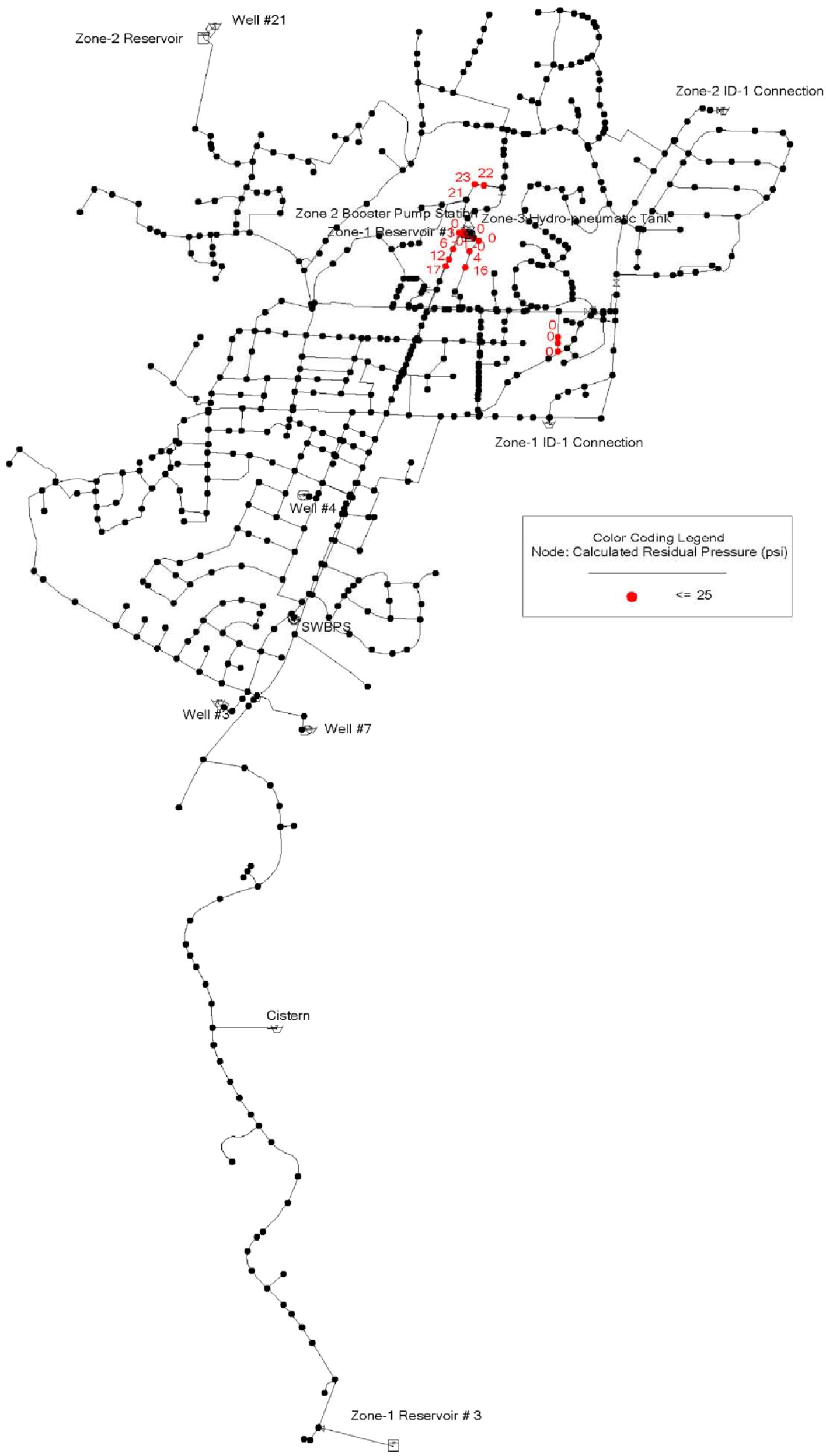
In general, most of the model nodes meet the fire flow requirement during power failure. Low residual pressure points are mainly occurred near Zone 2 booster station, Zone 1 reservoir and the Zone 3 hydro-pneumatic tank.

4.3.3 Summary

In general, most of the existing distribution system meets pressure requirements. Low pressure is mainly occurs near Zone 2 booster station. High pipe velocities occur on the mainline of Zone 2 booster station and downstream of Reservoirs 1 and 2.

Annotation showing nodes with residual pressures less than 25 psi when flowing at 750gpm

Scenario: Average Day + FF, No Power



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CITY OF SOLVANG

WATER DISTRIBUTION SYSTEM EVALUATION

SCENARIO 3: AVE DAY + FIRE FLOW PRESSURES <25 PSI

Not In Scale

FIGURE

4-5

4.4 Storage and Pumping Analysis

For this analysis, the maximum day demand was calculated to be 2,631 gpm. The system has a production pumping capacity of 2,340 gpm (1,300 SWP + 1,040 wells). Staff has noted difficulties keeping up with demands during hot weather. This would be expected with the production capacity less than the maximum day demand.

To analyze the storage and pumping capacities of the system, Stetson performed reservoir analyses for four different conditions based on current maximum day and maximum hour demands. These conditions are as follows:

Condition 1	Maximum Day Demands with Existing System Pumping Capacities
Condition 2	Maximum Day Demands plus 4 Hours of Maximum Hour Demands with Existing Pumping Capacities
Condition 3	Maximum Day Demands with Existing System Pumping Capacities Plus a New 350 gpm Well
Condition 4	Maximum Day Demands plus 4 Hours of Maximum Hour Demands with Existing Pumping Capacities Plus a New 350 gpm Well

The analyses look at the storage volumes over a 24 hour period (6 am to 6 am). Results of the four analyses are included in Appendix A.

In reviewing the reservoir analyses it is apparent that Solvang has adequate storage for current conditions. However, production capacity should be increased to accommodate periods of high demands. Conditions 3 and 4 were run with an additional 350 gpm well feeding the system. The results indicate this addition would address current high demand conditions. This additional production capacity will become critical when the State Water Project limits flow to Solvang to 125 AF per month.

5.0 SUMMARY AND CONCLUSIONS

Per AWWA standards and Santa Barbara County fire flow requirements, with the exception of a small number of locations near the Zone 2 booster station and Reservoirs 1 and 2, the existing distribution system meets minimum pressure and fire flow criteria. Although the system as a whole has some minor deficiencies, in general all pressure zones have adequate pressures and fire flows during all of the scenarios tested. During the worst-case scenario (average day plus fire flow and no power), eighteen model nodes have residual pressure less than 25 psi when flowing at 750 gpm. Zone 1 has eight low residual points. Most of them are located near the Zone 2 booster station and downstream of Zone 1 Reservoir #1. The remaining three low pressure nodes are located at a dead end on a 2-inch pipe. Zone 2 has ten low pressure nodes. All of them are located near Zone 2 booster station and Zone 3 Hydro-pneumatic tank.

With both the State Water Project Pump Station and Zone 2 Booster Station in operation, eight model nodes show pressures less than 25 psi, three of them are demand nodes. The low pressure nodes are all in northern portion of Zone 1, near the Zone 2 booster station. Under this condition two pipes have velocities greater than 5 feet per second (fps). Both of the high velocity lines in Zone 1 are located on the mainline of the Zone 2 booster pump station and downstream of Zone 1 reservoir.

The low pressures in the area of the Zone 1 Reservoir and Zone 2 Booster Pump Station are a result of the location of these facilities at high points in the Zone 1 system. Some of the nodes in this area are demand nodes. The demands in this area should be served by the Zone 2 system to provide adequate pressure. In pipelines that experience high velocities, consideration should be given to replacing existing pipelines with larger diameter pipe.

Solvang has adequate storage for current conditions. However, production capacity should be increased to accommodate periods of high demands. Reservoir analyses were run with an additional 350 gpm well feeding the system. The results indicate this addition would address current high demand conditions. This additional production capacity will become critical when the State Water Project limits flow to Solvang to 125 AF per month.

It is recommended that the City of Solvang update their water atlas to accurately reflect their water distribution system network. This updated water atlas should be used to verify the accuracy of the WaterCAD model data.

6.0 ABBREVIATIONS AND ACRONYMS USED IN THE REPORT

°F	Degrees Fahrenheit
AC	Asbestos Concrete
ACP	Asbestos Cement Pipe
Acre-feet	326,000 gallons
ADD	Average Day Demand
AF	Acre-feet
AFY	Acre-feet per Year
Avg	Average
AWWA	American Water Works Association
BG	Below Ground
C	Pipe Friction (roughness) Coefficient Value
CAD	Computer Aided Design
CCP	Concrete Pipe
CCWA	Central Coast Water Authority
CIMIS	California Irrigation Management Information System
CIP	Cast Iron Pipe
CMLCSP	Cement Lined and Coated Steel Pipe
DIP	Ductile Iron Pipe
ft	feet
ft/s	Feet per Second
GIP	Galvanized Iron Pipe
GIS	Geographic Information Systems
gpd	gallons per day
gpm	gallons per minute
h	height
HGL	Hydraulic Grade Line
ID1	Santa Ynez River Water Conservation District Improvement District #1
in	inch(es)
ISO	Insurance Service Office
K	1,000
mg	million gallons
mgd	million gallons per day
MSL	Mean Sea Level
Obs	Observed
pi	pi = 3.14
psi	pounds per square inch
PVC	Poly Vinyl Chloride Pipe
Ref	Refugio Pump Station
SCADA	Supervisory Control and Data Acquisition
SCP	Somastic Coated Pipe
sf	square feet
Sim	Simulated
STL	Steel pipe
SWP	State Water Project
SYRWCD	Santa Ynez River Water Conservation District
WC	WaterCAD
WS	Water Surface

7.0 REFERENCES

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APPENDIX A – RESERVOIR ANALYSES

City of Solvang
System Storage

Reservoir Analysis

Condition 1: Maximum Day & Existing System Pumping Capacities

Assumptions

Reservoir Capacity	937,000	gallons	3/4 full
Reservoir Inflow	2,340	gpm	SWP & Wells all on

Conditions

Max Day Demand:	3,788,640	gallons
Demand =	2,631	gpm
Storage in Res. @ Start:	937,000	gallons

Analysis

Hour Ending	Demand (gpm)	Inflow (gpm)	Required from Reservoir (gal)	Reservoir Storage (gal)	Notes
600	2631	2,340	17,460	937,000	
700	2631	2,340	17,460	919,540	
800	2631	2,340	17,460	902,080	
900	2631	2,340	17,460	884,620	
1000	2631	2,340	17,460	867,160	
1100	2631	2,340	17,460	849,700	
1200	2631	2,340	17,460	832,240	
1300	2631	2,340	17,460	814,780	
1400	2631	2,340	17,460	797,320	
1500	2631	2,340	17,460	779,860	
1600	2631	2,340	17,460	762,400	
1700	2631	2,340	17,460	744,940	
1800	2631	2,340	17,460	727,480	
1900	2631	2,340	17,460	710,020	
2000	2631	2,340	17,460	692,560	
2100	2631	2,340	17,460	675,100	
2200	2631	2,340	17,460	657,640	
2300	2631	2,340	17,460	640,180	
0	2631	2,340	17,460	622,720	
100	2631	2,340	17,460	605,260	
200	2631	2,340	17,460	587,800	
300	2631	2,340	17,460	570,340	
400	2631	2,340	17,460	552,880	
500	2631	2,340	17,460	535,420	
600	2631	2,340	17,460	517,960	

Negative flow from reservoir indicates net inflow

City of Solvang
System Storage

Reservoir Analysis

Condition 2: Max Day + 4 Max Hours & Existing System Pumping Capacities

Assumptions

Reservoir Capacity	937,000	gallons	3/4 full
Reservoir Inflow	2,340	gpm	SWP & Wells all on

Conditions

Max Day Demand:	3,788,640	gallons
Max Day Demand =	2,631	gpm
Max Hour Demand =	4,049	gpm
Storage in Res. @ Start:	937,000	gallons

Analysis

Hour Ending	Demand (gpm)	Inflow (gpm)	Required from Reservoir (gal)	Reservoir Storage (gal)	Notes
600	2631	2,340	17,460	937,000	
700	2631	2,340	17,460	919,540	
800	2631	2,340	17,460	902,080	
900	2631	2,340	17,460	884,620	
1000	2631	2,340	17,460	867,160	
1100	2631	2,340	17,460	849,700	
1200	2631	2,340	17,460	832,240	
1300	2631	2,340	17,460	814,780	
1400	2631	2,340	17,460	797,320	
1500	4,049	2,340	102,540	694,780	
1600	4,049	2,340	102,540	592,240	
1700	4,049	2,340	102,540	489,700	
1800	4,049	2,340	102,540	387,160	
1900	2631	2,340	17,460	369,700	
2000	2631	2,340	17,460	352,240	
2100	2631	2,340	17,460	334,780	
2200	2631	2,340	17,460	317,320	
2300	2631	2,340	17,460	299,860	
0	2631	2,340	17,460	282,400	
100	2631	2,340	17,460	264,940	
200	2631	2,340	17,460	247,480	
300	2631	2,340	17,460	230,020	
400	2631	2,340	17,460	212,560	
500	2631	2,340	17,460	195,100	
600	2631	2,340	17,460	177,640	

Negative flow from reservoir indicates net inflow

City of Solvang
System Storage

Reservoir Analysis

Condition 3: Max Day & Existing System Plus New 350 gpm Well

Assumptions

Reservoir Capacity	937,000	gallons	3/4 full
Reservoir Inflow	2,690	gpm	SWP & Wells all on + New Well

Conditions

Max Day Demand:	3,788,640	gallons
Demand =	2,631	gpm
Storage in Res. @ Start:	937,000	gallons

Analysis

Hour Ending	Demand (gpm)	Inflow (gpm)	Required from Reservoir (gal)	Reservoir Storage (gal)	Notes
600	2631	2,690	-3,540	937,000	
700	2631	2,690	-3,540	940,540	
800	2631	2,690	-3,540	944,080	
900	2631	2,690	-3,540	947,620	
1000	2631	2,690	-3,540	951,160	
1100	2631	2,690	-3,540	954,700	
1200	2631	2,690	-3,540	958,240	
1300	2631	2,690	-3,540	961,780	
1400	2631	2,690	-3,540	965,320	
1500	2631	2,690	-3,540	968,860	
1600	2631	2,690	-3,540	972,400	
1700	2631	2,690	-3,540	975,940	
1800	2631	2,690	-3,540	979,480	
1900	2631	2,690	-3,540	983,020	
2000	2631	2,690	-3,540	986,560	
2100	2631	2,690	-3,540	990,100	
2200	2631	2,690	-3,540	993,640	
2300	2631	2,690	-3,540	997,180	
0	2631	2,690	-3,540	1,000,720	
100	2631	2,690	-3,540	1,004,260	
200	2631	2,690	-3,540	1,007,800	
300	2631	2,690	-3,540	1,011,340	
400	2631	2,690	-3,540	1,014,880	
500	2631	2,690	-3,540	1,018,420	
600	2631	2,690	-3,540	1,021,960	

Negative flow from reservoir indicates net inflow

City of Solvang
System Storage

Reservoir Analysis

Condition 4: Max Day + 4 Max Hours & Existing System Plus New 350 gpm Well

Assumptions

Reservoir Capacity	937,000	gallons	3/4 full
Reservoir Inflow	2,690	gpm	SWP & Wells all on + New Well

Conditions

Max Day Demand:	3,788,640	gallons
Max Day Demand =	2,631	gpm
Max Hour Demand =	4,049	gpm
Storage in Res. @ Start:	937,000	gallons

Analysis

Hour Ending	Demand (gpm)	Inflow (gpm)	Required from Reservoir (gal)	Reservoir Storage (gal)	Notes
600	2631	2,690	-3,540	937,000	
700	2631	2,690	-3,540	940,540	
800	2631	2,690	-3,540	944,080	
900	2631	2,690	-3,540	947,620	
1000	2631	2,690	-3,540	951,160	
1100	2631	2,690	-3,540	954,700	
1200	2631	2,690	-3,540	958,240	
1300	2631	2,690	-3,540	961,780	
1400	2631	2,690	-3,540	965,320	
1500	4,049	2,690	81,540	883,780	
1600	4,049	2,690	81,540	802,240	
1700	4,049	2,690	81,540	720,700	
1800	4,049	2,690	81,540	639,160	
1900	2631	2,690	-3,540	642,700	
2000	2631	2,690	-3,540	646,240	
2100	2631	2,690	-3,540	649,780	
2200	2631	2,690	-3,540	653,320	
2300	2631	2,690	-3,540	656,860	
0	2631	2,690	-3,540	660,400	
100	2631	2,690	-3,540	663,940	
200	2631	2,690	-3,540	667,480	
300	2631	2,690	-3,540	671,020	
400	2631	2,690	-3,540	674,560	
500	2631	2,690	-3,540	678,100	
600	2631	2,690	-3,540	681,640	

Negative flow from reservoir indicates net inflow