Coastland | DCCM

January 2, 2025

Mr. Gordon Stankowski
General Manager
Rural North Vacaville Water District
P.O. Box 5097
Vacaville, CA 95696-5097
Via email: gordon@rnvwd.com

Subject: **FINAL** Engineering Modeling of Distribution System (rev1)

Dear Mr. Stankowski,

Coastland | DCCM is pleased to provide the following engineering evaluation of Rural North Vacaville Water District's existing potable water distribution system. Coastland | DCCM was contracted by the District to evaluate the capability of the existing potable water distribution system to supply potable water and firewater to parcels within the District's sphere of influence. The following is a description of the methods used to evaluate the existing system and the sources of data used in the evaluation methods.

Solano Local Area Formation Organization (LAFCO) uses a current capacity rating for the existing distribution system of 533 services. However, this capacity rating of 533 is actually the number of properties included in the original annexation to form the Rural North Vacaville Water District and support a bond issue for capital improvements. Recently, Coastland | DCCM issued an opinion letter dated February 09, 2023, that determined that the District's water supply could support 873 connections given the yield of the existing wells combined with the amount of available storage in the system. Coastland | DCCM's higher estimated connection capacity was the result of following the methodology outlined in Title 22, Section 64554. In general, Coastland | DCCM estimated a well production capacity of 442MGD and existing system storage capacity of 611 MG.

SUMMARY OF APPROACH

This modeling effort estimates the pressure throughout the current distribution piping system for various steady state conditions, for example average day, peak day and pressure at specific fire hydrant locations. This approach assumes an unlimited supply of water is available at all locations in the distribution system, ie the pipes and reservoirs are always full of water. The goals are to evaluate the system pressures for the current number of services using the system and then predict a potential maximum hydraulic capacity of the current piping system. This potential maximum hydraulic capacity is an estimate based on current conditions. If desired by the District, future modifications to the existing piping system could increase the piping and the pumping systems hydraulic capacities. Recommendations for increasing the capacity of piping pumping systems is not part of this effort.

Our engineering evaluation of the potable water distribution system was prepared in three steps. First, confirm required performance criteria. Second, build a computer model of the District's distribution system; Third, compare the model predictions for residual pressure to the required performance criteria. Performance criteria was developed from meetings with Solano County Local Formation Committee (LAFCO) and Vacaville Fire Protection District (VFPD). The District provided historical water consumption data as well as digital files of the distribution system facilities that were used to setup a computer model. With this model, predictions were made to locate areas within the existing distribution system where residual pressure and/or flow rate was insufficient to meet the performance requirements.

The District primarily serves rural properties with significant topographic elevation changes throughout the service area. Pressures in the system are affected by these topography changes. These changes in elevation were included in the model.

Please note that potable water consumption in many smaller community water systems in California is significantly less than the flow rate requirements for fire water supply. Therefore, it is generally true that if the distribution system can meet the performance requirement for fire supply, then the distribution system is typically, but not always, also capable of providing potable water supply.

DISTRIBUTION SYSTEM PERFORMANCE CRITERIA

Coastland | DCCM and the District met with LAFCO in August 2023. LAFCO approved the use of modeling to evaluate the distribution system for fire supply and also requested hydrant testing of the current system to establish current residual pressure in the service area. LAFCO agreed that the performance requirements for fire water supply are established by the Vacaville Fire Protection (VFPD) fire marshal. LAFCO also expressed a concern that accessory dwelling units could increase the demand for potable water within the District's distribution system.

The District has also had discussions with the VFPD regarding minimum fire water supply performance requirements. VFPD allows residents to receive fire water by connecting directly to the District's distribution system provided to pressure outside occupied structures is a minimum of 20 psi. When the pressure at the exterior of a structure is less than 20 psi, VFPD will allow residents to store fire water onsite. VFPD requires a minimum of 5,000 gallons of water stored on the resident's property. Fire water supply can also be achieved via hydrants throughout the service area if the hydrant can provide 250 gpm at 20 psi and is located within 300 feet of a structure. It is not a requirement of the District to construct, maintain or operated fire water storage tanks. Rather, the District only needs to provide 40 psi in the distribution system at the frontage property line, which is sufficient to fill the private supply tank located at the frontage.

Most 5,000-gallon capacity tanks that are NSF/ANSI 61 approved for potable water use have a typical fill height of 10 – 20 feet. For modeling purposes, the pressure loss through a water meter and backflow prevention device is 10 psi. Therefore, approximately 20 psi residual pressure in the distribution pipes is necessary to fill a water storage tank for properties using a private fire water storage system. However, this system pressure is inadequate for potable water service.

DISTRIBUTION SYSTEM SUMMARY

The District operates a distribution system composed of wells supplying potable water to an elevated storage system with pump stations to lift water between the elevated storage and users located at elevations above the elevation of the storage system. There are two wells supplying potable water. In general, water from the supply wells are pumped to storage reservoir #3. Pump station 3 then pumps water from reservoir #3 to reservoir #4. Pump station 4 then lifts water from Reservoir #4 to the higher elevations in the service area with the help of booster pump station 5. Water pressure in the system is maintained by a combination of pump pressure and gravity flow out of the reservoirs. Water pressure in the system is soley provided by gravity flow out of the reservoirs when the pumps are off except for services located above the elevation of 665 feet mean sea level. Services above this elevation require pumps 4 and pump 5 to provide service pressure at all times.

The following is a summary of the distribution components. The pump in Well #1 can provide approximately 500 gpm. Well #2 pump can provide approximately 350 gpm and water supplied by this well flows through a system to remove arsenic. Supply wells 1 & 2 fill reservoir #3 to a maximum elevation of 427 feet.

Pump station 3 is located adjacent to Reservoir #3. Two pumps at Pump station 3 can each provide approximately 250 gpm. These pumps fill reservoir 4 to a maximum elevation of 710 feet. These pumps also provide water directly to the distribution piping when operating.

Like pump station 3, pump station 4 Is located adjacent to a reservoir, in this case Reservoir #4. Pump station 4 is equipped with two pumps that can each provide approximately 250 gpm. Pumps at this station pump water directly into the distribution piping providing pressure for services above elevation 665 feet mean sea level.

Pump station 5 is located at an elevation of approximately 755 feet and is connected directly to the piping system. Pump station 5 is not located adjacent to a reservoir. Pump station 5 has two pumps. Each pump can provide approximately 65 gpm. Pumps at this station boost the pressure in the piping system for services above elevation 755 feet.

Reservoir #3 has a 300,000-gallon capacity. The fill elevation is approximately 407 feet in elevation and an overflow outlet of 427 feet. Reservation #4 also has a 300,000-gallon capacity. The fill elevation for Reservoir #4 is approximately 694 feet and an overflow outlet of 720 feet.

DISTRIBUTION SYSTEM COMPUTER MODEL

Several steps are required to develop a model for evaluating a distribution system. Components of the distribution system are added to the engineering model to provide the horizontal and vertical layout of piping system. Components that produce pressure to operate the system such as reservoirs and pumps are also added to the model along with the characteristics of how pressure changes with changes in flow ratees in the system. Water consumption is also added at each service location throughout the service area. However, the water consumption data is typically first evaluated to determine trends or patterns in the consumption data. Figure 1 shows the layout of the existing distribution system. Figure 2 provides a graphical presentation of the pressure zones in the system that was prepared by Solano Irrigation District (SID).

These basic steps result in an engineering representation of the physical distribution system but do not exactly reproduce the as-built system. Some simplifying assumptions about how to mathematically represent components such as pumps and pressure regulating valves are needed to insure the software mathematical iterations can converge to an acceptable answer. The inputs for the engineering model and some of the simplifying assumptions are summarized in the following paragraphs.

Piping, Valves, Meters

The distribution system computer model was prepared using WaterCAD software developed by Bentley Systems. Much of the system components in the model used record information provided by the District. RNVWD also provided electronic files containing Graphical Information System (GIS) data that provided the horizontal layout of the system. Horizontal coordinates for the GIS data imported into the model were referenced to California State Plane Zone 2 – feet (NAD83 State Plane IIF).

Pumps

Record information for pump curves for pumps in supply wells 1 & 2 were retrieved from manufacturers websites by using the pump model and the number of pump stages provided by Luhdorff & Scalmanini Civil Engineers. Record information for the pumps installed at pump stations 3 & 4 first required recording the make and model for each pump in the field and then retrieving historical pump curves. Manufacturers for these pumps have merged with other manufacturers and the historical information is not available from the original manufacturers nor the current manufacturer. However, general pump curves for the make and model of pumps at stations 3 and 4 were available from the US Department of Agriculture. Solano Irrigation District provided record information for the new pumps at station 5 and the operating conditions for the arsenic treatment system at Pump Station 1.

Design operating points for each of the pumps were converted to total dynamic head (TDH). As the modeling effort evaluated the ability of the distribution to serve water at a steady state with flow in the system determined by consumption, pumps were replaced in the model by reservoirs with a fixed hydraulic elevation and the reservoir provides an unlimited quantity of water. The hydraulic elevation was calculated by adding the TDH to the ground elevation of the pump station. Pumps stations 3 and 4 were simply eliminated from the model as these stations were represented by existing reservoirs 3 and 4. Pump stations 3 and 4 are located immediately adjacent to reservoirs 3 and 4.

Pump stations 1 and 2 were represented by a single reservoir with a fixed hydraulic elevation of 430 feet. Pump station 3 was eliminated and represented by reservoir 3 as previously mentioned. The fixed elevation for reservoir was set at half of the tanks operating range added to elevation of inlet/outlet; 407 feet. The fixed elevation for reservoir 4 was calculated like reservoir 3 with the elevation set at 706 feet.

Pump station 5 was replaced with a reservoir with a fixed elevation equivalent to maintaining at least 70 psi in the hydropneumatic tank; which is 950 feet. Replacing pump station 5 with a reservoir supplying an unlimited supply of water assumes that the distribution system is capable of continuously producing the net positive suction head (NPSH) required for the pumps at pump station 5.

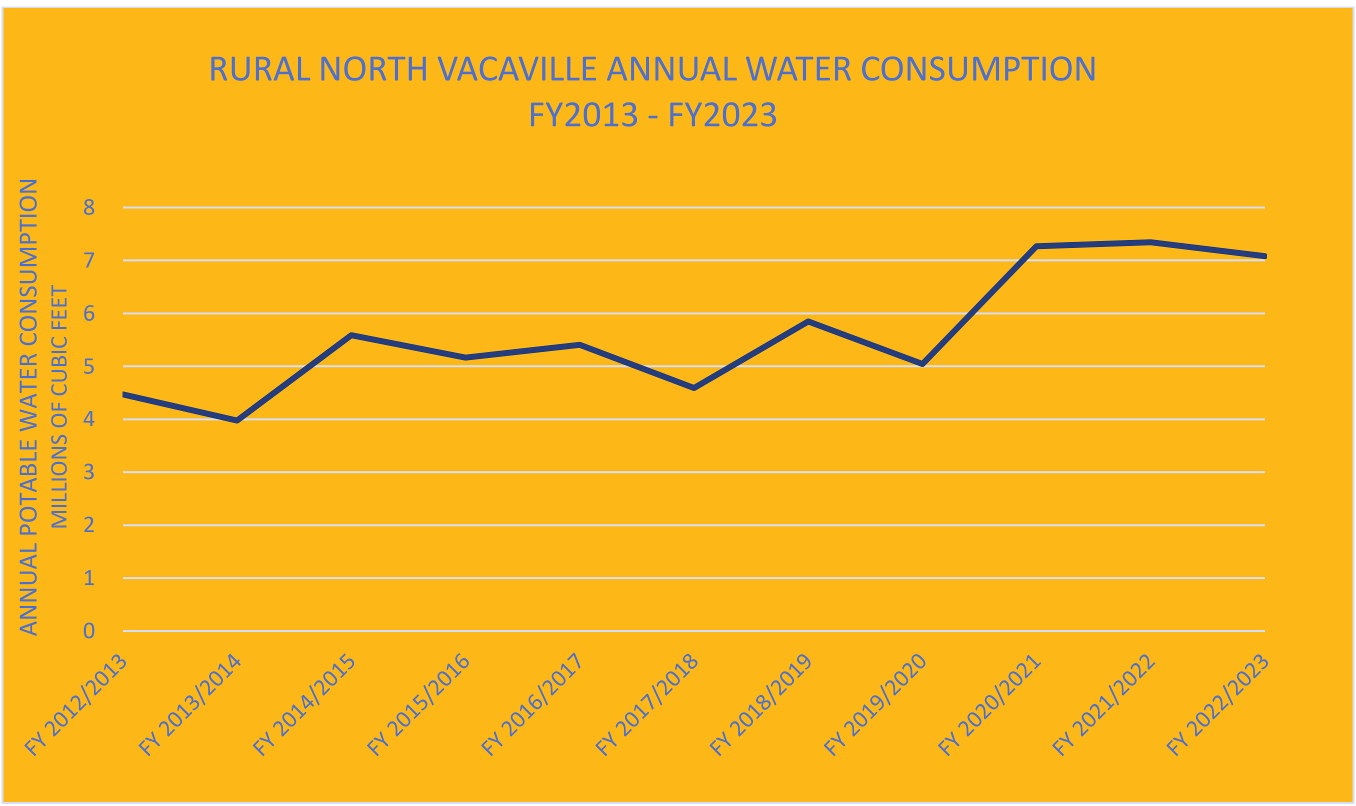
Reservoirs

Record information for existing reservoirs 3 and 4 was provided by the District. The record information included elevations for the tank inlet and tank overflow height from design drawings prepared by California Water Service Company in 2003. Coastland | DCCM confirmed the record information using topography. Water level recordings for the reservoirs was provided by Solano Irrigation District. These readings confirmed that the water levels in the reservoirs are generally maintained between 12 and 29 feet above the inlet of the reservoir. Twelve feet above the inlet/outlet was used in the model for the fixed elevation in reservoirs 3 and 4.

Water Consumption

The District provided the total annual water consumption based on meter readings for 10 calendar years 2013 - 2023. Partial data for 2024 through August was also evaluated. This data was used to evaluate the overall trend of water consumption within the District and identify years of peak annual consumption. Trends identified a significant gain in water consumption from 2019 to 2020 with a leveling in demand during the period between 2020 – 2022. Annual consumption declined in 2023. The trend in 2024 is on track to increase consumption compared to the consumption pattern in 2023. See Figure 1.

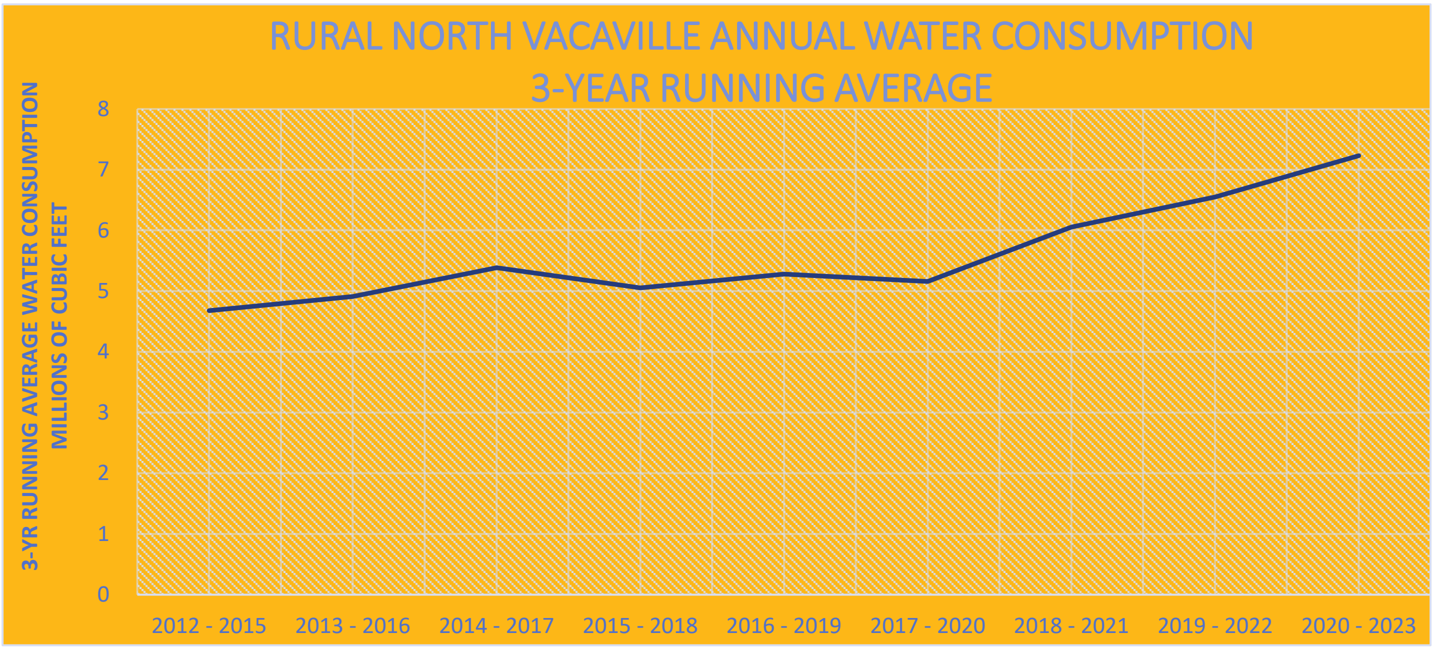
FIGURE 1



It is assumed that observed increases in potable water consumption during the period 2020 – 2022 were due to the LMU fire reconstruction and possibly due to COVID-19 restrictions. Coastland | DCCM has observed increases of water consumption during 2021 – 2022 in other water district's consumption data that correspond to COVID.

Annual water consumption was then averaged over a running three-year period to evaluate the trend in water consumption and smooth out year to year differences for weather and other variables that affect consumption. No effort was made to account for increases in water consumption due to unusual events such as the LNU Lightning Complex Fire in 2020.

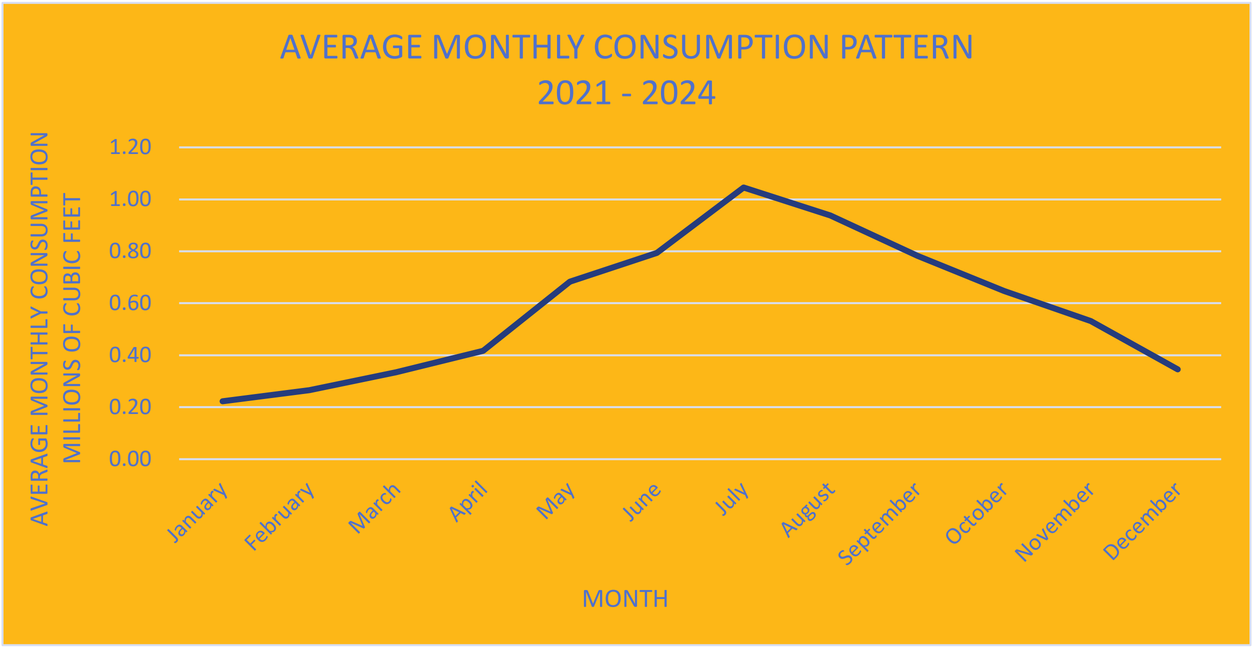
FIGURE 2



The trend shows an increase in consumption year by year within the District through 2021. Annual consumption levels off through 2023 around 7.1 million cubic feet. The running 3-year average also shows a steady increase in consumption. See Figure 2.

Water consumption within each year varies month to month due to weather related uses and user agreements by the District. There are 287 users every month of the year. In addition to these 287 users, there are another 50 users during the months starting May through October. Water consumption patterns averaged each month from 2021 through August of 2024 showed average consumption peaks in July for the District. See Figure 3.

FIGURE 3



Water demand for the model was developed from monthly consumption for January 2021 through August 2024. Because the number of users changed during the year, daily consumption per user (water service) was estimated for months with the 287 annual users separate for the months May through October when that additional 50 users consume water. Then the daily consumption per user for the two sets of users were averaged together to get the average daily consumption based on the total annual consumption that is typical for most municipal water systems. This later average was the daily consumption value used in the model to represent a typical user in the system.

The following tables 1 through 3 summarize the procedure.

TABLE 1

	AVERAGE CONSUMPTION January - April & November - December				
	2021	2022	2023	2024	Average
Jan - Apr & Nov - Dec Total (gallons)	15,355,692	21,187,100	12,178,936	8,082,140	15,840,458
Total Days	181	181	181	120	
Ave Daily Demand (gallons)	84,838	117,056	67,287	67,351	84,133
Daily Users	287	287	287	287	287
Ave Daily Demand Per User (gpd)	296	408	234	235	293
Ave Daily Demand Per User (gpm)	0.205	0.283	0.163	0.163	0.204

TABLE 2

AVERAGE CONSUMPTION May - October	2021	2022	2023	2024	Average
May - Oct Total (gallons)	37,470,312	36,711,840	35,370,676	26,082,760	33,908,897
Total Days	184	184	184	123	
Ave Daily Demand	203,643	199,521	192,232	212,055	201,863
Daily Users	337	337	337	337	
Ave Daily Demand Per User (gpd)	604	592	570	629	599
Ave Daily Demand Per User (gpm)	0.420	0.411	0.396	0.437	0.416

TABLE 3

OVERALL AVERAGE ANNUAL CONSUMPTION	2021	2022	2023	2024	Average
Annual Average per user (gpd)	450	500	402	432	446
Annual Average per user (gpm)	0.31	0.35	0.28	0.30	0.31

Peak daily demand was also estimated based on the peak month demand. July has the highest average monthly consumption. The maximum number of users also consume water during the month of July. Therefore, 337 users were included in the calculation to determine the peak daily consumption per user summarized in Table 4.

TABLE 4

PEAK CONSUMPTION - JULY

	2021	2022	2023	2024	Average
July Total (gallons)	7,674,480	7,505,432	7,693,928	8,409,764	7,820,901
Total Days	31	31	31	31	
Ave Peak Demand (gpd)	247,564	242,111	248,191	271,283	252,287
Daily Users	337	337	337	337	
Ave Peak Demand per User (gpd)	735	718	736	805	749
Ave Peak Demand per User (gpmd)	0.51	0.50	0.51	0.56	0.52

The final model input related to consumption is the peaking factor. This factor is the ratio of the average peak daily demand to the average daily demand. Table 5 summarizes the calculation.

TABLE 5

MODEL PEAKING FACTOR ESTIMATE

	2021	2022	2023	2024	Average
Annual Average per user (gpm)	0.31	0.35	0.28	0.30	0.31
Ave Peak Demand per User (gpmd)	0.51	0.50	0.51	0.56	0.52
Peaking Factor	1.6	1.4	1.8	1.9	1.7

Distribution Model Data Import

The model for the District's distribution system was developed in WaterCAD software. Components from the GIS data were first extracted into CAD software and then imported into WaterCAD modeling software using the ModelBuilder application in WaterCAD. ModelBuilder was then used to verify that all of the components were connected together forming a unified distribution system.

GIS records lacked elevation data for system components. Two approaches were used to assign elevation data. There are relatively few reservoir and pump components. Therefore, it was quickest to assign elevation data by hand to these components. Hand input data came from record drawing information.

While reservoir and pump elevations were assigned by hand, elevations for other distribution system components such as pipes, valves, hydrants, pressure reducing valves, and meter locations were assigned automatically using the TerrainBuilder application of WaterCAD. This process required importing a freely available digital elevation model (DEM) created by the USGS in 2018 and then 'draping' the distribution model components onto the DEM. These elevations reference North American Vertical Datum (NAVD88). Elevations derived from the DEM should be considered accurate to plus or minus 1/2 meter (1.6 feet) as the source of data is satellite LiDAR (1 meter resolution).

Water Consumption Values Assigned to Meters

Evaluation of month-to-month water consumption for meters throughout the system varied significantly. However, the changes in monthly consumption did not seem to correlate with predictable patterns of use such as irrigating crops or landscaping, cold versus warm weather patterns, or morning versus evening uses. To compensate for the apparent lack of water consumption patterns, the average monthly consumption from 2020 through August of 2024 was converted to an average daily demand in the overall system and then converted to an average demand per day per service. Peak daily demand for the District services were estimated by examining the total consumption per month to identify the highest month of consumption and then convert that average monthly consumption to an average peak day demand per service.

MODELING SCENARIOS

WaterCAD evaluates the performance of the distribution system for potable water supply by distributing the potable water demand to each service location in the system and then calculating the residual pressure at each node/junction defined in the network. Fire water supply to hydrants was evaluated differently. WaterCAD sets a minimum pressure for all hydrants in the system, sets the potable water demand at the defined flow rates for all potable water service locations and then calculates the flow rate that the system can supply at each fire hydrant location. Model results identify locations in the distribution system where the required flow rate for a hydrant is less than 250 gpm at 20 psi.

Two scenarios were used to evaluate the system's capacity to provide potable water at 40 psi residual pressure: average day consumption per water service location and peak day demand per location. Two additional fire water scenarios were evaluated as a companion to the potable water scenarios; 250 gpm at a hydrant with 20 psi residual for fire flow supply and the average day water potable water consumption in the piping system and 250 gpm at a hydrant with 20 psi residual for fire flow and the peak day water potable water consumption in the piping system.

One additional scenario was performed to determine the maximum hydraulic capacity of the piping system (maximum flow rate of water) at 40 psi while also delivering fire water to hydrants in the system at a flow rate of 250 gpm with a pressure of 20 psi. This was an iterative process. The consumption for the services in the model was incrementally increased until the potable water pressures dropped below 40 psi in a pipe segment other than pipe segments identified in the average day and peak day scenarios described in previous paragraphs. For example, there are locations in the piping system where 4-inch diameter pipes exceed 150 lineal feet in length that are estimated to be less than 40 psi and there are a couple of services at high elevations in the system that receive potable water at less than 40 psi pressure. The maximum hydraulic capacity condition occurred when 471,750 gallons per day flowed through the piping system.

DISTRIBUTION CAPACITY CONCLUSIONS

Model results for the distribution system identified limited areas where estimated pressure in the piping system would fall below 40 psi during average day water consumption. These areas also correspond to areas where hydrant fire flow would drop below 250 gpm when the pressure reaches 20 psi at than individual hydrant during average day water consumption. The aerial extent of the locations increases slightly when the peak day water consumption is used in the model. There are also areas where the distribution system can provide a residual pressure of 40 psi but fall short of the need fire flow at 20 psi. Areas where the distribution system pressure is below requirements are shown in Figure 3.

It should be noted that the pressures in the water system were calculated for the elevation of the water meter. Pressures at habitable structures on a property could be higher or lower than the estimated pressures at the meter if the finished floor of the structure is higher or lower in elevation relative to the service meter.

It should also be noted that the residual pressures are calculated values based on several assumptions about water use in the system and friction characteristics of the pipe material. There could also be small errors in the topographic elevation for components. Five percent should be considered the assumed accuracy of the model. Therefore, three areas identified on Figure 1a may provide the required residual pressure when measured in the field.

An estimate of the maximum hydraulic capacity of the current piping system is predicted to be 471,750 gallons. Because the hydraulic capacity is a maximum capacity, the maximum number of available services for the piping system was estimated using the average peak day demand per service. Therefore, the piping system can supply 630 services consuming 749 gallons per day during the peak month of consumption of July.

Modeling of fire hydrants demands throughout the distribution system identified hydrants at or below the required flow rate for fire hydrants. Results identified hydrants in geographical areas that are below the 250-gpm flow rate when the residual pressure is 20 psi. These areas are generally located near the perimeter areas of the system or at the end of short distribution runs serving areas with higher topographic elevations.

Extending the existing hydrant network beyond its current aerial extent has limited possibilities. Mains in many locations within the distribution system are 4-inch diameter pipes. Adding hydrants beyond the current extent of the distribution system would not likely meet the minimum flow criteria for a hydrant of 250 gpm when the residual pressure is 20 psi if extending an existing 4-inch pipe. High flow rates through small diameter pipes resulting in significant friction head loss due to high velocities in the pipes. Therefore, extending 4-inch diameter pipes would fail to provide needed pressures and flow rates. The variability of the topography also limits expanding into areas outside the current service area that are high in elevation. Opportunities to extend the network of hydrants might be possible further west on Cantelow Road and further south on Gibson Canyon Road. These locations have 6-inch distribution mains.

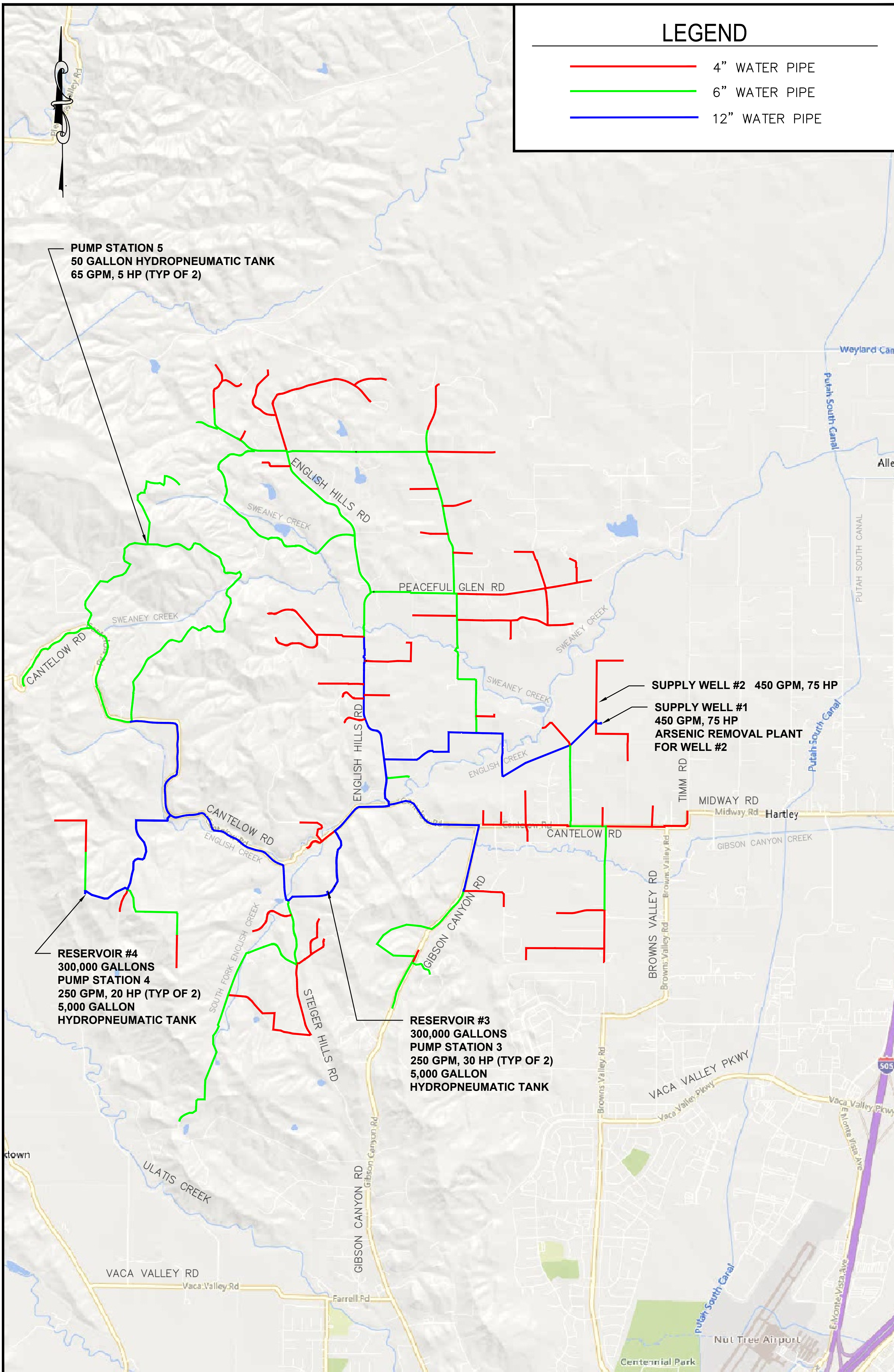
Within the limits of the current service area, sufficient pressure is available to provide service for both potable water and fire water to 630 services. This estimated number of services is the capacity of the buried distribution piping for the estimated peak average day demand. As stated previously, the ultimate capacity of the District was 873 services based solely on the current available supply of water for the District. While there is water to supply 873 connections, the buried piping system can only distribute water to 630 services.

Because the terrain varies within the District, the County and VFPD will likely require that owners of new service connections demonstrate that residual pressure and flow rate requirements are met given the available pressure in the distribution main. The District's current distribution system model can be used to predict the pressure in the distribution main at the property frontage. Owners of the new connections will need to demonstrate compliance with regulations between the distribution main and structures on the parcel.

We appreciate the opportunity to provide this evaluation of your distribution. If you have any questions regarding the report and its conclusions, please contact me.

Sincerely,

Hugh Miles, PE C49427
Supervising Engineer



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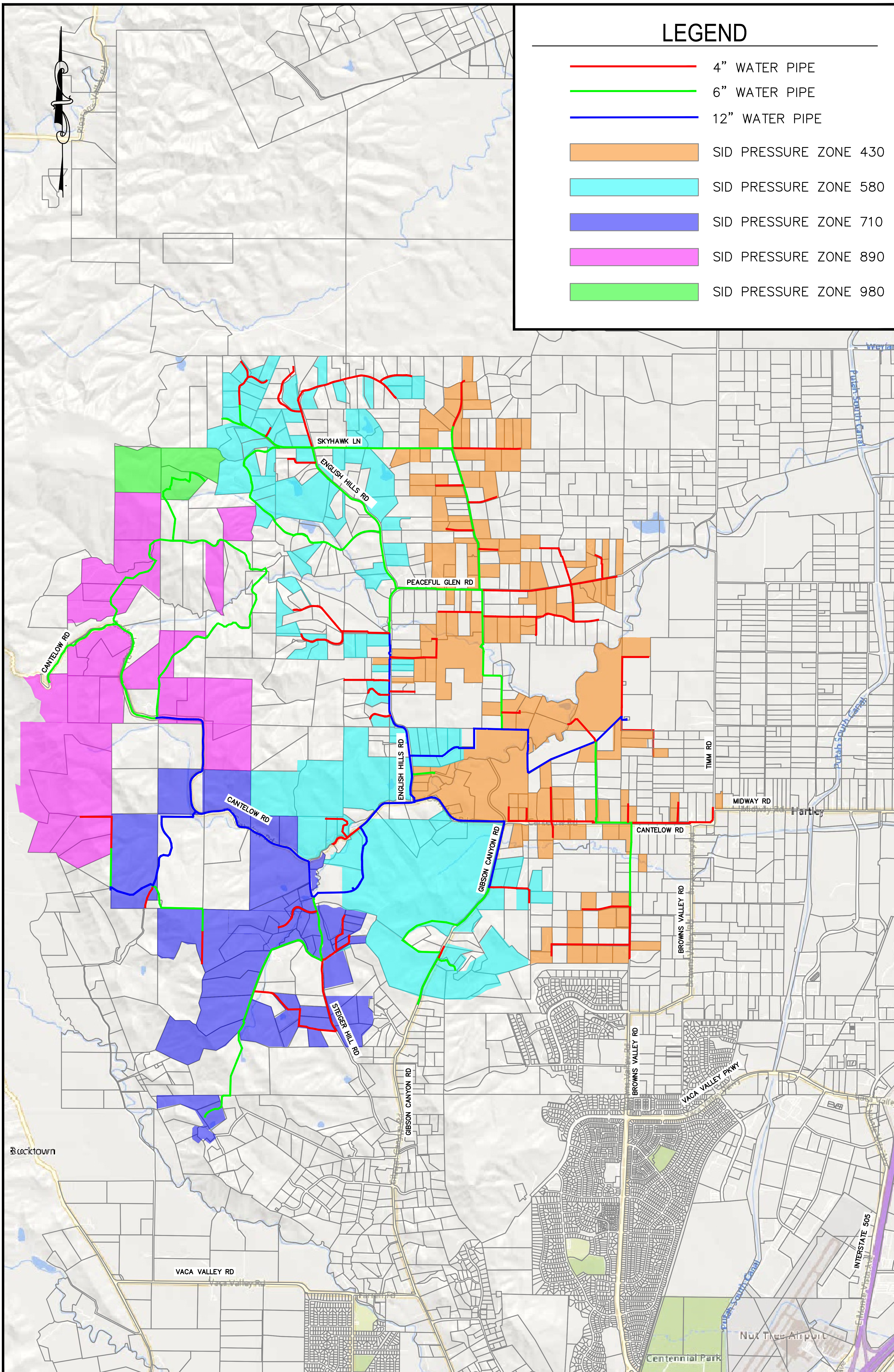
			1"=2500'	HM	FIGURE 1 EXISTING DISTRIBUTION SYSTEM



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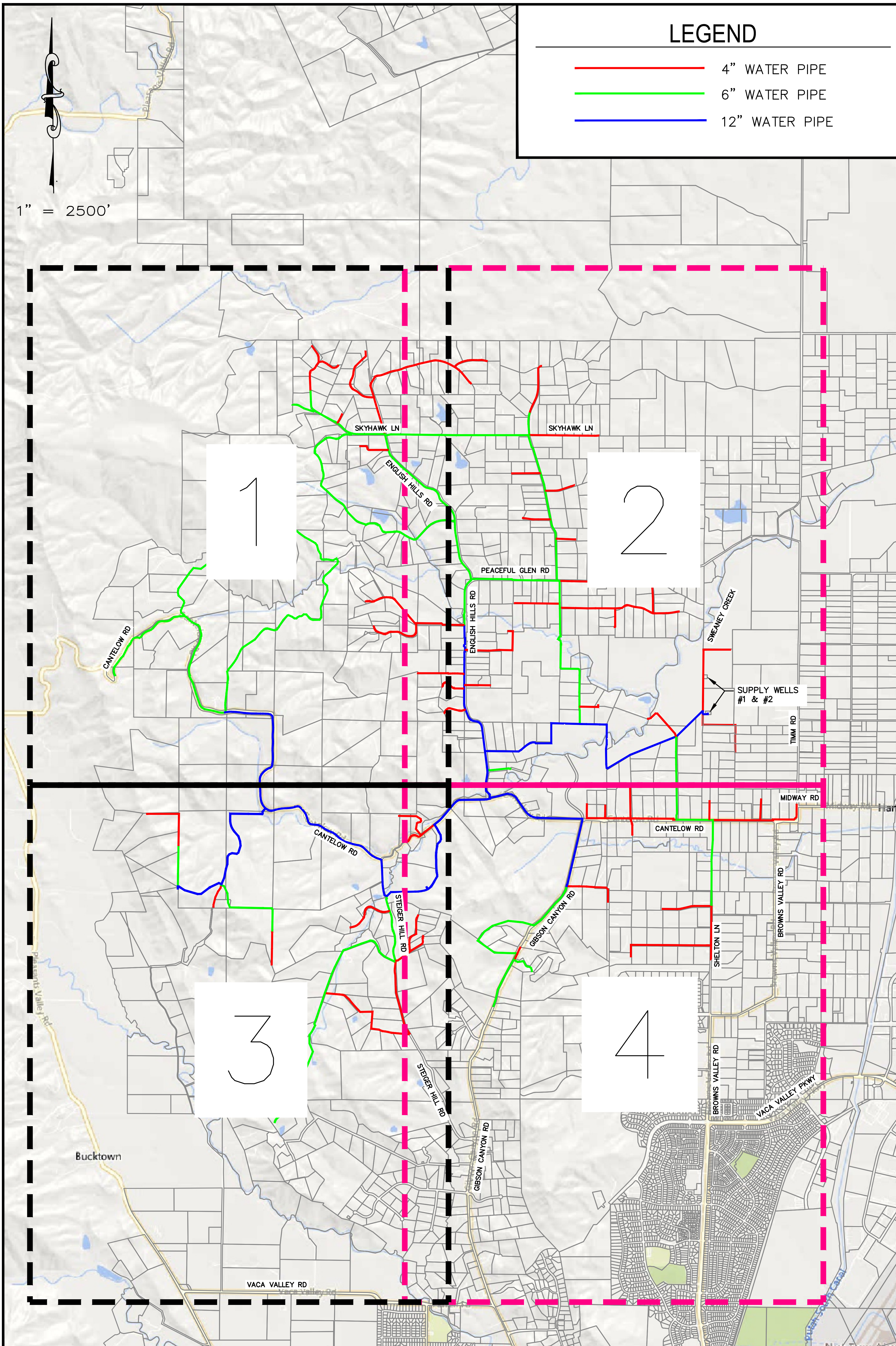
09/13/2024	KL	RURAL NORTH VACAVILLE
1"=2500'	HM	FIGURE 2 SID PRESSURE ZONES MAP

FIGURE 2
SID PRESSURE ZONES MAP



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	1" = 2500'	HJM	FIGURE 3 SYSTEM MODEL RESULTS KEY MAP
	SHEET 1 OF 5		

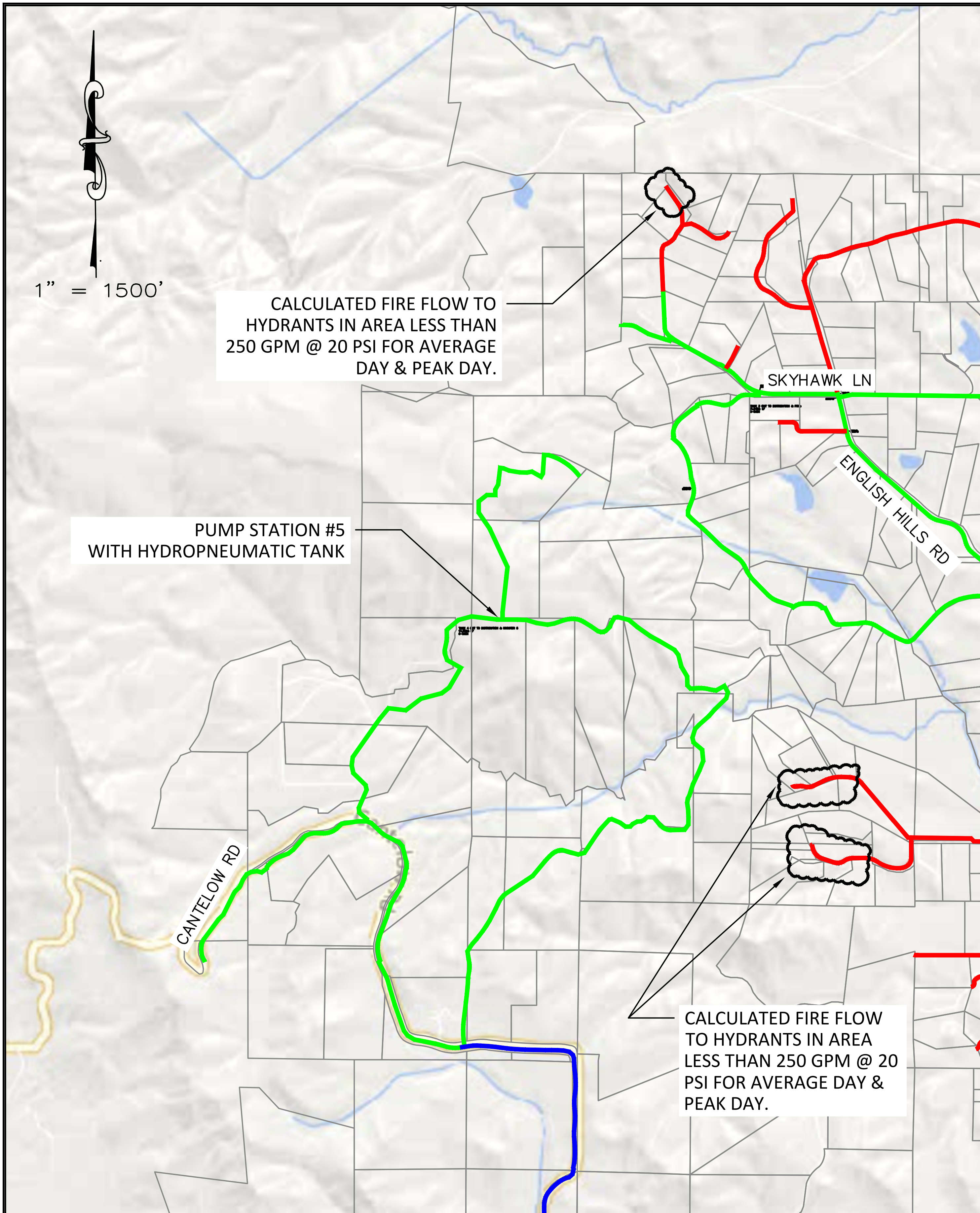

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FIGURE 3a SYSTEM MODEL RESULTS MAP 1

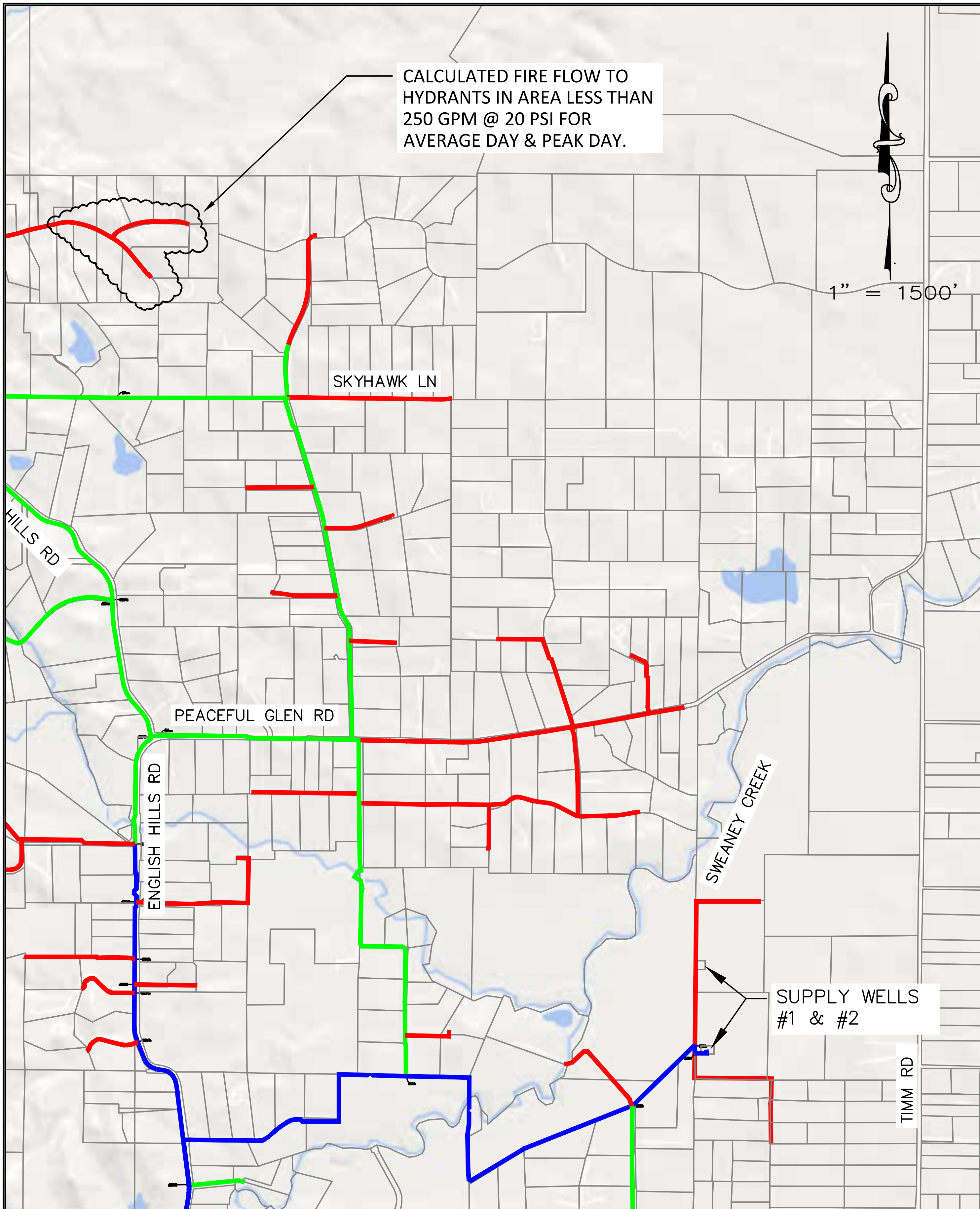

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FIGURE 3b SYSTEM MODEL RESULTS MAP 2

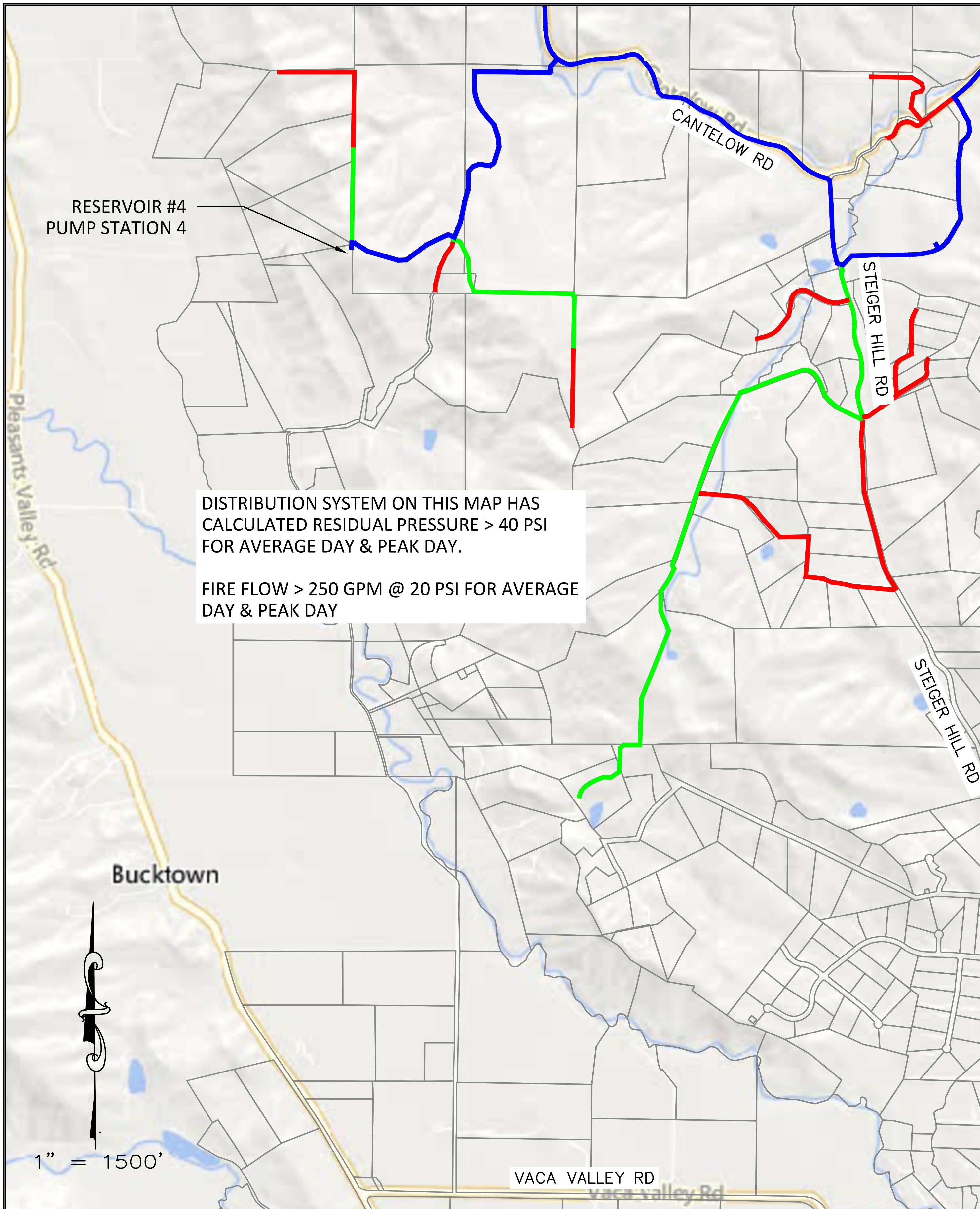

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FIGURE 3c SYSTEM MODEL RESULTS MAP 3

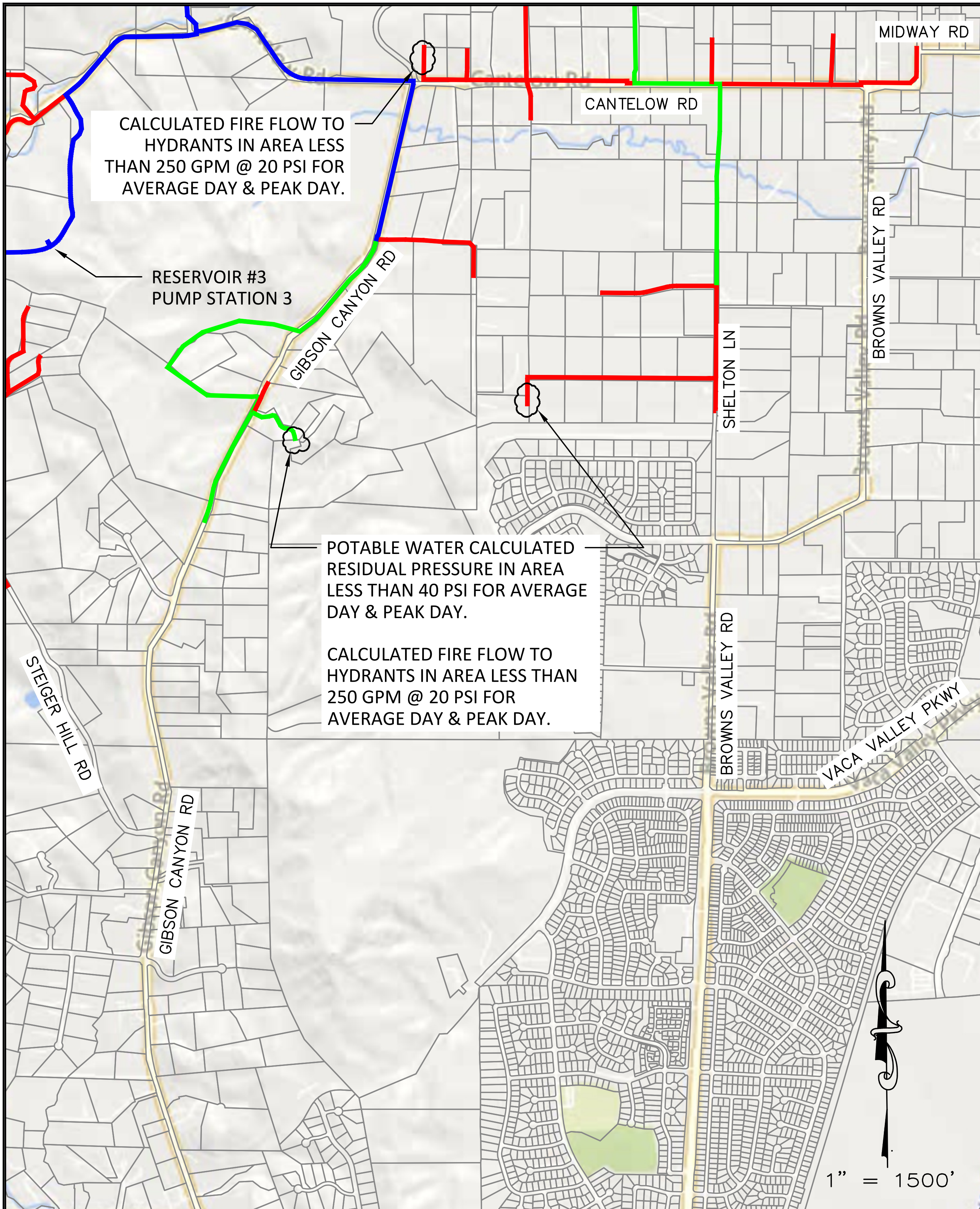

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FIGURE 3d SYSTEM MODEL RESULTS MAP 4