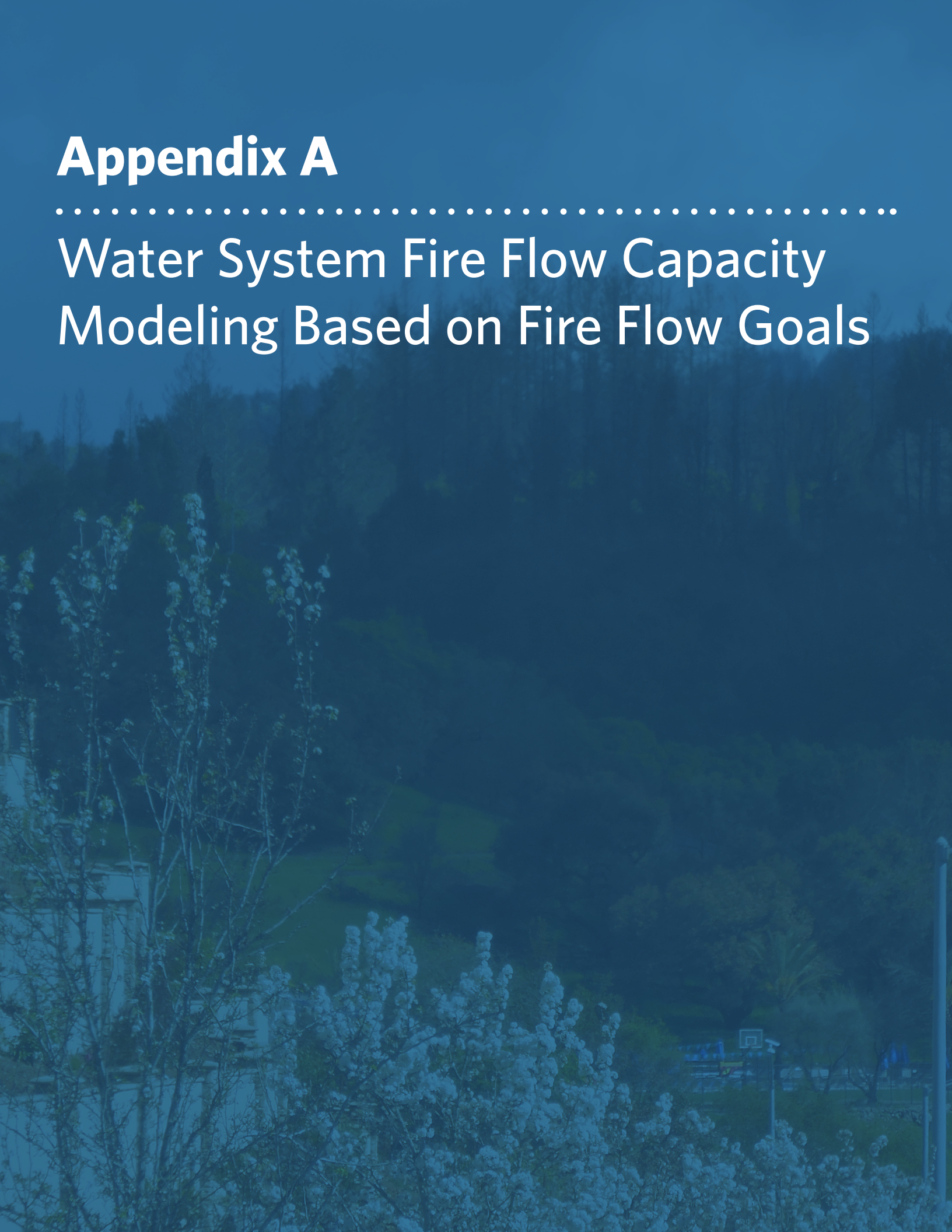
Appendix A

Water System Fire Flow Capacity Modeling Based on Fire Flow Goals

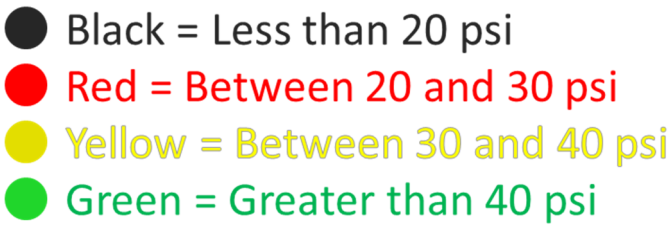


Appendix A. Water System Fire Flow Capacity Modeling Based on Fire Flow Goals

Fire flow capacity modeling was performed to show the areas of the system that are capable of providing fire flows of 1,500 gpm for a duration of 2 hours, which is the goal of the water system based on the minimum fire flow requirements in the City Fire Code. These scenarios used the operations and demands occurring during the first week of October as a basis for the modeling operations and demands. These scenarios simulated a fire flow at each model junction which represents a system valve, fitting, or cap but no an actual hydrant and the result was a calculated pressure at each junction that would be experienced if the noted flow occurred.

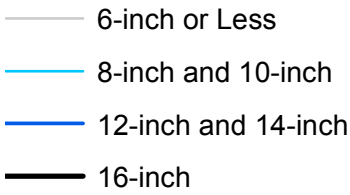
Pressures less than 20 psi at a junction indicate that there is a potential deficiency in the system to meet that fire flow. Many structures might require fire flows of less than 1,500 gpm and a few could require more than 2,500. However, this was selected as the evaluation criteria to evaluate the capability of the system to provide the fire flow goal of the water system.

The following symbology is used in these figures at each junction:



Black symbolized junctions indicate that there is a *potential* deficiency in meeting the fire flow at that location. It should be noted that many residential locations could require a fire flow of less than 1,500 gpm as calculated by industry best-practices but the minimum required fire flow base on City Fire Code is 1,500 gpm.

Pipes are shown by the blue lines and symbolized by diameters as such:



The red outlines show the pressure zone boundary for the zone in question, as well as any subzones that are fed through the main zone through pressure regulating valves.

PRESSURE ZONE R17

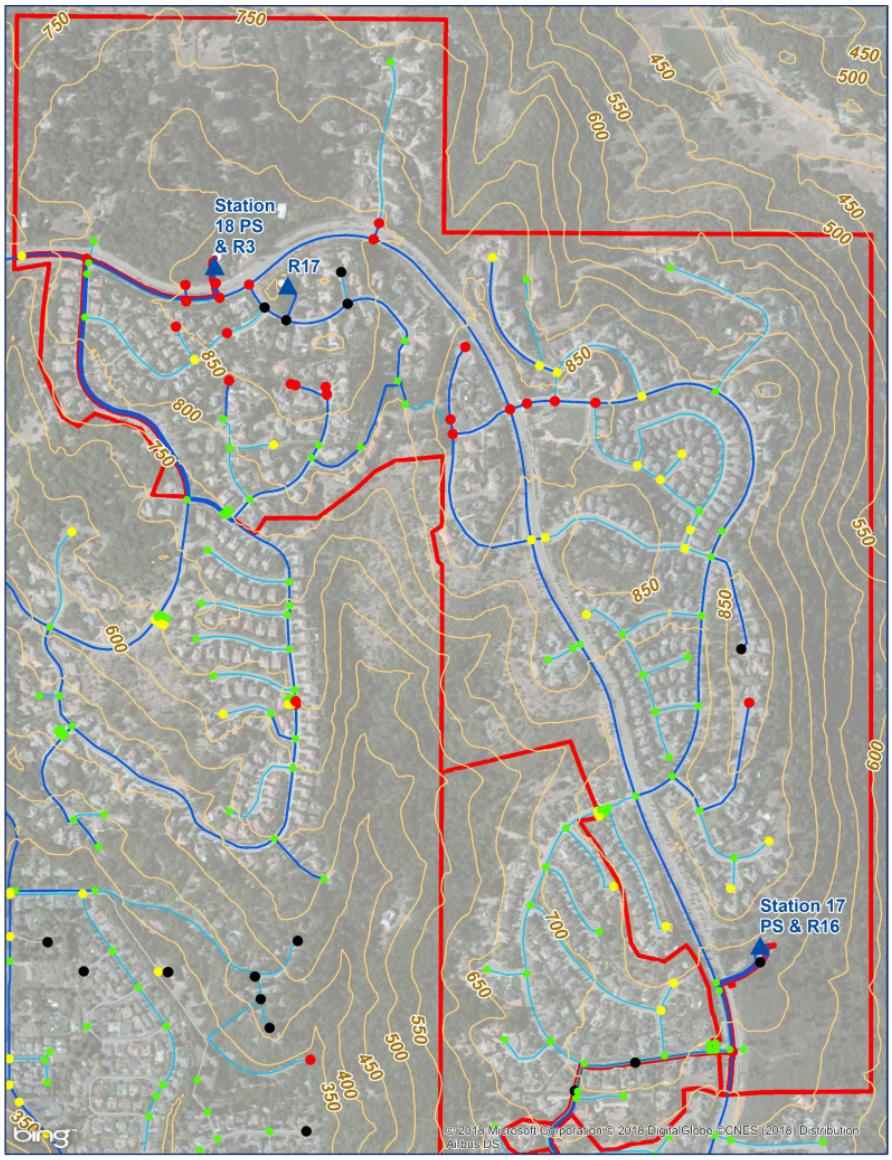


Figure A-1 Pressure Zone R17, Pressures for 1,500 gpm Fire Flow

- There are high ground areas within the R17 Pressure Zone where 1,500 gpm could not be met without dropping below 20 psi. These areas occur directly near the R17 tank site along high ground and at the east of the Pressure Zone in at the end of a dead-end pipe.
- Other than the areas noted above, all other areas could meet a fire flow of 1,500 gpm at pressures greater than 20 psi.

PRESSURE ZONE R16

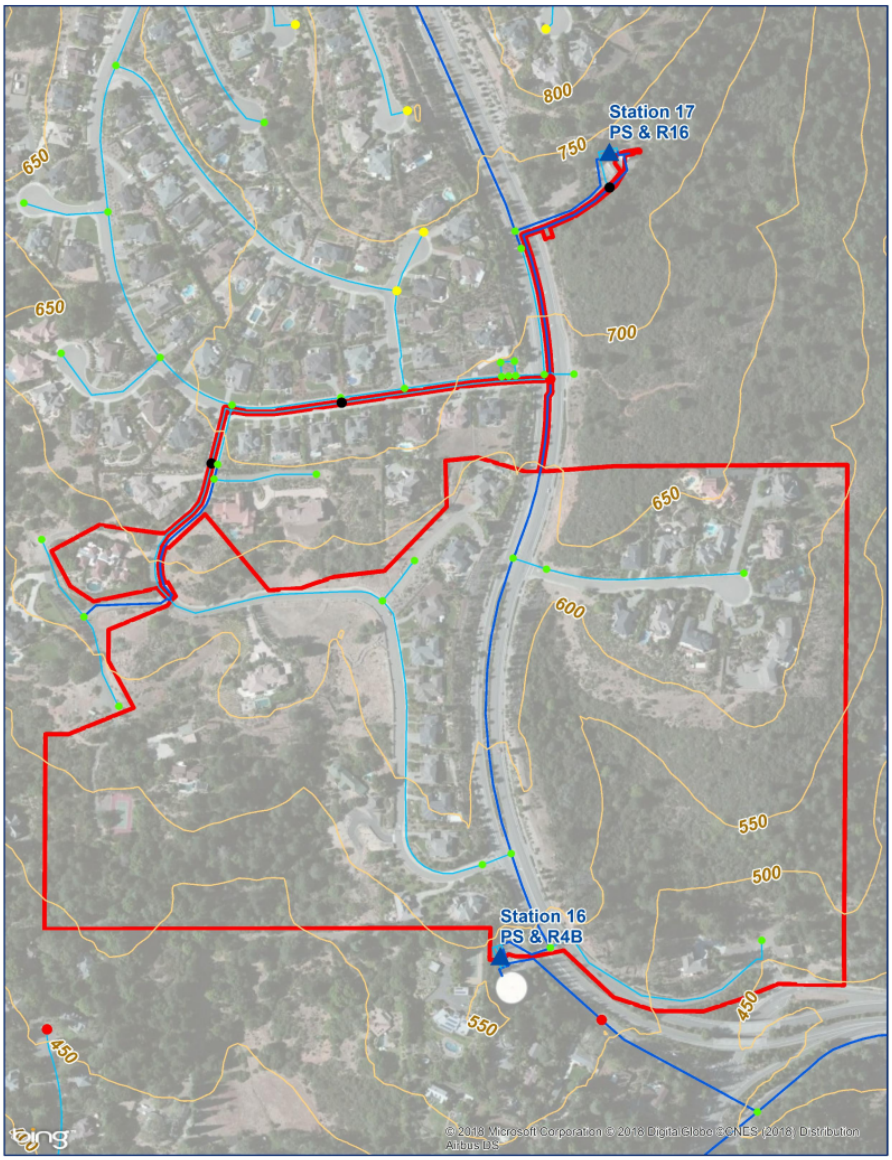


Figure A-2 Pressure Zone R16, Pressures for 1,500 gpm Fire Flow

- There are a few areas where fire flow of 1,500 gpm would result in pressures less than 20 psi on the northwest. However, these pipes are supply lines to Tank R16 and do not have any connections that provide domestic or fire service to the zone. There are Pressure Zone R16 pipes running parallel to the supply line which provide the needed fire flow of 1,500 gpm at these locations (note that there are green junctions adjacent to those shown in black).

PRESSURE ZONE R5

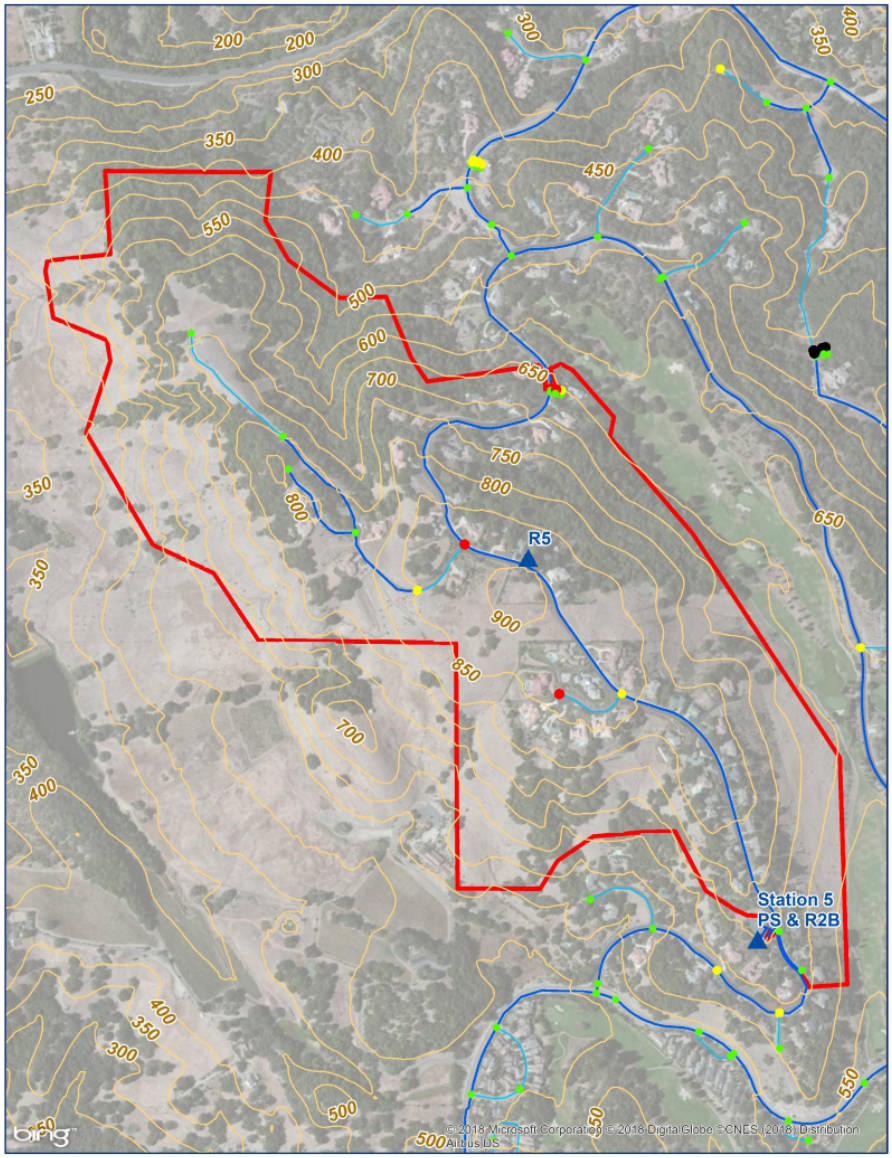


Figure A-3 Pressure Zone R5, Pressures for 1,500 gpm Fire Flow

- All locations in Pressure Zone R5 would be able to supply a fire flow of 1,500 gpm at pressures greater than 20 psi. This is possible because of the high-flow pumping capacity of Station R5.

PRESSURE ZONE R4

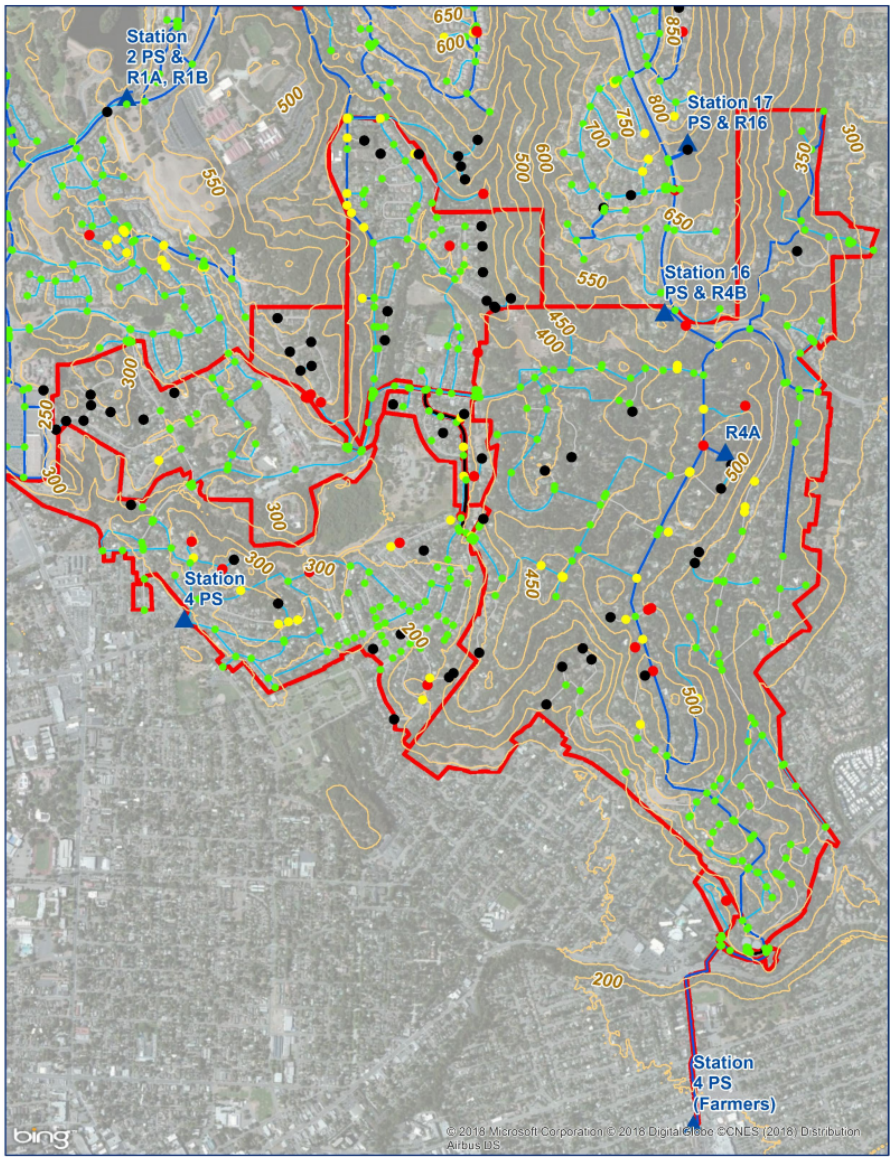


Figure A-4 Pressure Zone R4, Pressures for 1,500 gpm Fire Flow

- There are many locations within Pressure Zone R4 that are not likely to provide fire flows of 1,500 gpm at pressures greater than 20 psi. These are the result of small diameter mains and dead-end pipes. Pipes that are 6-inches or less in diameter and non-looped areas will have difficulty providing 1,500 gpm at pressures greater than 20 psi. Many of these, including all the 4-inch diameter pipes, will not have hydrants along them.
- In the main body of the memo it is suggested that some of the small diameter mains should be considered candidates for replacement with larger pipes if they are found to have hydrants along them.

PRESSURE ZONE R3

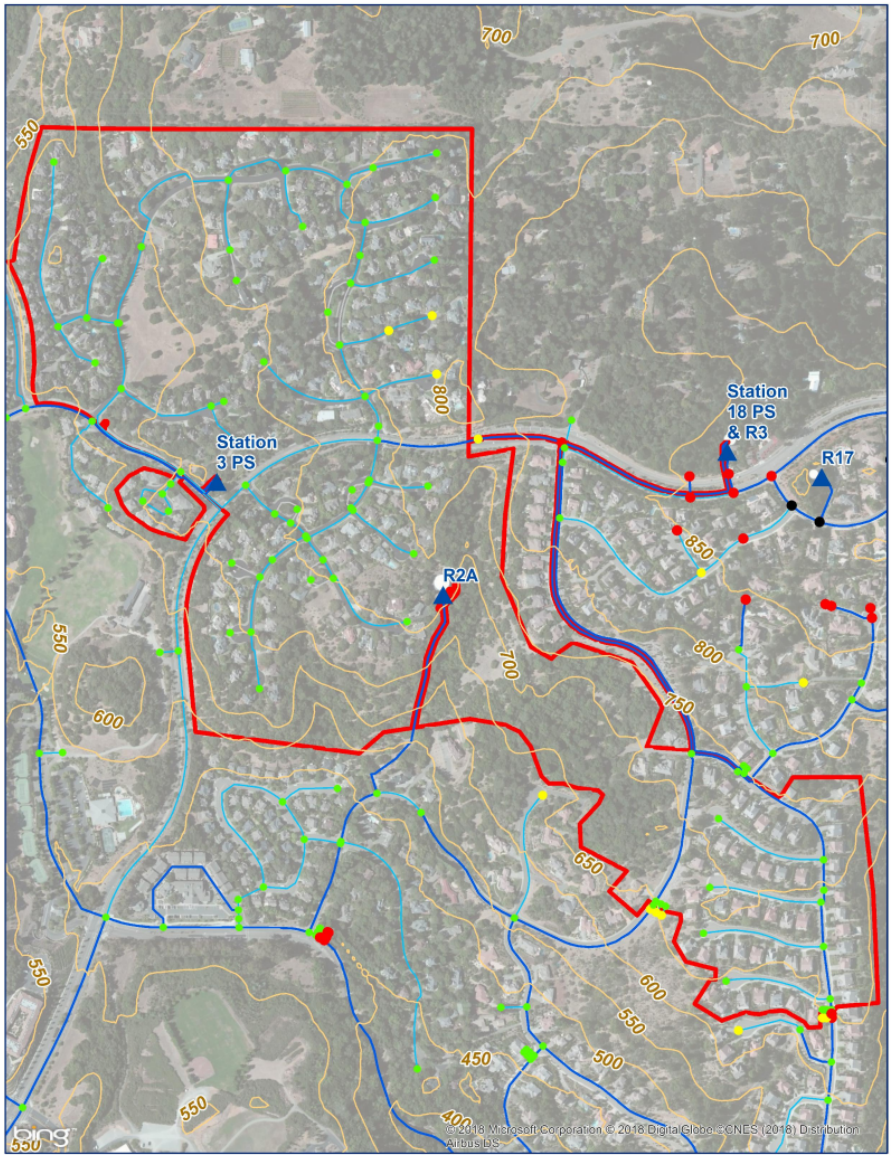


Figure A-5 Pressure Zone R3, Pressures for 1,500 gpm Fire Flow

- All areas within Pressure Zone R3 are capable of providing fire flow of 1,500 gpm at pressures greater than 20 psi.

PRESSURE ZONE R2

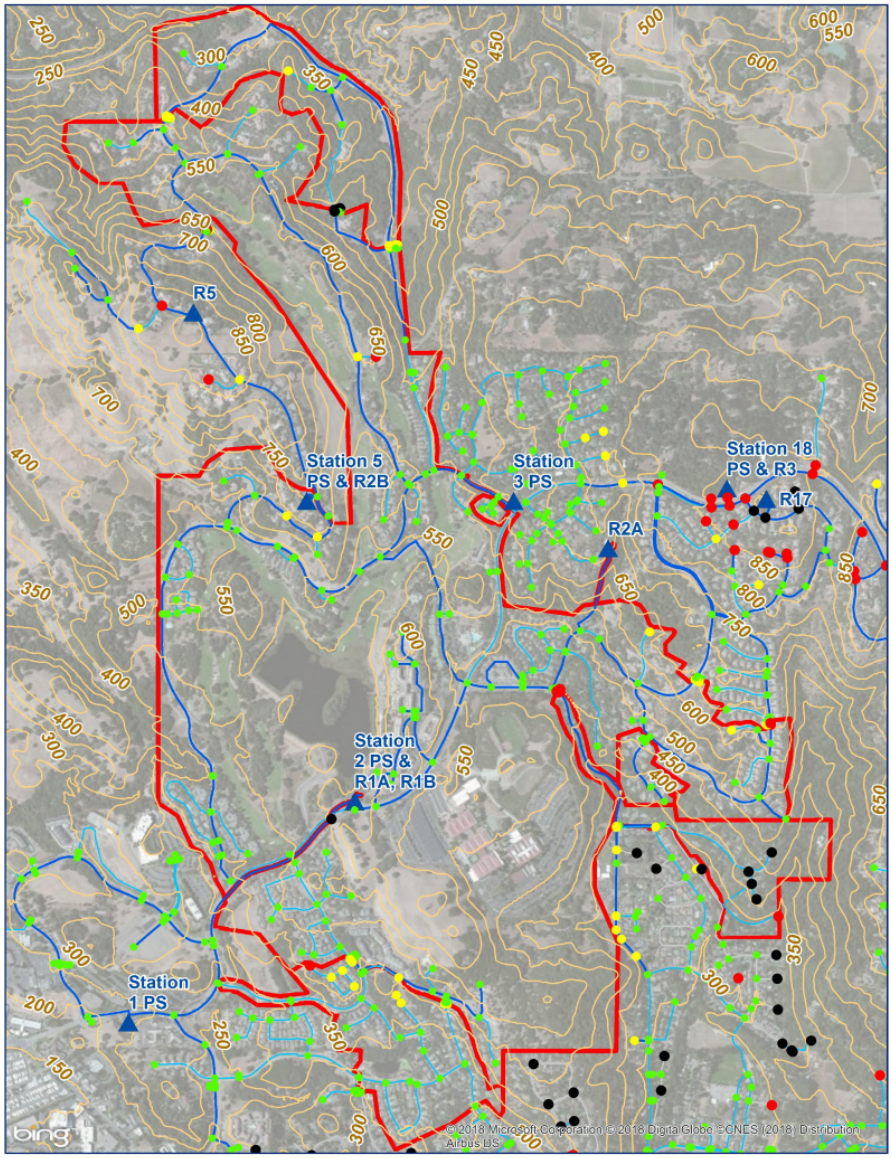


Figure A-6 Pressure Zone R2, Pressures for 1,500 gpm Fire Flow

- All areas in Pressure Zone R2 are capable of providing a fire flow of 1,500 gpm at pressure greater than 20 psi with the exception of the isolated area at the east to the south. This is an isolated section of pipe, and although it is an 8-inch pipe, the long length would cause significant head-loss with flows at 1,500 gpm.

PRESSURE ZONE R1

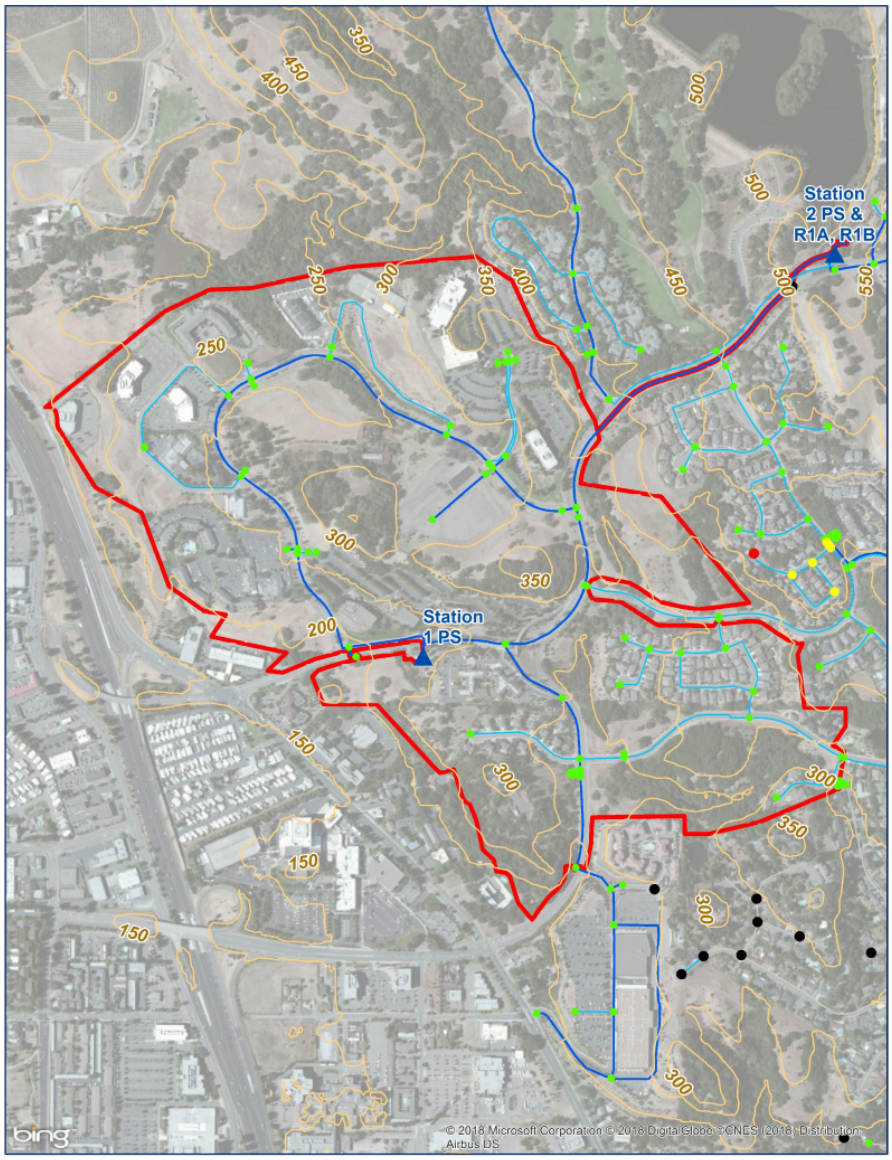
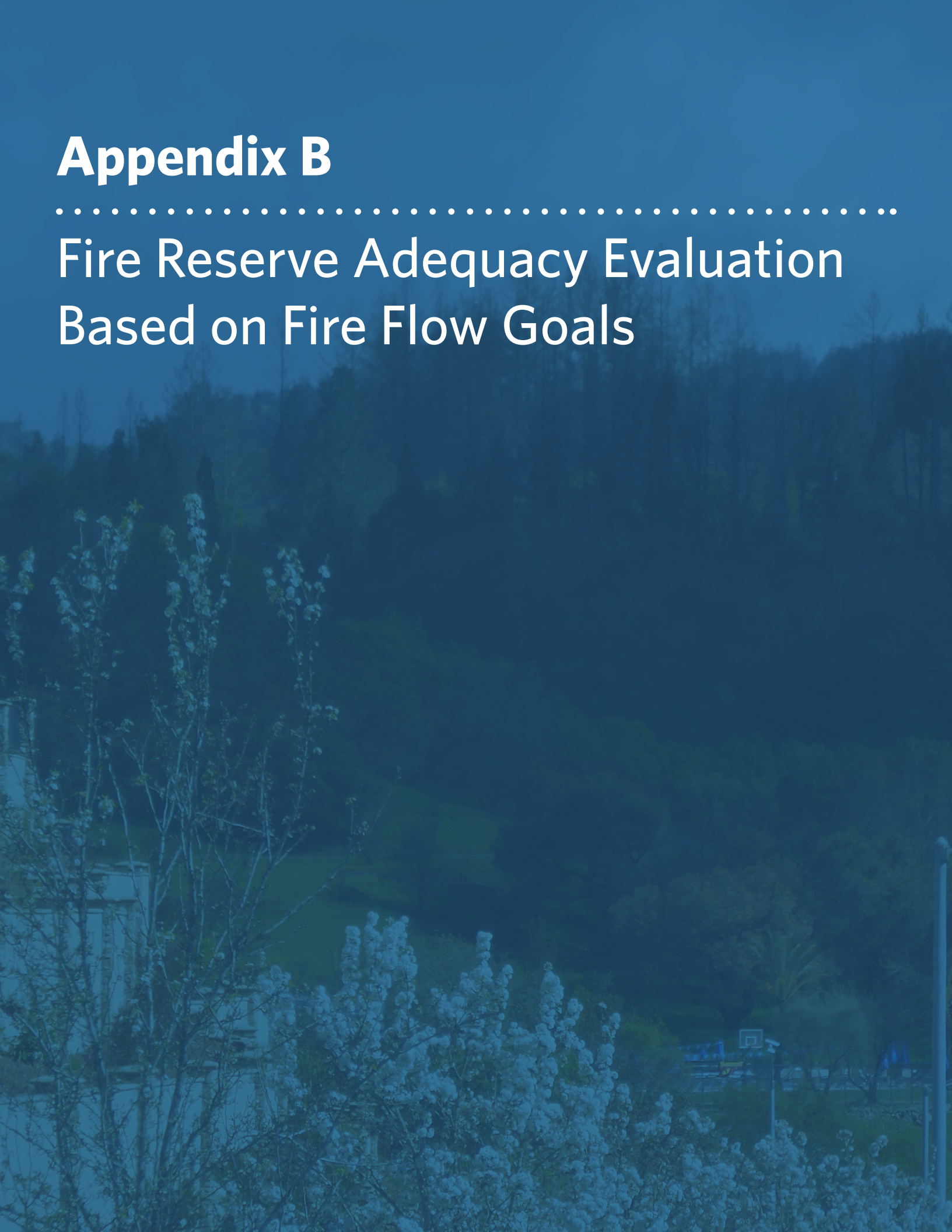


Figure A-7 Pressure Zone R1, Pressures for 1,500 gpm Fire Flow

- All areas within Pressure Zone R1 can support fire flows of 1,500 gpm at pressures greater than 20 psi.

Appendix B

Fire Reserve Adequacy Evaluation Based on Fire Flow Goals



Appendix B. Fire Reserve Adequacy Evaluation Based on Fire Flow Goals

The previous appendix showed the capability of the system to provide fire flows of 1,500 gpm for a duration of 2 hours at pressure greater than 20 psi. However, the analysis did not evaluate the impact to storage within each pressure zone that would occur. To fully evaluate the impact to storage and the fire reserve adequacy in each pressure zone, extended period simulation (EPS) fire flow evaluations were performed. These evaluations applied a fire flow demand to a specific junction over a duration and reviewed the impact to storage during the simulation.

Figure B-1 shows the model results, by tank, for tank levels the week prior to the fire. This provides the baseline for comparisons with other model results. The points (red square, blue circle, and green triangle) show the maximum, average, and minimum tank levels that occurred over the week prior to the fire in the October data provided. The model controls for these EPS evaluations were based on the data provided in an attempt to mimic as closely as possible the same tank levels over the EPS scenario that had occurred in the system in October before the fires. The red, blue, and green line series show the model results as they relate to the points. This shows that the model closely resembled the actual system operations and that the results of the EPS fire flow evaluations were reasonable to draw conclusions from.

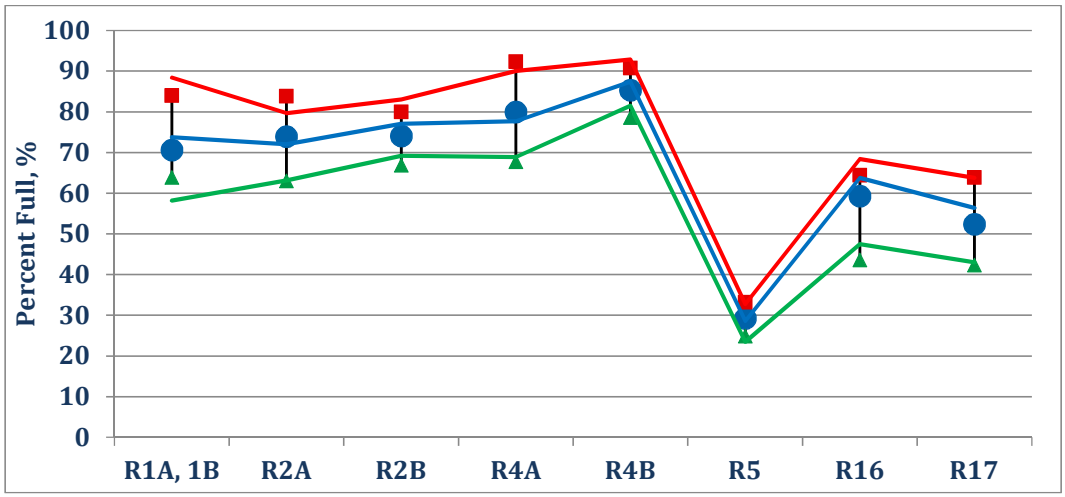


Figure B-1 Observed (point) maximum, minimum, and average tank levels vs. Modeled (line) maximum, minimum, and average tank levels in Week Prior to the Fire

The following figures by pressure zone show the tank levels over a 24-hour period without fire demand (blue series), with a fire demand of 1,500 gpm for a duration of one hour (red series). Many pressure zones also have the ability to provide additional pumping capacity in the case of a fire which could take the place of additional storage. However, these evaluations excluded back-up pumping for a pure evaluation of storage contained within each individual pressure zone.

PRESSURE ZONE R17

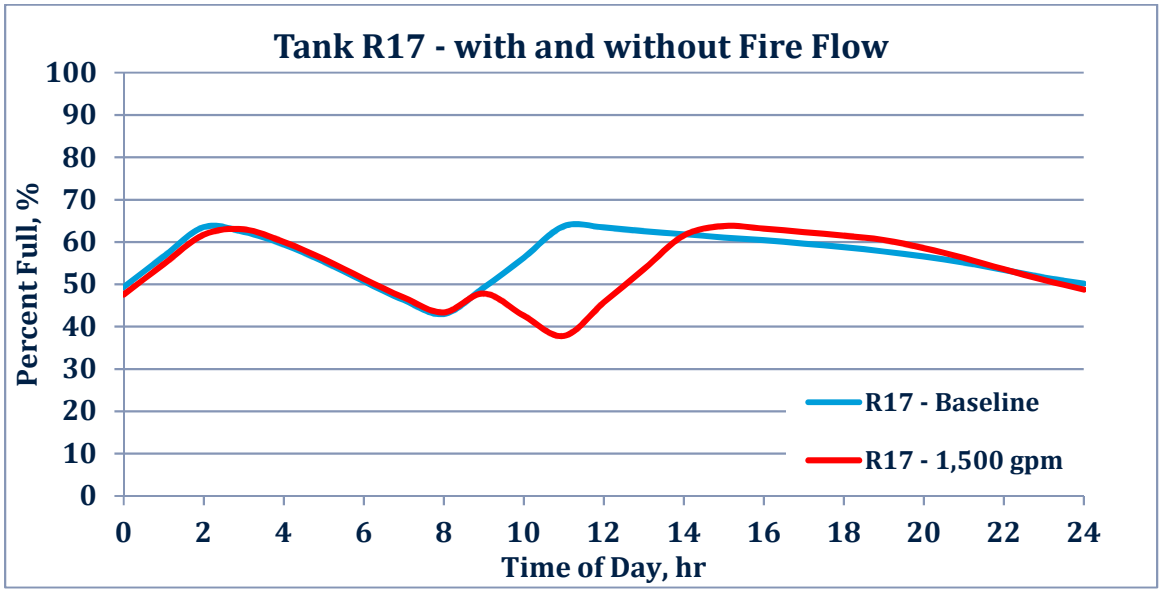


Figure B-2 Pressure Zone R17 Storage Adequacy Evaluation

The model results show that Pressure Zone R17, with Tank R17 operating the way it did during the first week of October (at lower percent full) is capable of providing the 1,500 gpm fire flow over a duration of 2 hours without running out of storage volume.

PRESSURE ZONE R16

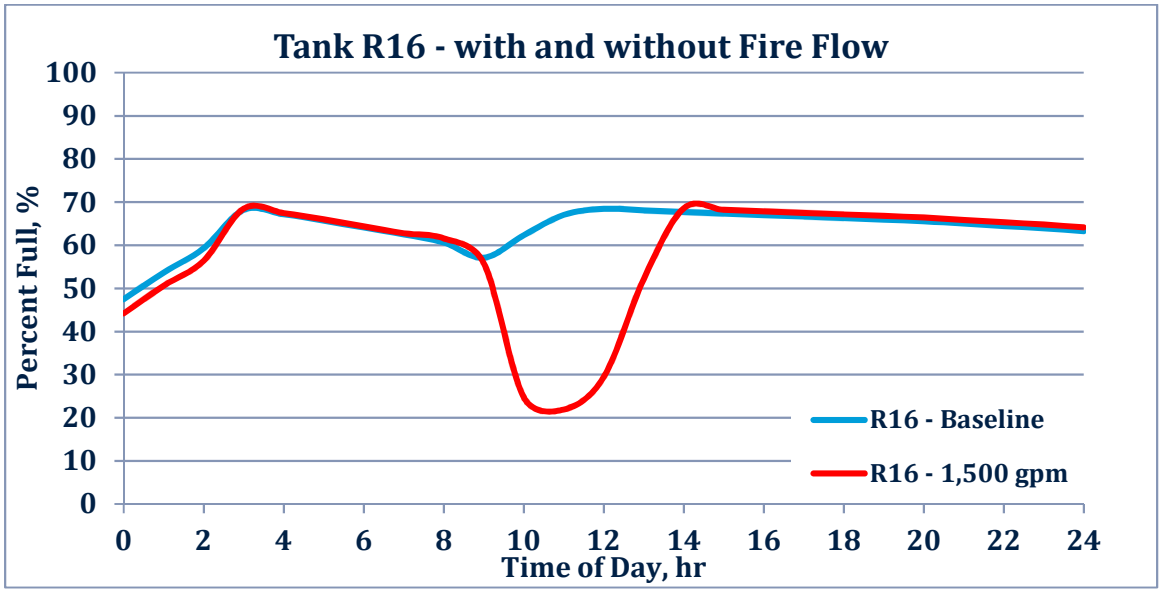


Figure B-3 Pressure Zone R16 Storage Adequacy Evaluation

The model results show that Pressure Zone R16, with the Tank R16 operating the way it did during the first week of October (at lower percent full) is capable of providing the 1,500 gpm fire flow over a duration of 2 hours without running out of storage volume.

PRESSURE ZONE R5

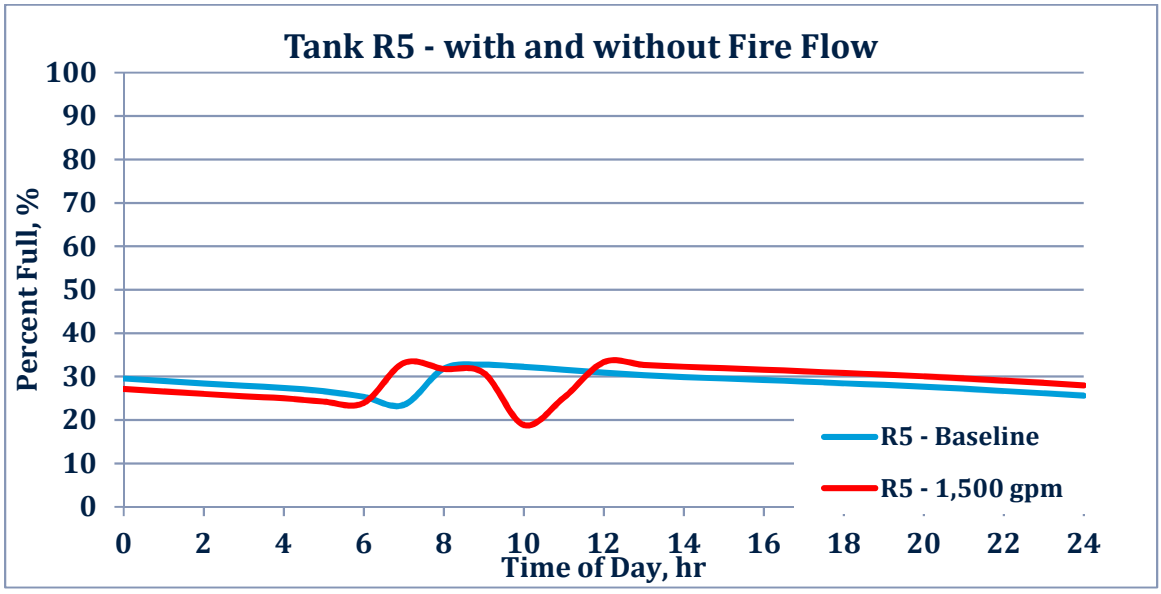


Figure B-4 Pressure Zone R5 Storage Adequacy Evaluation

The model results show that Pressure Zone R5, with Tank R5 operating the way it did during the first week of October, can provide the 1,500 gpm fire flow over a duration of 2 hours without running out of storage volume.

PRESSURE ZONE R4

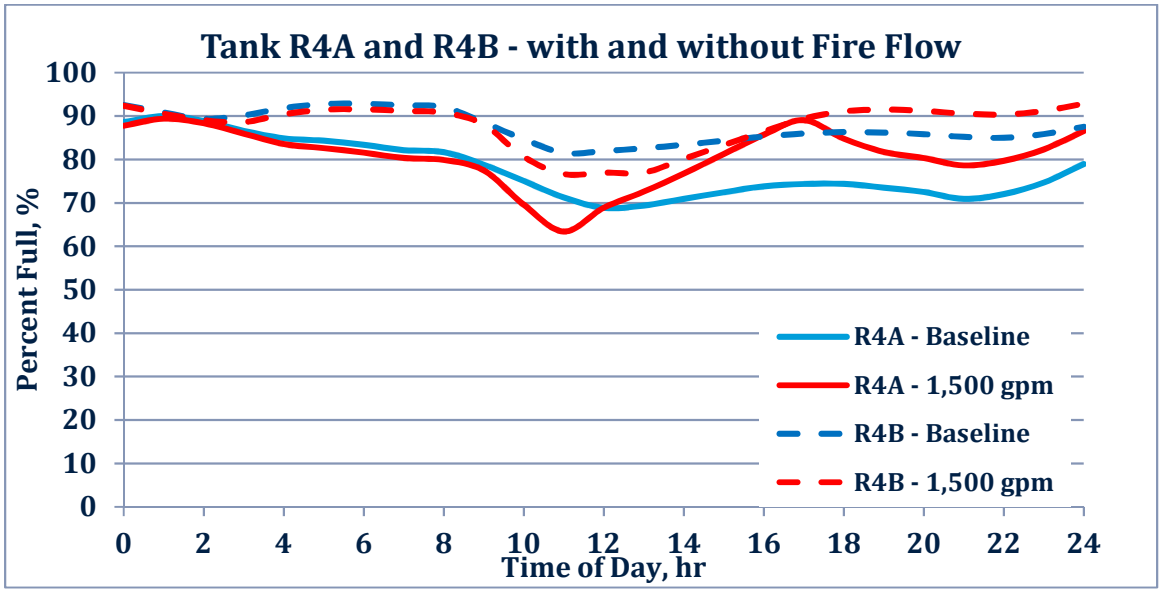


Figure B-5 Pressure Zone R4 Storage Adequacy Evaluation

The model results show that Pressure Zone R4, with Tanks R4A and R4B operating the way they did during the first week of October, can provide the 1,500 gpm fire flow over a duration of 2 hours without running out of storage volume.

PRESSURE ZONE R3

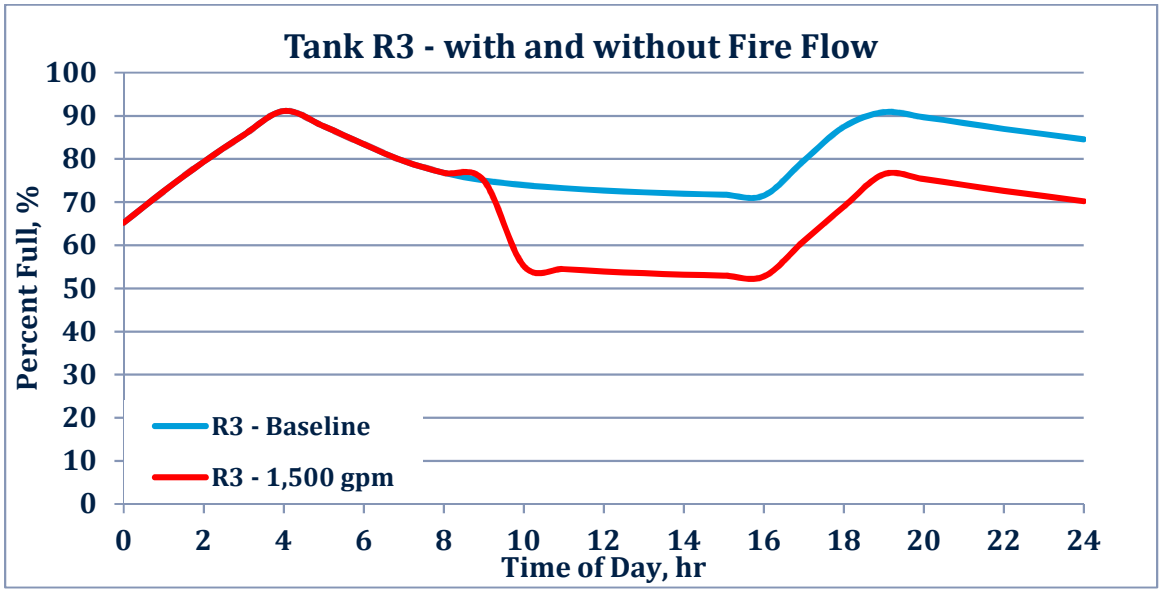


Figure B-6 Pressure Zone R3 Storage Adequacy Evaluation

Because this tank was out of service in October, there is no baseline data to show the manner in which it would be operated. For this storage adequacy evaluation, the tank was put back in service in the model and evaluated with no fire flow to show what baseline conditions would look like, and with a 1,500 gpm fire flow for a duration of 2 hours. The model results show that Pressure Zone R3 can provide the 1,500 gpm fire flow over a duration of 2 hours without running out of storage volume.

PRESSURE ZONE R2

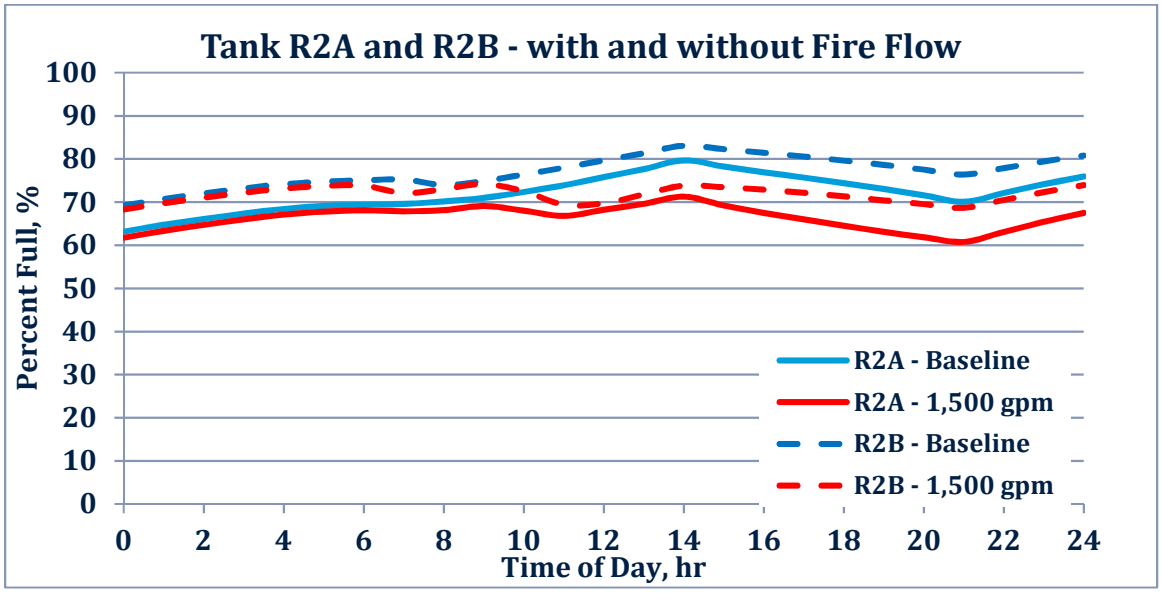


Figure B-7 Pressure Zone R2 Storage Adequacy Evaluation

The model results show that Pressure Zone R2, with tanks R2A and R2B operating the way they did during the first week of October, can provide the 1,500 gpm fire flow over a duration of 2 hours without running out of storage volume.

PRESSURE ZONE R1

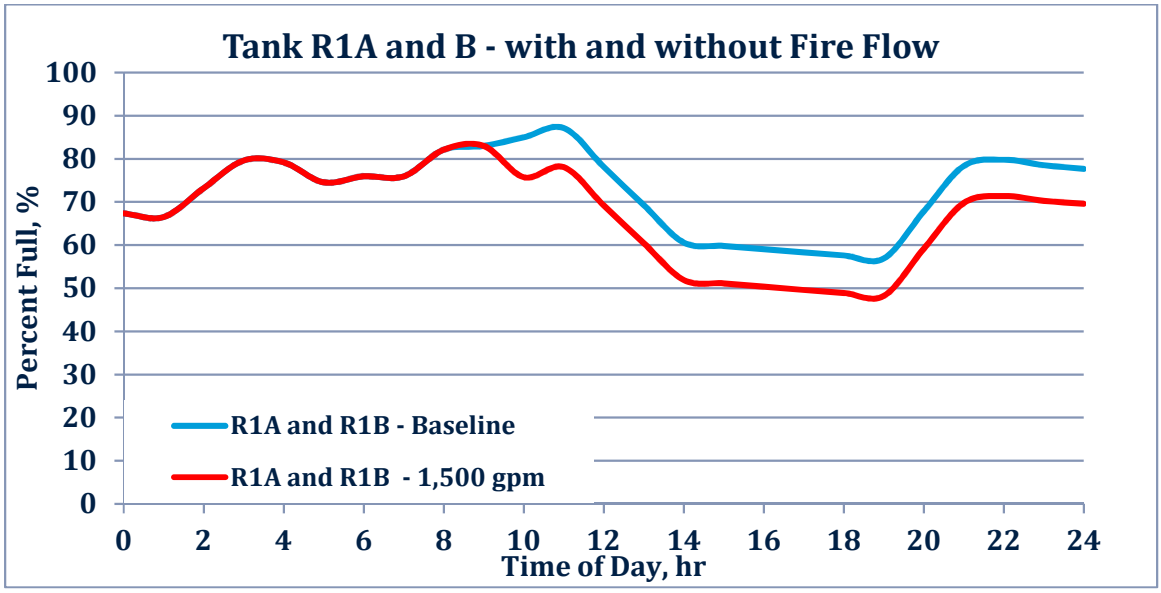
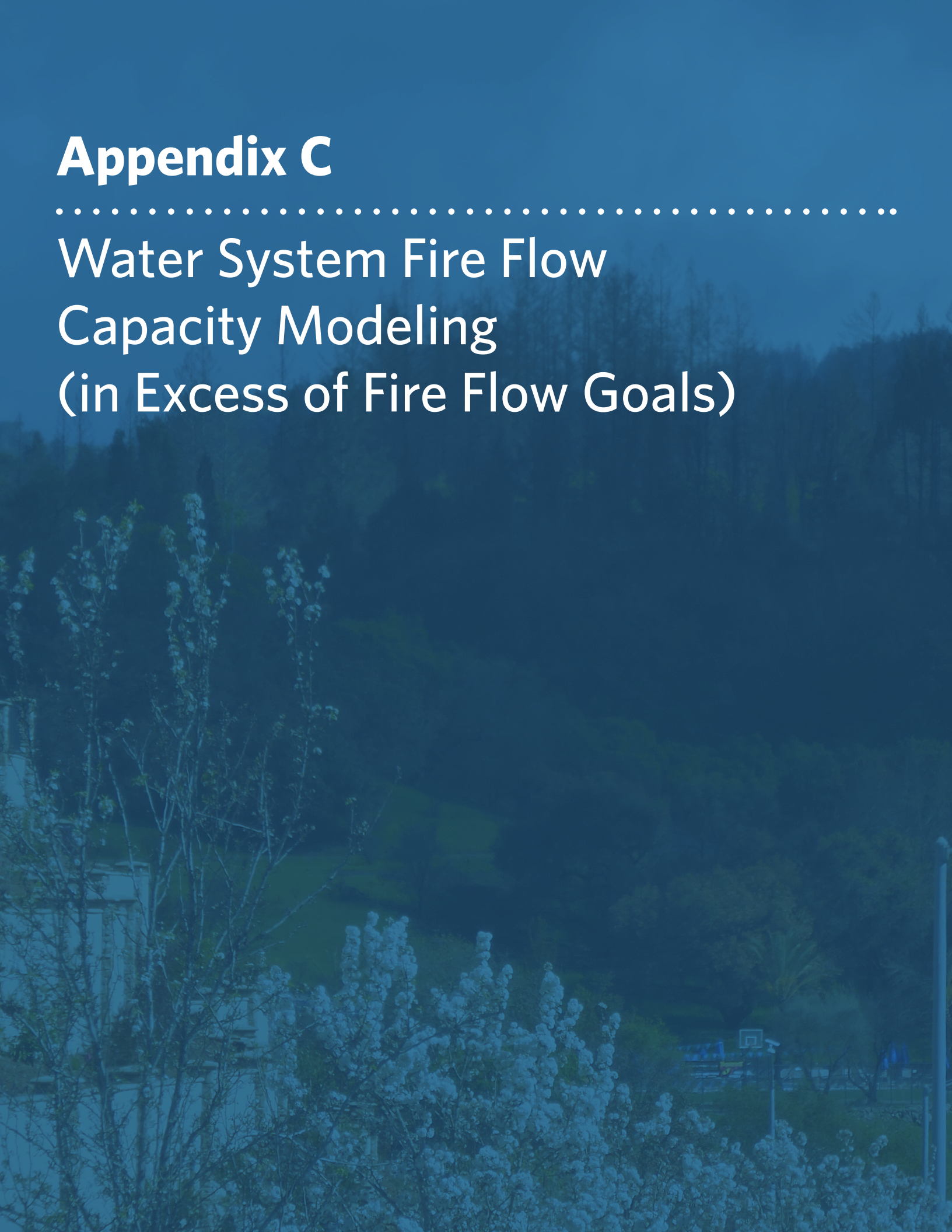


Figure B-8 Pressure Zone R1 Storage Adequacy Evaluation

The model results show that Pressure Zone R1, with Tank R1A and B operating the way they did during the first week of October, can provide the 1,500 gpm fire flow over a duration of 2 hours without running out of storage volume.

Appendix C

Water System Fire Flow Capacity Modeling (in Excess of Fire Flow Goals)

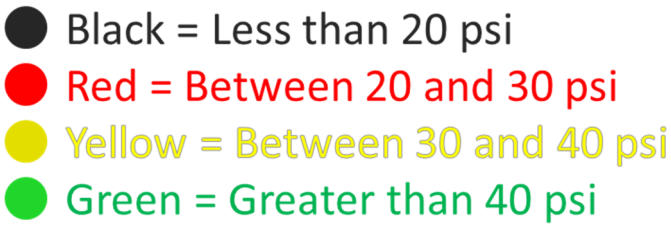


Appendix C. Water System Fire Flow Capacity Modeling (in Excess of Fire Flow Goals)

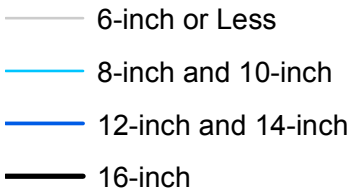
Fire flow capacity modeling was performed to show the areas of the system that are capable of handling fire flows 2,500 gpm for a duration of 2 hours. This is 1,000 gpm above the 1,500 gpm fire flow goal for the water system based on the minimum required fire flow in the City Fire Code. These scenarios used the operations and demands occurring during the first week of October as a basis for the modeling operations and demands. These scenarios simulated a fire flow at each model junction which could represent a system valve, fitting, or cap but not an actual hydrant and the result was a calculated pressure at each junction that would be experienced if the noted flow occurred.

Pressures less than 20 psi at a junction indicate that there is a potential deficiency in the system to meet that fire flow. Most of the areas within the Fountaingrove Area would not require fire flows of 2,500 gpm, and according to industry best-practices, many structures might require fire flows of less than 1,500 gpm. However, the fire flow demand of 2,500 gpm for two hours was evaluated to determine the level of resiliency that exists in the system.

The figures provided show a zone by zone evaluation of the fire flow for 2,500 gpm. The following symbology is used in these figures at each junction:



Pipes are shown by the blue lines and symbolized by diameters as such:



The red outlines show the pressure zone boundary for the zone in question, as well as any subzones that are fed through the main zone through pressure regulating valves.

PRESSURE ZONE R17

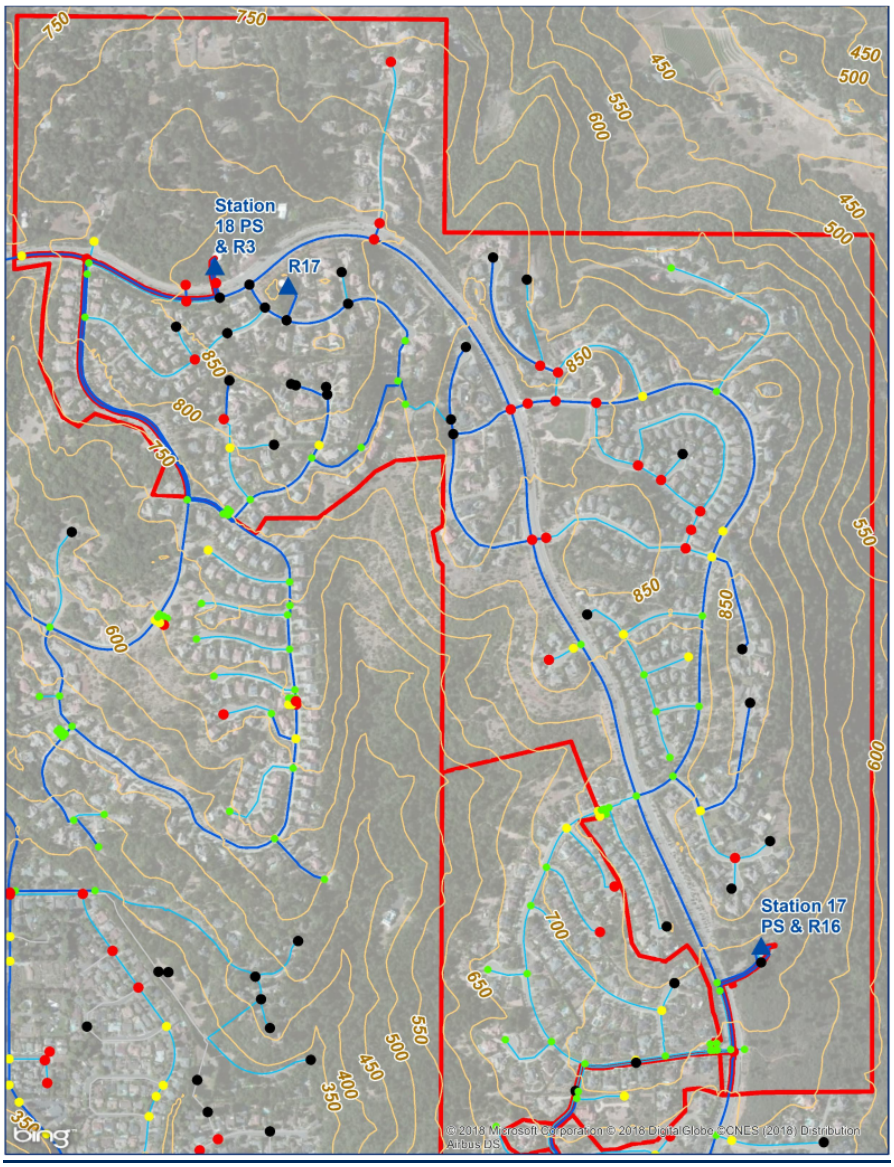


Figure C-1 Pressure Zone R17, Pressures for 2,500 gpm Fire Flow

- With a 2,500 gpm fire flow, the area around the tank and many other locations along high ground in the zone would experience pressures less than 20 psi.
- Note that there are currently no locations in this Pressure Zone that would require a fire flow of 2,500 gpm as estimated using industry best practices (see body of memo for discussion).

PRESSURE ZONE R16

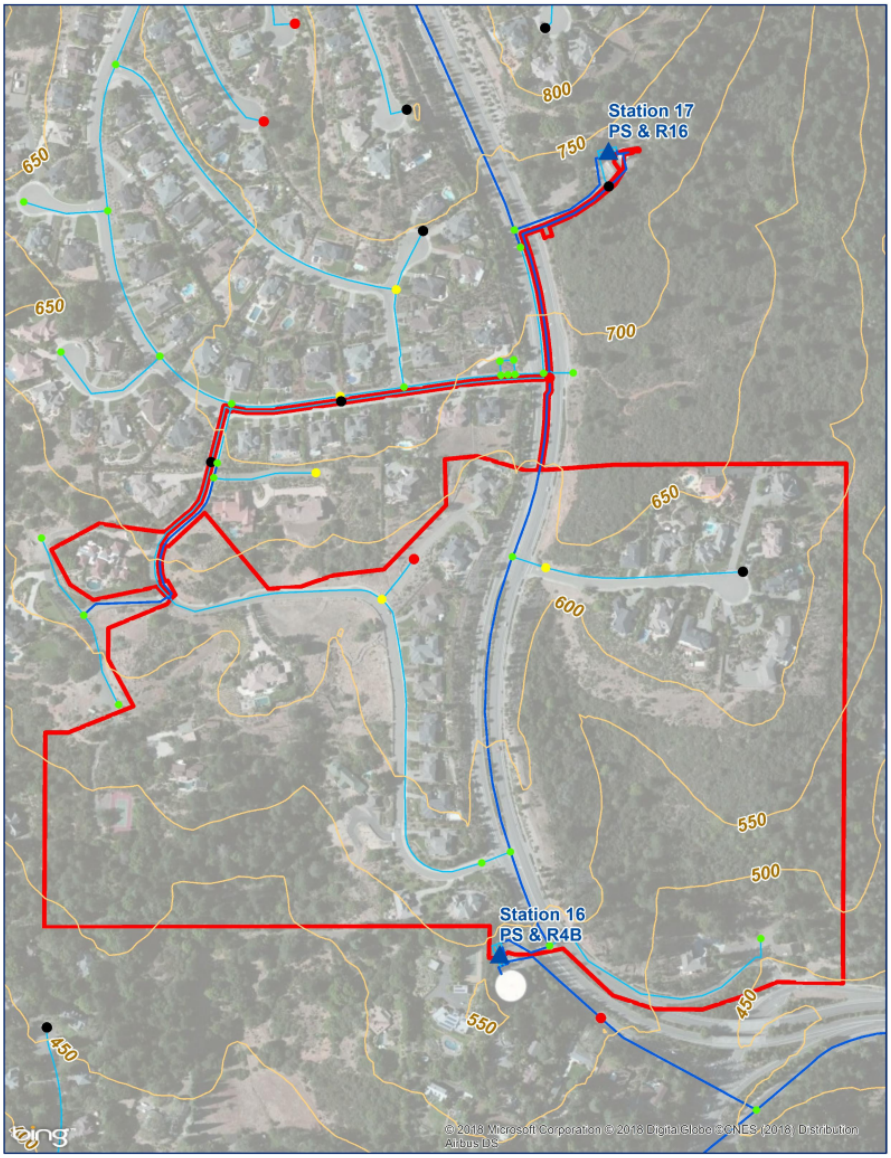


Figure C-2 Pressure Zone R16, Pressures for 2,500 gpm Fire Flow

- With a fire flow of 2,500 gpm, the neighborhood to the east would experience pressures lower than 20 psi.
- There are several areas in the middle of the zone and to the northwest that could provide for a fire flow of 2,500 gpm at pressures greater than 20 psi.
- Note that there are current no locations in this Pressure Zone that would require a fire flow of 2,500 gpm as estimated using industry best practices (see body of memo for discussion).

PRESSURE ZONE R5

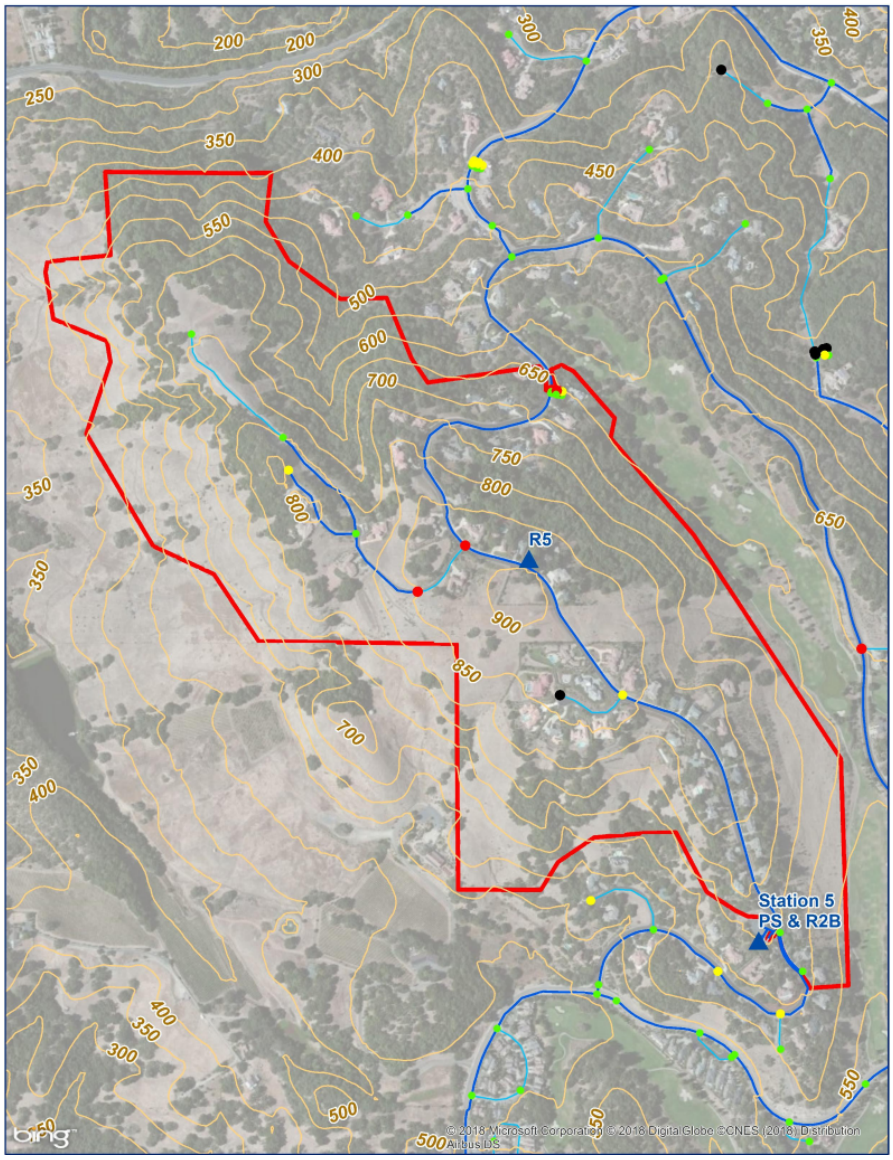


Figure C-3 Pressure Zone R5, Pressures for 2,500 gpm Fire Flow

- There is one area at the end of a dead-end pipe to the west that would not be able to provide a fire flow of 2,500 gpm.
- There are many areas that would support a fire flow of 2,500 gpm at pressures greater than 20 psi.
- Note that there are no current locations in this Pressure Zone that would require a fire flow of 2,500 gpm as estimated using industry best practices (see body of memo for discussion).

PRESSURE ZONE R4

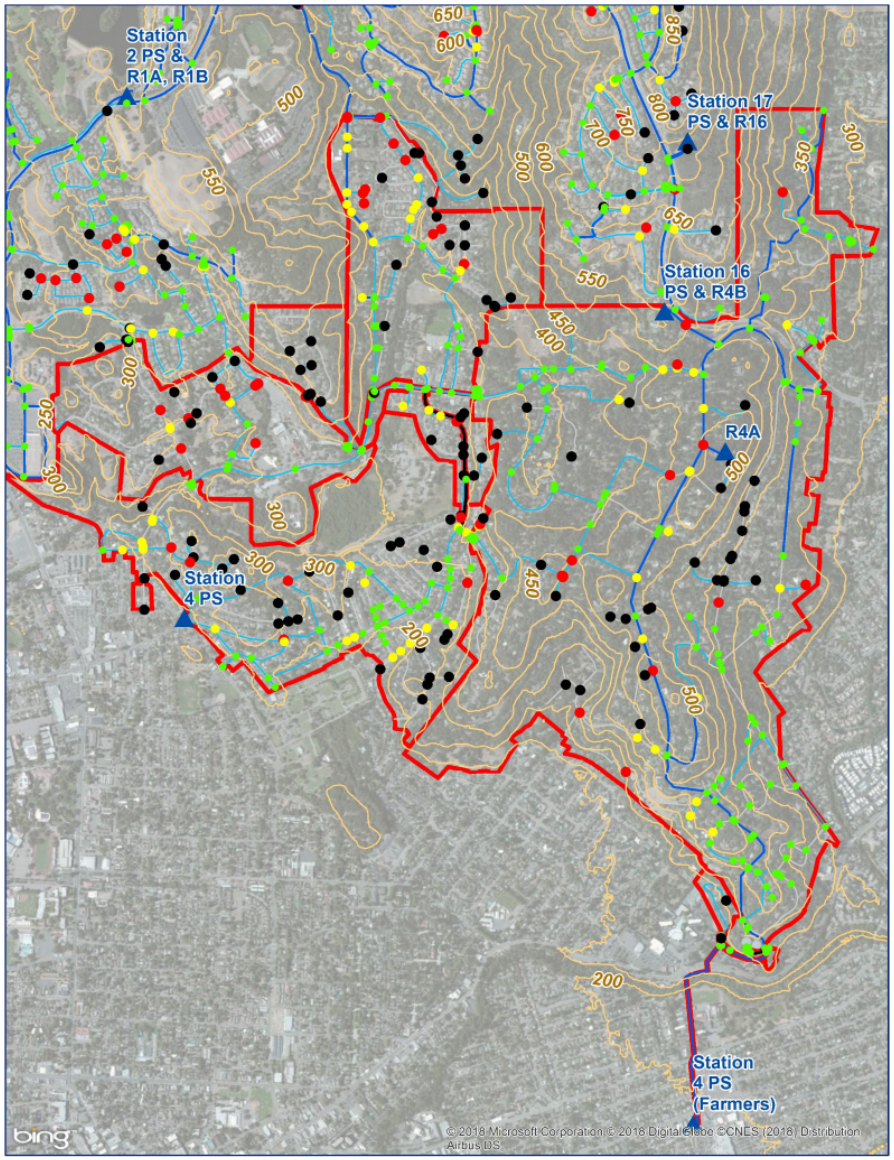


Figure C-4 Pressure Zone R4, Pressures for 2,500 gpm Fire Flow

- Similar to the previous figure, there are many locations within Pressure Zone R4 that may not be capable of providing fire flows of 2,500 gpm at pressures greater than 20 psi. These are related to small diameter mains and dead-end pipes. It is noted that no pipes of 4-inch diameter have hydrants along them.

PRESSURE ZONE R3

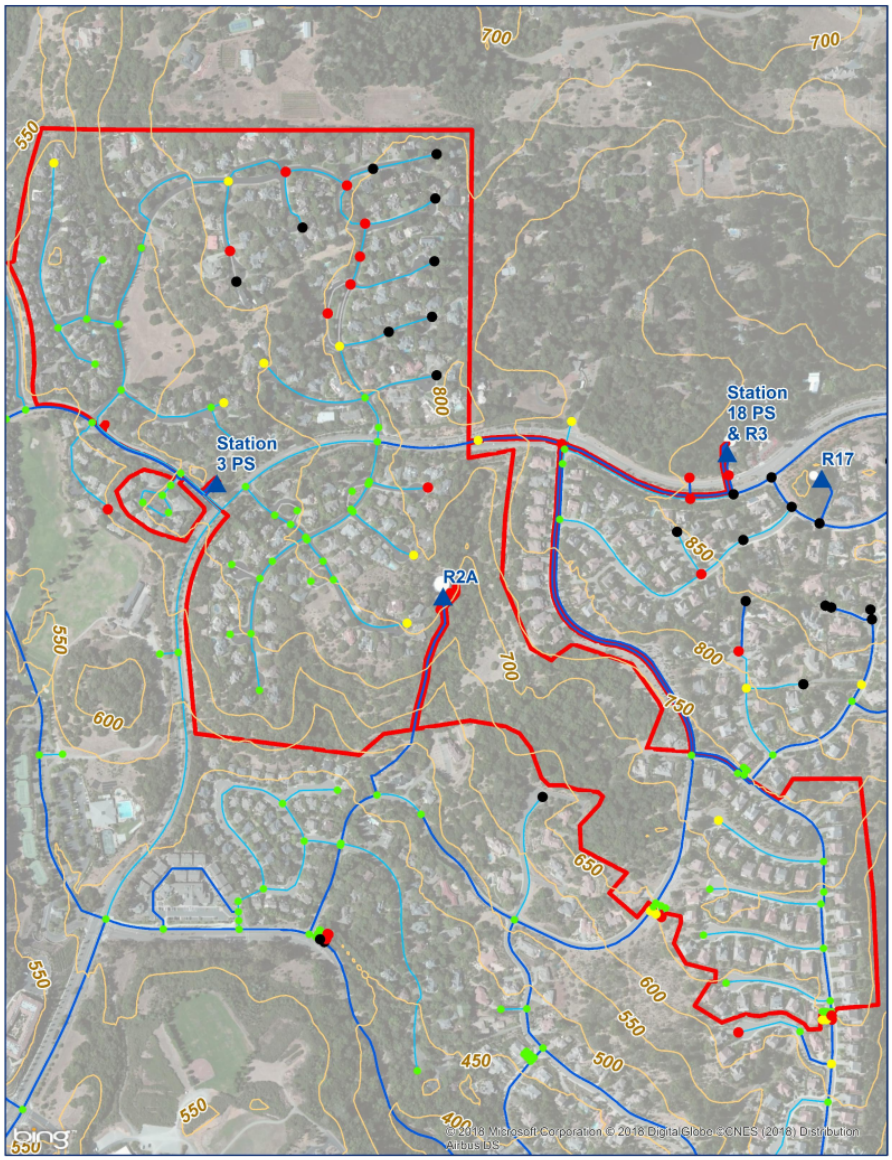


Figure C-5 Pressure Zone R3, Pressures for 2,500 gpm Fire Flow

- There are several areas in the northeast that would have difficulty providing fire flow of 2,500 gpm at pressures greater than 20 psi.
- Note that there are no current locations in Pressure Zone R3 that would require a fire flow of 2,500 gpm as estimated using industry best practices (see body of memo for discussion).

PRESSURE ZONE R2

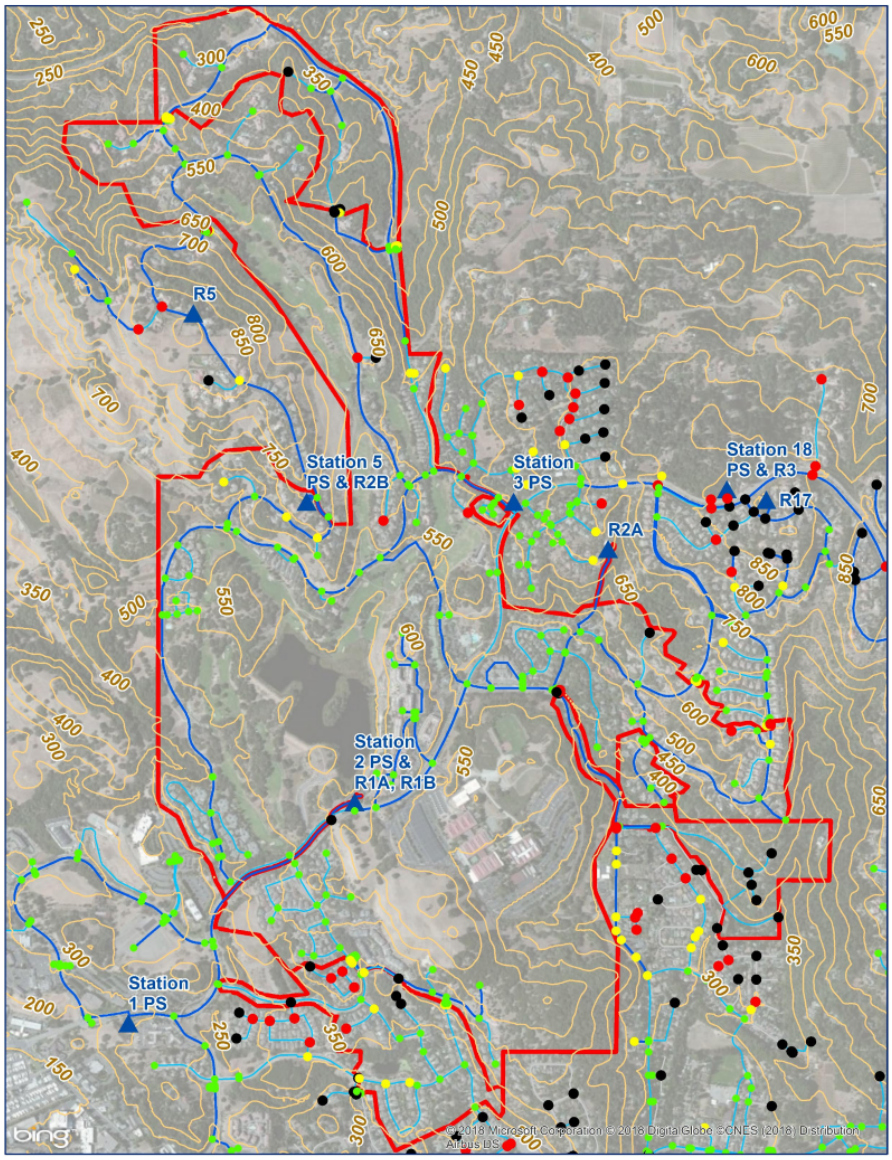


Figure C-6 Pressure Zone R2, Pressures for 2,500 gpm Fire Flow

- There are several areas that would have difficulty providing fire flow of 2,500 gpm at pressures greater than 20 psi. However, there are also many areas where this fire flow could be met. A land-use approach should be used to evaluate if the areas that would require higher fire flows are within the areas that can support them.

PRESSURE ZONE R1

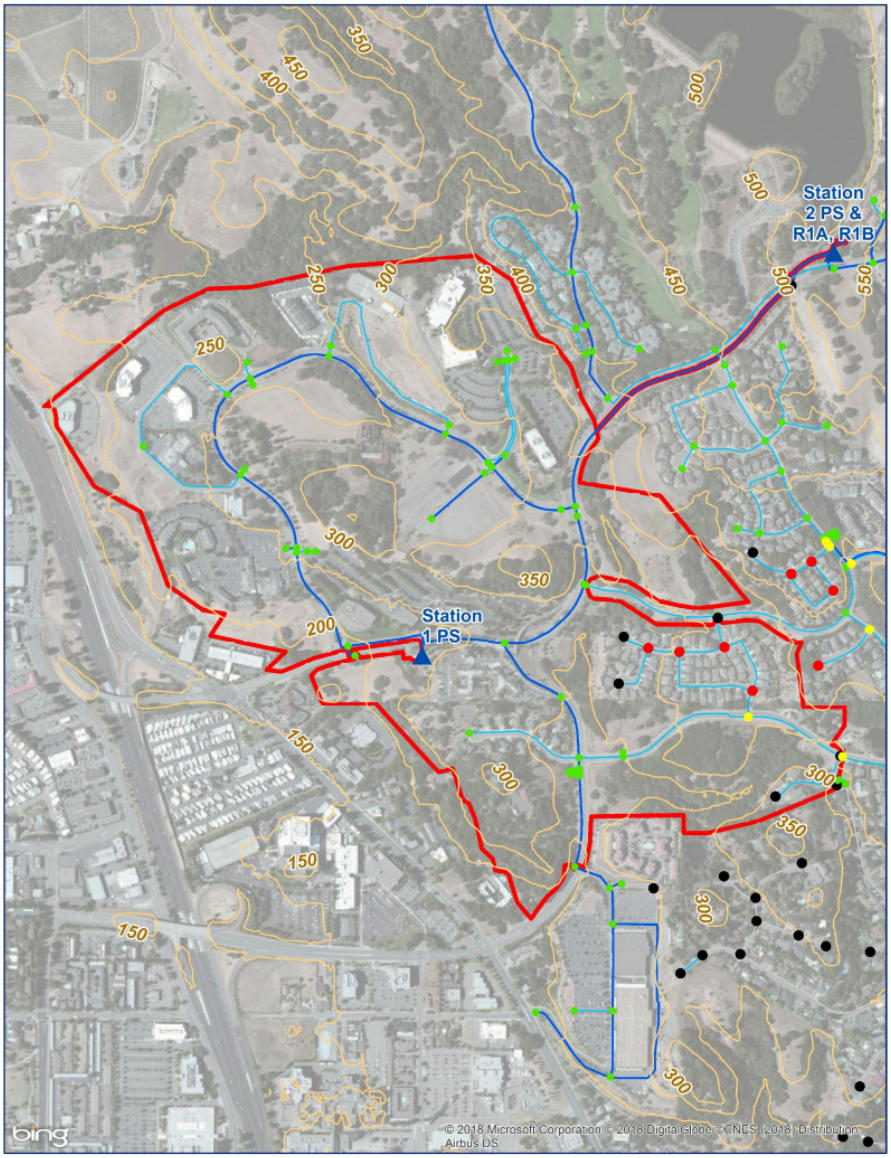
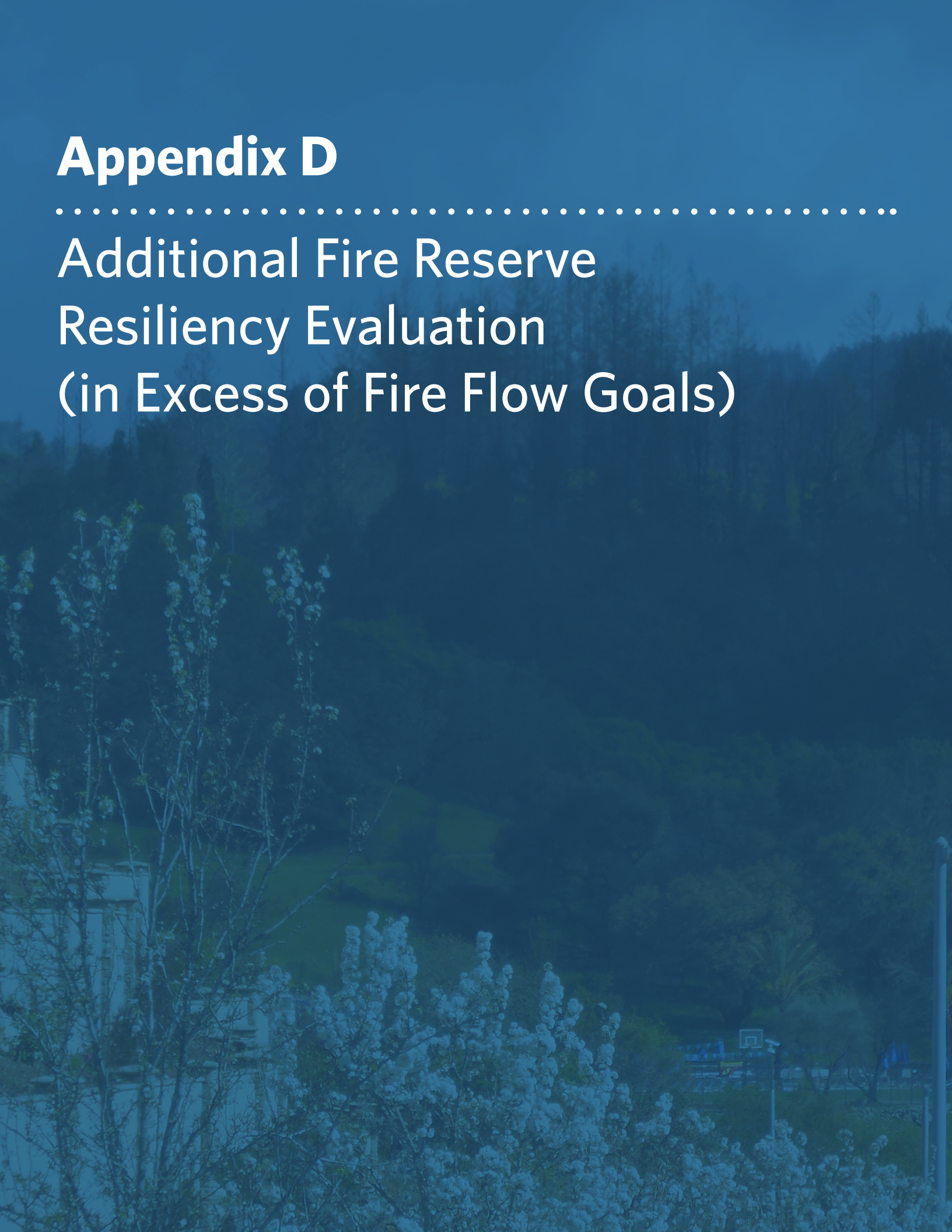


Figure C-7 Pressure Zone R1, Pressures for 2,500 gpm Fire Flow

- The area to the southeast would have some difficulty supporting fire flows of 2,500 gpm at pressures greater than 20 psi. It should be evaluated if there are any structures/properties that would require this level of fire protection.

Appendix D

Additional Fire Reserve Resiliency Evaluation (in Excess of Fire Flow Goals)



Appendix D: Fire Reserve Resiliency Evaluation (in Excess of Fire Flow Goals)

The previous appendix showed the capability of the system to provide fire flows and 2,500 gpm for a duration of 2 hours at pressure greater than 20 psi. However, the analysis did not evaluate the impact to storage within each pressure zone that would occur. To fully evaluate the impact to storage and the fire reserve adequacy in each pressure zone, extended period simulation (EPS) fire flow evaluations were performed. These evaluations applied a fire flow demand to a specific junction over a duration and reviewed the impact to storage during the simulation. A fire flow of 2,500 gpm, a duration of 2 hours was used. Each pressure zone had this condition applied and the impact to storage was graphed.

Figure D-1 shows the model results, by tank, for tank levels the week prior to the fire. This provides the baseline for comparisons with model results. The points (red square, blue circle, and green triangle) show the maximum, average, and minimum tank levels that occurred over the week prior to the fire in the October data provided. The model controls for these EPS evaluations were based on the data provided in an attempt to mimic as closely as possible the same tank levels over the EPS scenario that had occurred in the system in October before the fires. The red, blue, and green line series show the model results as they relate to the points. This shows that the model closely resembled the actual system operations and that the results of the EPS fire flow evaluations were reasonable to draw conclusions from.

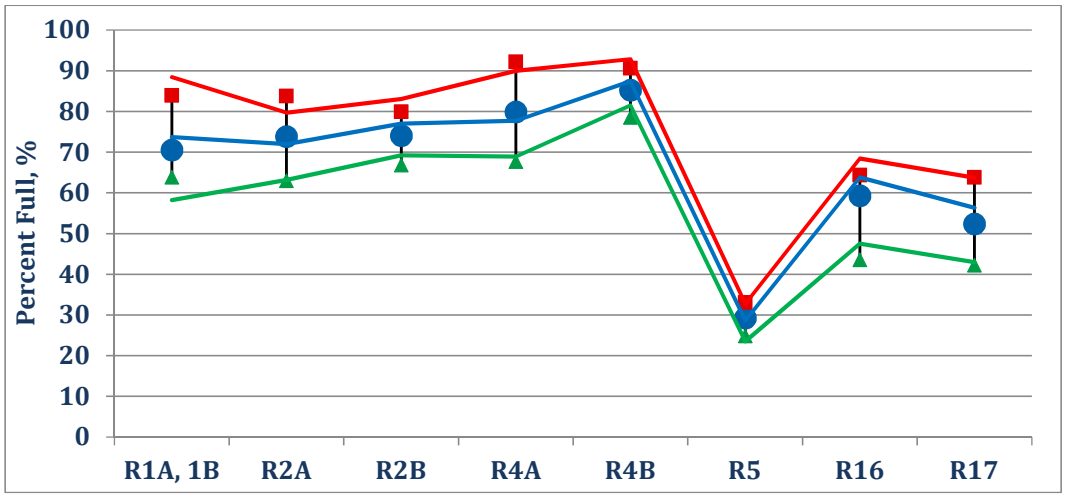


Figure D-1 Observed (point) maximum, minimum, and average tank levels vs. Modeled (line) maximum, minimum, and average tank levels in Week Prior to the Fire

The following figures by pressure zone show the tank levels over a 24-hour period without fire demand (blue series and with a fire demand of 2,500 gpm for a duration of 2 hours (green series). Many pressure zones also have the ability to provide additional pumping capacity in the case of a fire which could take the place of additional storage. However, these evaluations excluded back-up pumping for a pure evaluation of storage contained within each individual pressure zone.

PRESSURE ZONE R17

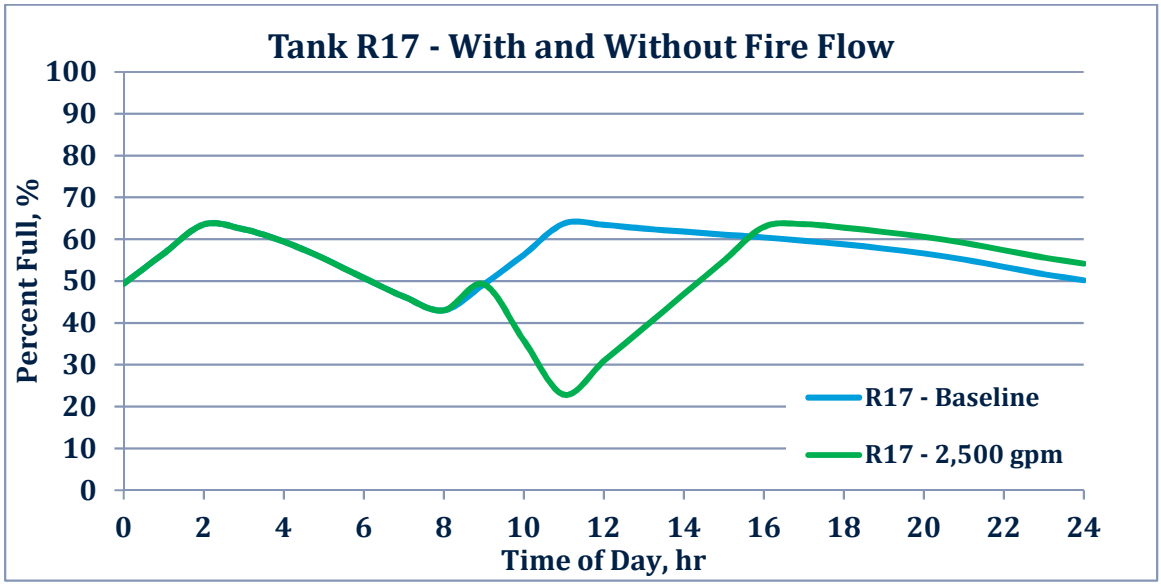


Figure D-2 Pressure Zone R17 Storage Adequacy Evaluation

The model results show that Pressure Zone R17, with Tank R17 operating the way it did during the first week of October (at lower percent full) is capable of providing 2,500 gpm for a duration of 2 hours although there is no land-use of the type that would require this according to industry best-practices.

PRESSURE ZONE R16

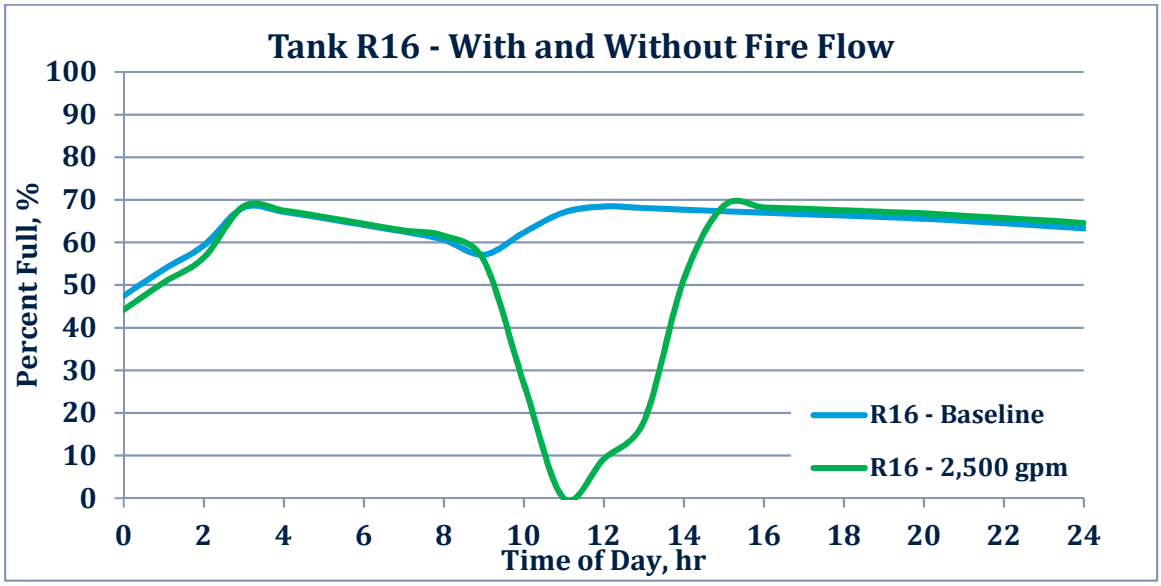


Figure D-3 Pressure Zone R16 Storage Adequacy Evaluation

The model results show that Pressure Zone R16, with the Tank R16 operating the way it did during the first week of October (at lower percent full) is not capable of providing 2,500 gpm for a duration of 2 hours while still maintaining water. Currently there is no land-use of the type that would require this according to industry best-practices. However, if development of this type occurs in this pressure zone, the addition of storage volume should be considered.

PRESSURE ZONE R5

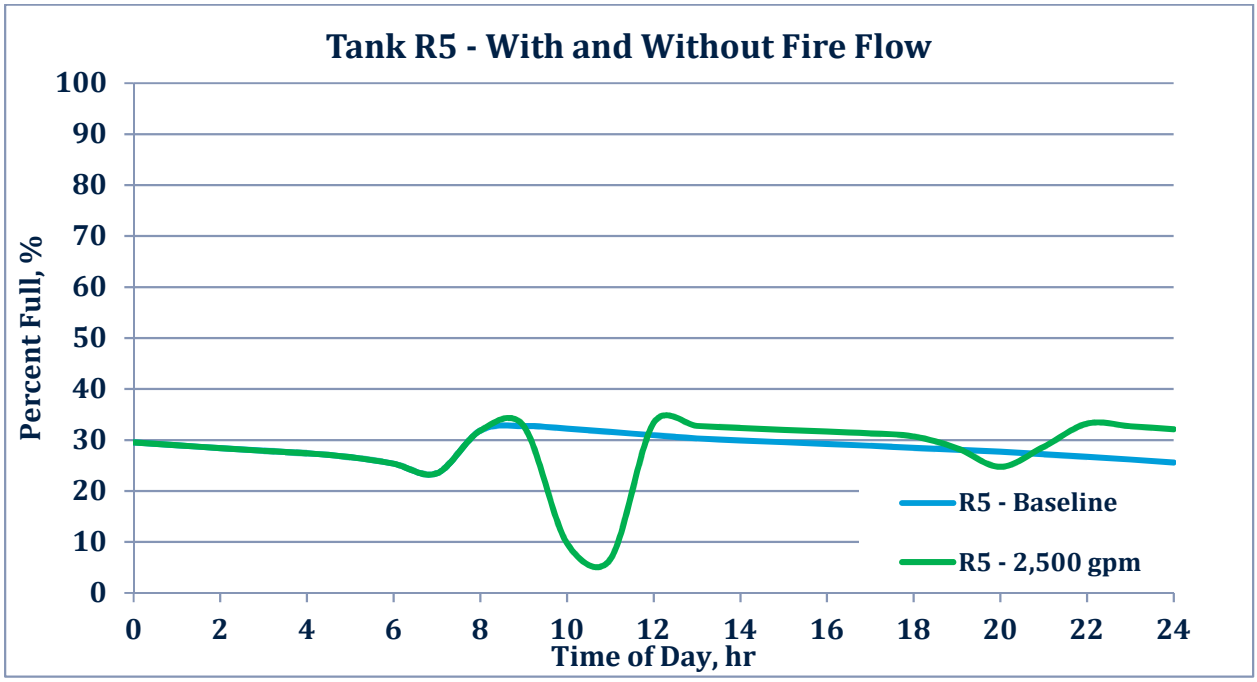


Figure D-4 Pressure Zone R5 Storage Adequacy Evaluation

The model results show that Pressure Zone R5, with Tank R5 operating very low-the way it did during the first week of October, can provide 2,500 gpm fire flow over a duration of 2 hours without running out of storage. Currently there is no land-use of the type that would require this according to industry best-practices. However, if development of this type occurs in this pressure zone, the addition of storage volume should be considered.

PRESSURE ZONE R4

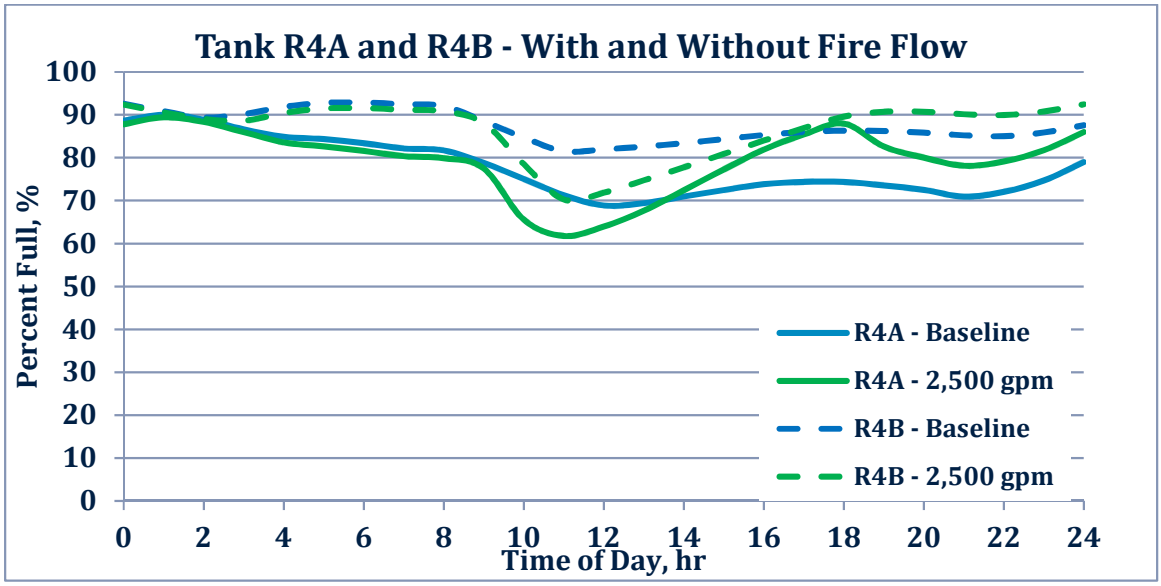


Figure D-5 Pressure Zone R4 Storage Adequacy Evaluation

The model results show that Pressure Zone R4, with Tanks R4A and R4B operating the way they did during the first week of October, can provide 2,500 gpm fire flow over a duration of 2 hours without running out of storage.

PRESSURE ZONE R3

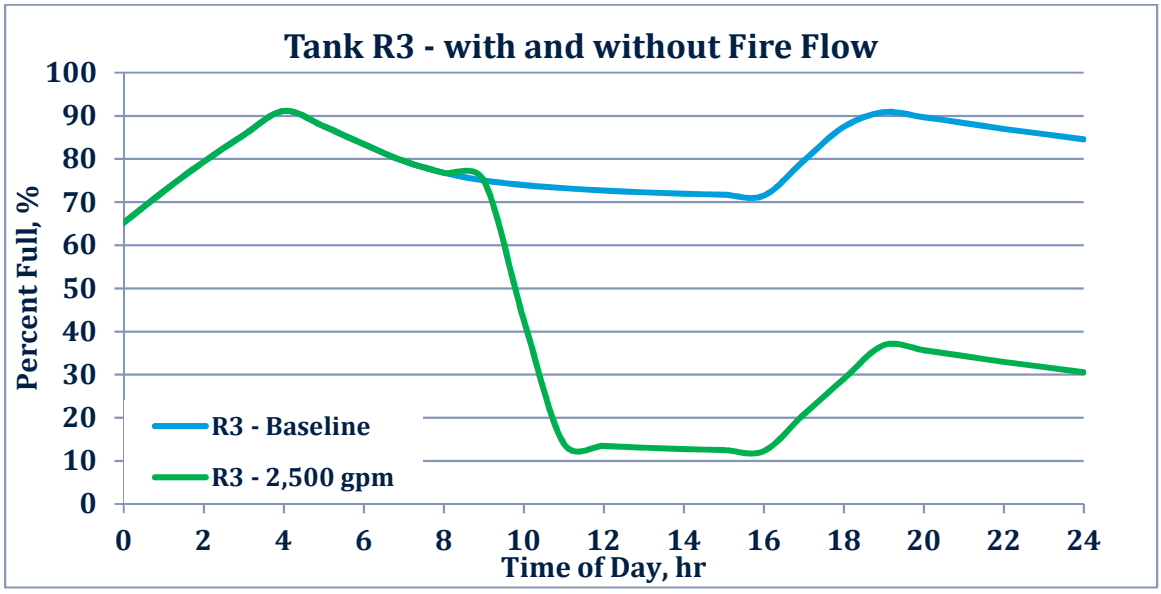


Figure D-6 Pressure Zone R3 Storage Adequacy Evaluation

The model results show that Pressure Zone R3 can provide 2,500 gpm fire flow over a duration of 2 hours without running out of storage although it would come close to draining during this scenario unless additional pumping is turned on. There is additional pumping capacity into this pressure zone to accomplish this.

PRESSURE ZONE R2

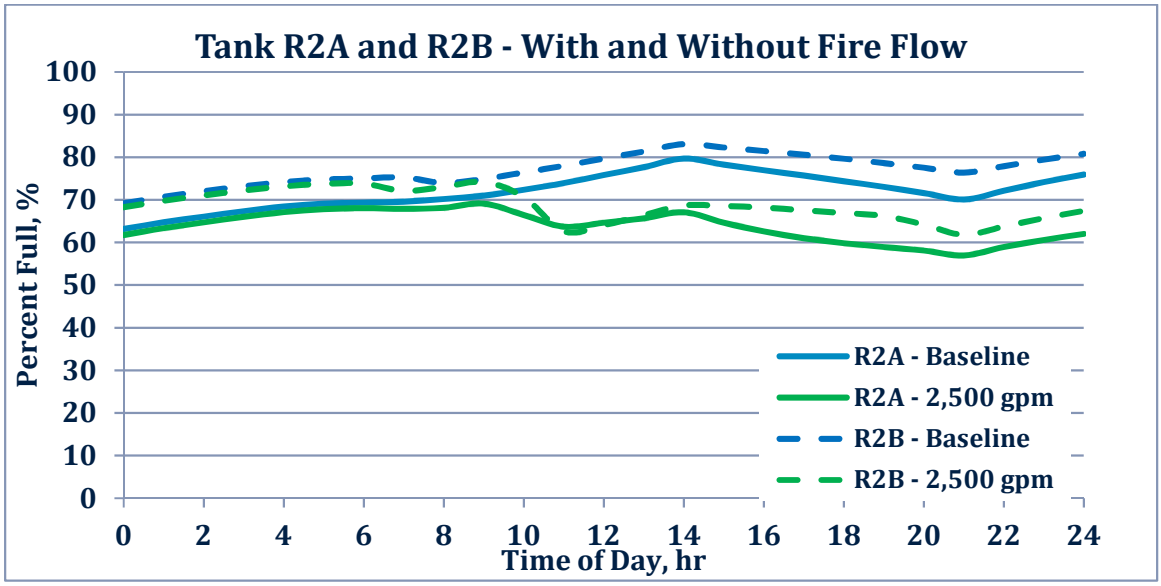


Figure D-7 Pressure Zone R2 Storage Adequacy Evaluation

The model results show that Pressure Zone R2, with tanks R2A and R2B operating the way they did during the first week of October, can provide 2,500 gpm fire flow for a duration of 2 hours without running out of storage.

PRESSURE ZONE R1

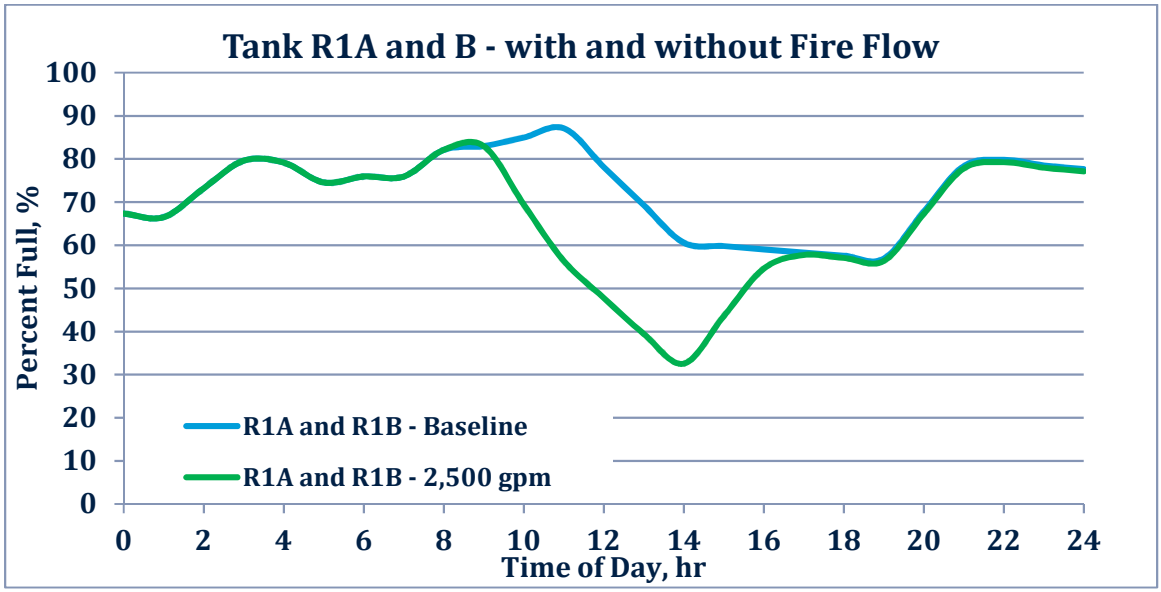
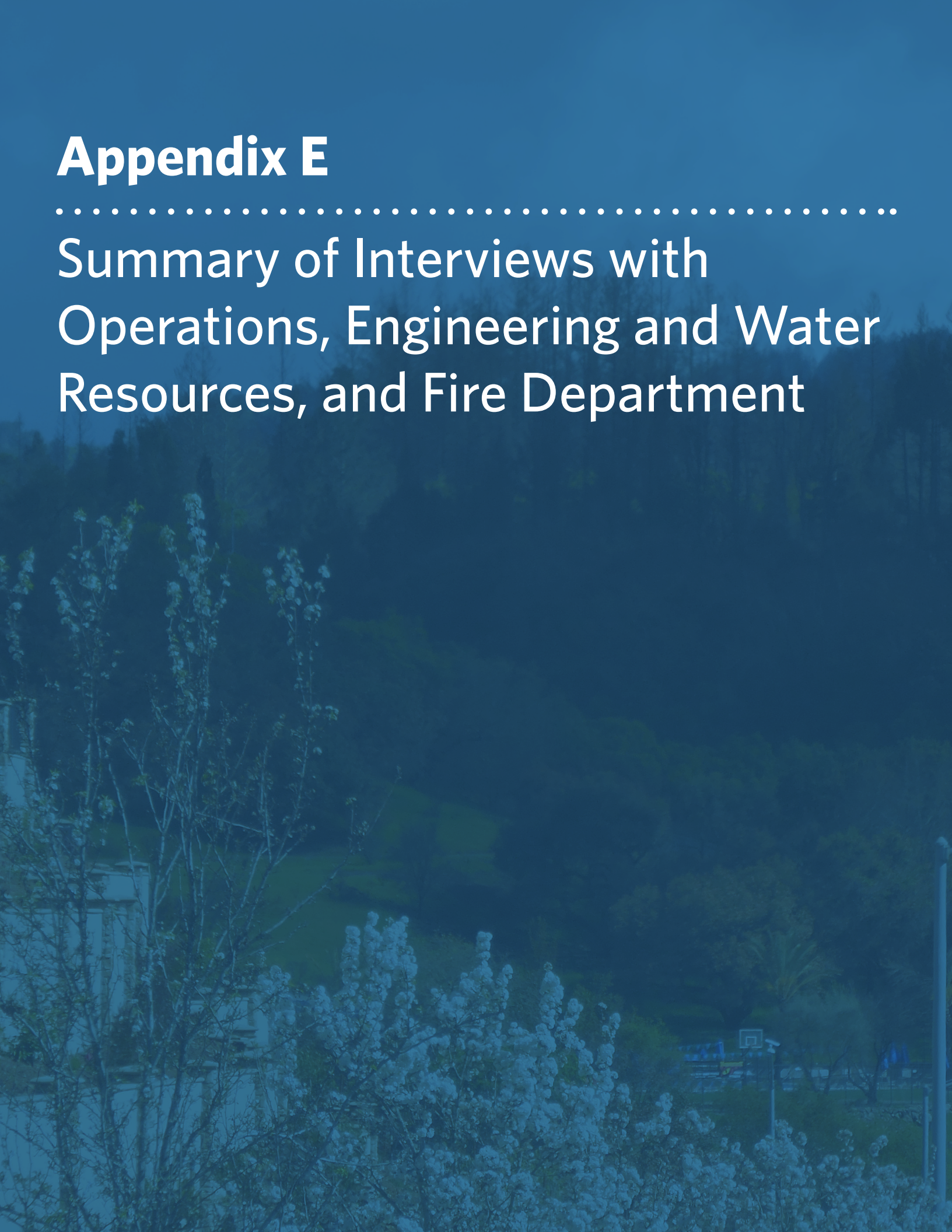


Figure D-8 Pressure Zone R1 Storage Adequacy Evaluation

The model results show that Pressure Zone R1, with Tank R1 operating the way it did during the first week of October, can provide 2,500 gpm fire flow for a duration of 2 hours without running out of storage volume.

Appendix E

Summary of Interviews with Operations, Engineering and Water Resources, and Fire Department



Appendix E. Summary of Interviews with Operations, Engineering and Water Resources, and Fire Department

Day 1 of 2 – Morning Session

To: City of Santa Rosa
From: Karen Burgi

Prepared By: Karen Burgi
Reviewed By: James Maher

Date: March 26, 2108
Subject: Interviews with Operations and Water Supply

Purpose: The purpose of these meetings is to review the events of October 8 and 9, 2017 and the performance of the distribution system.

In attendance:

Santa Rosa Water Operations	Black & Veatch
Santa Rosa Water Engineering	
Santa Rosa Water Resources	

The following topics were discussed. This description includes Black & Veatch's interpretation of what was said. Several items were discussed multiple times, but the information given was reorganized so that each facility and topic is discussed once with a summary of the pertinent information.

The morning session included representatives from the operations department.

1. Began with developing a rough timeline of events, which will need to be compared with debriefing notes taken at the time of the incident.
    a. The Tubbs Lane Fire began late on October 8th (evacuations began around 10:30 p.m.).
    b. At 1:00 a.m. Water indicated that power was out and were getting a portable generator going at BPS2 (the regular generator was out, so there was a portable diesel generator available for use at the site). The power outage was due to downed lines from wind, which is not an unusual occurrence.
    c. There were widespread power outages.
    d. EOC opened at 12:30. Santa Rosa Water operates a DOC, which is different. Santa Rosa Water wasn't formally notified of the EOC opening.

e. Fire was asking for extra people to help with barricades. Water opened the DOC to call in half of their people. By about 3:30 or so, Water started looking at opening other pumps and moving generators.

f. Because of the power outage, the Santa Rosa Water couldn't monitor at tanks However, there were no hydraulic issues when SCADA froze, there was some time lag to understand that SCADA had frozen based on tank levels not fluctuating and last default value continuously the same.

g. At 2:00 the portable generator for BPS2was pulled because the fire was at the boundary line.

h. From SCADA, Water also knew that BPS3 was also running on a generator. Unfortunately, BPS3 doesn't run well on generators because of harmonics with the pumps and when the 3rd pump got called at BPS3 (the 1500 gpm pump), the generator shutdown. However, the suction pressure in the zone from which it pumps could also be the reason why the pump station stopped. Both occurred simultaneously.

i. Pumps that could be remotely operated were but it was unclear what was going on in the system because of the loss of SCADA. In addition, operations started adjusting reservoir levels to allow reservoirs to fill. However, the large demand caused by openly flow services prevented this in many tanks.

j. R5 has a seismic issue and is kept low (20%). A new high volume pump had been added at S5 for fire protection. Staff couldn't enter the area, but water staff was staged to get in as soon as possible.

k. BPS 3 normally pumps to R3A, which was out of service at the beginning of a previously scheduled outage to address seismic concerns. generator from capital improvements. This project was also going to address the generator at BPS2.

l. 3,098 homes were destroyed in about 12 hours within the Santa Rosa City Limits.

m. There were hydrants being used in Zone 2, because the hydrants were open and flowing when the system was later repressurized.

n. By about 5 o'clock on the 9th Water was able to start getting in to look at the damage and shutting openly flowing services with a fire department escort.

o. The fire spread from the east, going down the canyon and had spread to the Coffey Park area by morning.

p. There were troubles with all of the generators due to the heat and extended operation, but after a couple of days Water was able to keep them operating when they weren't in crisis mode any more.

q. The Fire Department was reluctant to send in distribution people initially for safety concerns.

r. Santa Rosa Water was operating in split shifts from one to one. On the afternoon of the 9th, they suspected, but could not confirm that SCADA had frozen. Water was able to start going back in on the evening on the 9th and running routes to monitor fuel and tank levels.

s. Water had to be reactive again to address restoring the system. Asked the county to increase pressure to maintain Coffey Park and help with S1. S17 and R16 were the first problems. Generator out at S17, oil leak. Had issues with generators due to heat and constant running.

t. Water began to get utility billing out there to canvas service lines and shut them off. Found out that meter specialists had already started in Coffey Park. Stopped after dark for safety.

u. Power wasn't restored for about a week.

2. Facility Notes

a. R3A Tank. The R3 project is part of a 20-year project to seismically retrofit tanks. This is one of the final tanks (along with Oakmont and Rincon Valley). Take about a year off-line. It had only been out of service a couple of weeks and construction had not begun. R3A will not be back in service until around December of this year. Santa Rosa Water had worked with fire department for a long time to understand that these tanks would be out of service during a fire season. 20 years of precedence with taking reservoirs off-line with the fire department knowing and is a tried and true way to operate. Coatings are temperature driven and cannot be applied in the winter.

b. BPS3. The BPS3 was rebuilt the year before: pumps refurbished (two domestic), high flow/velocity (1,500 gpm) pump added, and generator. Also a water main improvement from BPS to reservoir. Main was finished summer of 2017. Harmonics was a punch list item. Originally thought it was a quick fix, but those didn't work. New project to address

c. BPS2. The regular generator for this pump station had a cracked engine manifold from earlier in 2017. While the regular generator was out of service, a portable generator had been moved to the site for the fire season. The repair of the regular generator was going to be included with the harmonics filter project at BPS3.

d. Portable Generator. The portable generator at BPS2 was brought back up on the 9th, but they were unable to repressurize the system.

e. Fire Lines. There was a list of several companies with large fire lines and included in the SOP. When Santa Rosa Water was trying to repressurize the system, they couldn't make progress until staff were able to close the meters

f. Facilities have battery back-up for SCADA for power outages, Santa Rosa Water staff were out running routes to check batteries, generator fuel levels, checking tank levels manually, etc. as soon as practical.

g. R17 Tank. Is normally kept low for water quality (low chlorine and HPC). This is a standpipe, so it is normally kept around half full and allowed to draft more than most tanks. The operating levels are changed seasonally. The SOP is to change levels if a fire is reported. R17 was finally refilled on the 12th. R17 was built by developer and operations probably didn't have much input. The high homes in this area were required to be constructed with in-home booster pumps.

h. Coffey Park. Although Santa Rosa Water doesn't have reservoirs or pump station in the Coffey Park area, there were pressure problems. Coffey Park gets water at Meter 191.192 (an 8" and 12" meters). These are PRVs.

i. Sonoma County Water Agency (Agency) delivers water at meters 196.197 at a pressure for BPS2.

j. Santa Rosa Water normally takes water at station 6, Santa Rosa Water turned off PRA66 to allow Agency to get water to other systems, which were also fighting fires.

k. Question was asked about whether or not R5 would be returned to service. Santa Rosa Water would like to abandon it, but it is a radio antenna for fire and police, so they want it to stay in service.

l. SCADA. At least some of the SCADA was recording even if it wasn't transmitting. 2A and 2B were full on SCADA, but not accurate. There will be pressure readings from the routes, but staff only looked at the actual water levels if they were checking water quality.

m. Most of the tanks were built by developers.

3. High homes had booster pumps.

4. R5 is a radio antenna for fire and police, so they want it to stay in service.

5. Santa Rosa Water has put in for a grant to take a better look at firefighting options.

6. Typically, distribution systems are designed for a 1 to 3 hour fire with one or two facilities. AWWA has a Manual of Practice that gives goals. ISO also give direction.

7. There is some information from the Agency that may be helpful including the meter readings at 191.192 and 196.197. The Tank levels at Ralphine may also be helpful.

8. The City does not have any SCADA data outside the pump stations and tanks.

9. When operations restored service they chlorinating on refilling tanks, fully filled reservoirs to allow them to skim debris, etc. The boil order ended when reentry was allowed, although the system was rechlorinated and had passed testing before that time.

10. In addition to the Tubbs Lane fire, there was another fire in Oakmount and Nunn. The cause has not been established, although PG&E lines may have triggered fires.

11. The tanks weren't full, but the system was being operated according to the Action Plan. The BPS 2 was operating according to an Action Plan as well. The Action plan was developed based on fighting a fire, but not for the fire being at the BPS.

Day 1 of 2 – Afternoon Session

The afternoon session included representatives from the water supply and asset management department.

12. The Agency provides the majority of the water to the City. The source is primarily rainy wells under the Russian River. The system is a free chlorine system.

13. Santa Rosa Water has seen a significant drop in per capita water use through conservation. Recalculated demand in 2015 Urban Water Master Plan. Last year under 100 gpcd. About 50 gpcd for indoor use. Do not believe they have a need for additional sources. Started to see rebound in 2013, so they feel like the 100 gpcd is a good long-term demand.

14. The boil order notice happened during the switch from day to night shifts. The Boil order was Fountaingrove and Oakmount.

15. R3 Seismic Retrofitting. It is probably the 6 or 7th tank to be retrofitted. It was out to bid. Foundation, recoating, access facilities, mixing manifolds for water quality. BPS 3 was rehabbed, but the new harmonic filter had not yet been installed. City has about 20 tanks and about half have been retrofitted and a couple of tanks are still remaining. Other tanks are more recent and don't need to be retrofitted.

16. There was difficulty with communication with the fire department. Difficult to know who was running event and trying to get information was difficult especially from CalFire. Sometimes the information was coming from press releases. For example, re-entry was planned on night 4 and then canceled. Worked to have as much water as possible.

17. It was noted that balancing water quality and fire flow is a difficult.

18. Taps had to be shut down before pressure could be returned.

19. Lost commutations with SCADA early on and did their best to understand what was going on in the distribution system based on information called in.

20. Fire went through and then they were in various areas. As they were able, Utilities closed meter stops and set tanks above 90% for all tanks. And some point there was a discussion about whether or not R3 could be refilled. Part of the reason to rush to restore was because of recurring wind shifts. R5 was kept off-line because it was so hard to keep full and there weren't any homes left to need water.

21. Contamination is still a concern. The loss of pressure led to negative pressures that pulled contaminants into the system in Zone 3.

22. There was a similar fire in 1964 with nearly the same path, but no homes in the area at that time.

Meeting Minutes Day 2 of 2

Date: March 27, 2108
Subject: Interviews with Fire Department
Purpose: The purpose of these meetings is to review the events of October 8 – 12, 2017
In attendance:

Santa Rosa Water Staff	Black & Veatch
Santa Rosa Fire Department	

This summary of the interview includes Black & Veatch's interpretation of what was said. Several items were discussed multiple times, but the information given was reorganized so that each facility and topic is discussed once with a summary of the pertinent information.

1. Sequence of events
    a. The fire department had been busy even before the fire came between 9:30 and 11:00 p.m., including several small fires and a larger fire in the Old Courthouse Square.
    b. At 11:30 fire staff was called to a 2-structure fire on the way to Callistoga, but when staff called into dispatch they didn't know about it.
    c. By 10:00 p.m. the Fire Department had called in all chief officers and by 10:45 had called in the entire department to help out.
    d. The EOC was opened around midnight.
    e. By 1:00 a.m. the fire was at Cross Creek, which is when it entered Fountaingrove. Fire Department started with evacuation. Most structures were not hardened and when they burned there were sprinkler systems and other open connections. Sweet Teas and multiple apartments also burned in the area. By the time it blew through, over 3000 homes and businesses were lost.
    f. The fire department was not really fighting the fire until 5 or 6, they were focused on evacuating. There was some fighting in Coffey Park to try to create a fire line, but had to pull back several times. When mutual aid starting arriving in the morning and the winds died down they were able to start fighting the fires.
    g. Winds abated around 5 or 6 and that, combined with the railroad allowed them to stop progression.
    h. At 6:30 or 7:00 a.m. at Fire Station 3, they noticed that pressures were so low that the toilets wouldn't flush. Called water staff at EOC and started asking about getting more water.
    i. Fire Department Staff got a call on the house line at 2:15 a.m. and went to EOC, working next to water department. Multiple commercial structures destroyed.
    j. In the morning Fire Department Staff went with Santa Rosa Water to start checking facilities and restoring them and closing connections. They weren't able to replenish tanks and R5 was shutdown. Water was diverted to Skyhawk to try to

help with additional fires. Around 10:00 a.m. in the morning is when they started shutting down connections (30 commercial structures burned). There was some isolation in the distribution system, but commercial structures (30 of them burned) had to be shutdown manually.

k. Fire Department Staff noted that there was good communication with Santa Rosa Water about where they could focus efforts. Fire Department Staff also felt that Santa Rosa Water did a phenomenal job with what they had.

l. Incidences were noted where Santa Rosa Water was limited by needing fire department escorts.

m. Still losing structures two days later. Needed more pressure and people. At 6:30 or 7:00 a.m. they had the fire contained, but during the day they would see new structures going up in flames that had been missed when the fire first swept through.

n. In addition to the Tubbs Fire they were fighting through the 9th, the Nunns and Oakmount fires were also active in the following days.

2. Water supply and equipment during the fire.

a. Fire Department reported that they never ran out of water, but sometimes there was very little and very low pressure.

b. Water Tenders. The Fire Department was using 1,500 gallon fire tenders in Fountaingrove and at least one at Kmart in Coffey Park. It was asked how far they had to go to refill but this varied.

c. Fire engines. There is a tank on the truck. A line is connected to the hydrant, which fills the tank and then the engines repump the water at higher head. They are rated for 1500 gpm, but can sometimes run up to 2,500 gpm if there is adequate flow and head and the engine is just boosting the flow.

d. Fire Department noted that there is at least 1500 gpm available throughout the city.

e. Wildland Urban Interface. Fire Department Staff remembered that in the early 2000s there was a requirement for 2500 gpm in these areas, but in around 2010 the City changed to California minimum of 1500 gpm. Staff noted that part of the reason the standard was pulled back to 1500 gpm was because it was going to be a $100million upgrade and there was debate about whether or not that was needed.

f. Water Quality. Fire Department knows that they have also struggled with water quality in the Fountaingrove area and that tanks couldn't be kept full. R17 generally has 6 feet of water. There was a fire station at the base of it that had to add a fire pump in order to get enough pressure. It was noted that the tanks were fairly full when the fire hit.

g. The Fire Department was aware that there was a tank out of service during the fires.

h. Sprinkler systems. All new homes in CA have sprinkler systems, as well as all multi-family and commercial. These generally are designed to put out fires that start in the home and can only have two heads open before they start to lose pressure. They do not work well on fires that begin on the roof or attic.

i. The City has 10 engines and two ladder trucks (which have tanks). There are also 4 reserve vehicles and 2 wildland fire units. Also a water tender truck

j. Additional assistance. At about 11:00 p.m. 25 strike teams (5 engines and a leader) were ordered for Sonoma. At 12:30 a.m. 3 strike teams were ordered for Fountaingrove. Sonoma Valley was also fighting fires. Resources were stretched thin and although they ordered strike teams, the area had run out of resources.

k. The decision was made at some point to shift resources from the R17 area to areas that could still be protected.

l. Air Support. The fire started at 9:45 and got to the City at 11:00 p.m. There were no flights the first two days due to night, wind, and no visibility. Once the smoke lifted, they used up to 21 helicopters to drop water over the next week or so.

3. Changes since October.

   a. Santa Rosa Water now fills tanks when there is a red flag warning. One tank was out of service for seismic, which they were aware of. Communication between Water and Fire has been better.

   b. It was noted that there are earthquake valves for gas and wondered if there was anything similar that would shut house service down when there was no backpressure.

   c. Fire Department spoke with Ventura and they had similar issues with higher zones. Open flowing connections made it impossible to pressurize the system.

   d. Fire department thought communication was great.

   e. Now working on providing fire flow during the rebuild.

4. Black & Veatch asked for a time sequence map of fires. Santa Rosa Water will get with GIS to provide.

5. It was asked about past experience with fires in Fountaingrove and there have been other fires. The biggest was a grass fire with just under 5 acres of land and there were no issues with water supply. They have also had several smaller fires in the area and the water system worked fine for all of them. Black & Veatch asked for some specific dates and fire water volumes, so we can compare system operations during more typical fires.

6. Fire department does work with communities to help prevent wildland fires.

7. Contributing Factors to why the fires were so bad that night. Single digit humidity. North winds (happen 2 or 3 times a year). 5 years of drought, stressed trees, record rains in 2017 with lots of grass. Winds were not supposed to be that high (40 to 90 miles per hour for 12 hours). Once you get to teens in humidity things burns faster.

8. CalFire says this will be happening in CA for several years due to stressed vegetation and recent droughts.

9. It was asked about specific reports of no water. Fire Department Staff responded that there was low water and pressure in Fountaingrove and then in Coffey Park later in the morning.

10. Santa Rosa Water noted that they didn't know as early as they would have liked to. At first Water wanted to help but didn't know what to do. Fire Department Staff noted that the first 12 hours is always tough in a situation like that. Need to push information out faster.

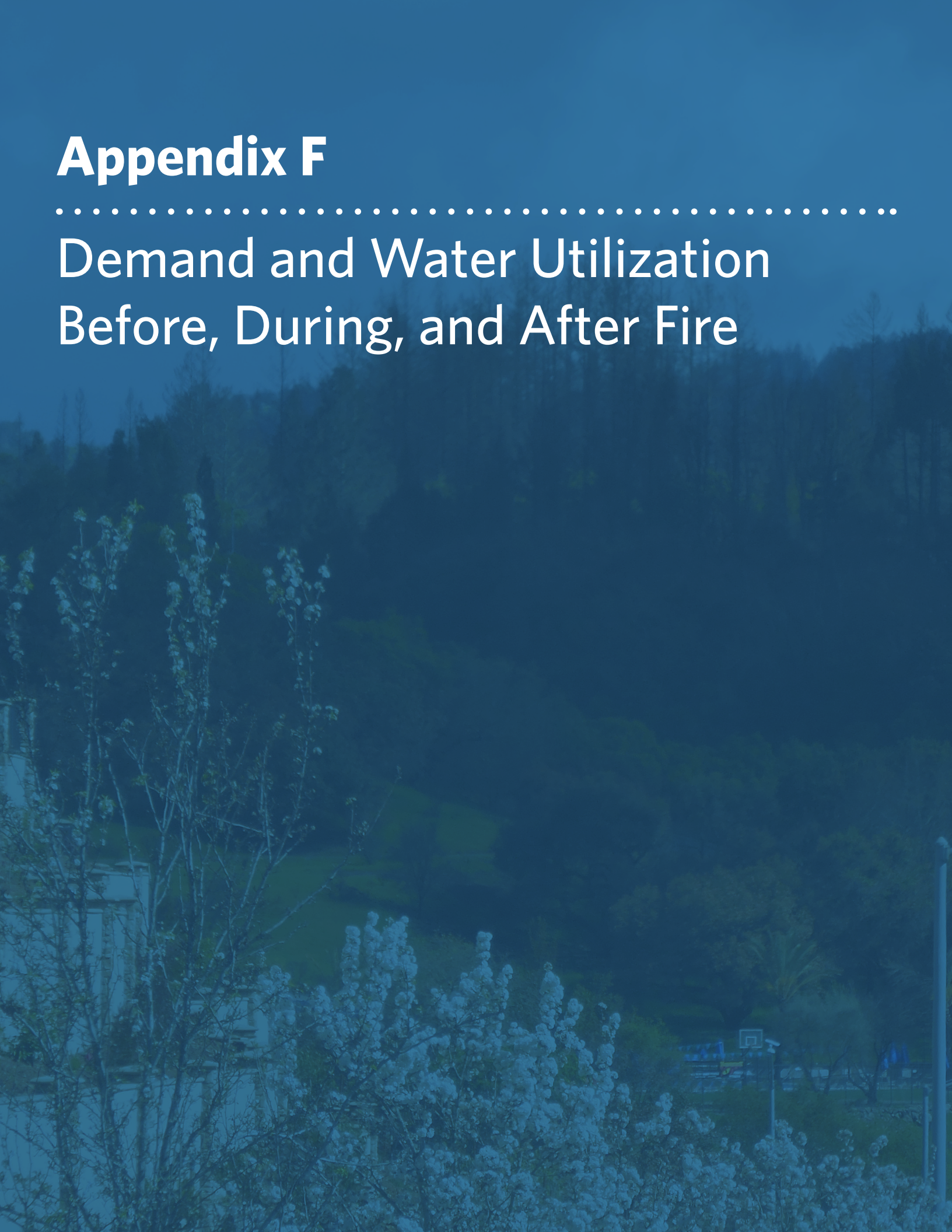
11. It was noted that Santa Rosa Water may also need to re-evaluate emergency communication.
12. The City is also investing in improved notification system.
13. Fire Department Staff noted that they haven't met with Water to debrief.
14. City may have to replace 5 miles of pipe due to benzene and other contaminants pulled into the system during the depressurization. There has been discussion of a separate system that is non-potable, but the fire department doesn't want that. May need to harden Water Pump Stations to better protect them during fires.
15. Fire Department Staff mentioned that at the Wilson Street Fire, they experienced low pressure, but then it started recovering on its own. Fire department may want contact water for major Fountaingrove fires so that adjustments can made by the Water Department if needed.
16. Final questions asked at the end of the interview for improving things going forward. How do we connect better with the community on alerting. When people got alerts they called 911 and jammed up the system. Need to educate public on personal responsibility.

<u>Debrief and Next Steps</u>.

17. Fire Department asked about the City's criteria and whether or not they system meets the criteria. Fire Department noted that the criteria per California is 1500 gpm, which Santa Rosa Water meets. AWWA is another possible source for criteria.
18. Fire Department does understand that fire reserve storage and water quality it is a balance. Now there is a red flag communication piece to fill tanks on high risk fire days, which is helpful to the Fire Department.
19. Fire Department asked about off-line and secondary fire systems, which are being considered in San Francisco. Black & Veatch is considering them for Colorado Springs. However, they are generally very expensive and bring up water quality problems. In a situation like Santa Rosa, they may have lasted a little longer, but would have not been enough.

Appendix F

Demand and Water Utilization Before, During, and After Fire



Appendix F. Demand and Water Utilization Before, During, and After Fire

SCADA data were used to determine the system demands and water utilization before the fire, during the fire, and after the fire. Data from October 1 through October 16th was provided by the City and was compiled to determine the usage characteristics in each pressure zone. Because of unmetered valves between each zone that do not normally operate but would be in operation under emergency conditions, the daily and hourly demands during the time of the fire and afterwards are difficult to determine with accuracy and some pressure zones would calculate to have higher than their true consumption while other pressure zones would calculate to have lower than their true consumption. The best overall indicator of the changes caused to the system by the effects of the fire is the overall Fountaingrove Area demand (PZALL in the figures). System demands before the day of the fire are true demands, i.e. demand based on user consumption, and system demands during and after the fire is more indicative of user consumption plus the demand put upon the system by the effect of the fires, i.e. openly flowing appurtenances, firefighting water use, etc.

Figure F-1 shows the daily zone by zone and overall demand/water utilization from October 7th through the 14th. Figure F-2 shows the daily demand for the Fountaingrove Area from October 1st through the 16th. It should be noted that the demand would have gotten continuously greater if tanks would have stayed full because the pressure would have driven up the flow in the openly flowing fire and service lines.

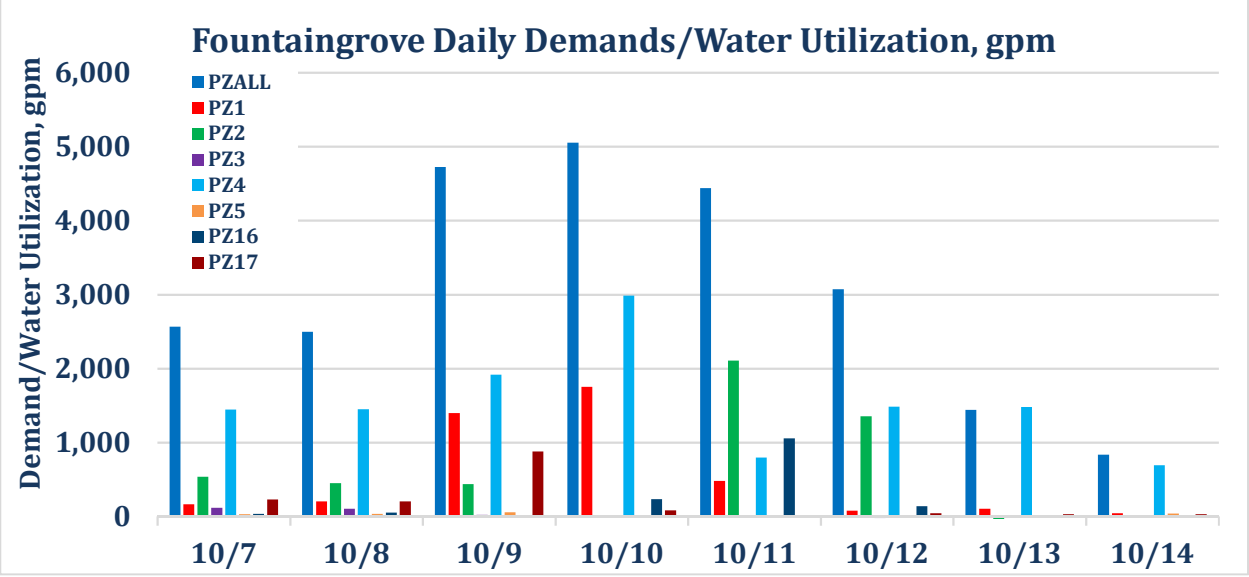


Figure F-1 Fountaingrove Area Daily Demands (By pressure zone) 10/7 – 10/14, 2017

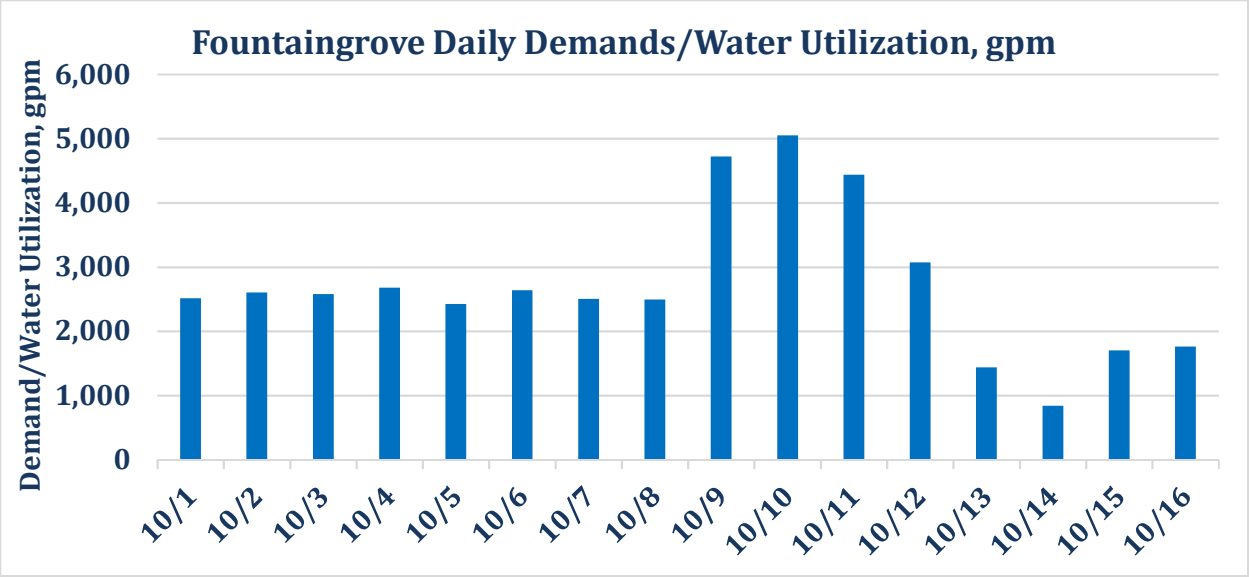


Figure F-2 Fountaingrove Area Daily Demands (overall) 10/1 – 10/16, 2017

Figure F-3 shows the hourly zone by zone and overall demand/water utilization from October 7th through the 14th. Figure F-4 shows the daily demand for the Fountaingrove Area from October 1st through the 16th.

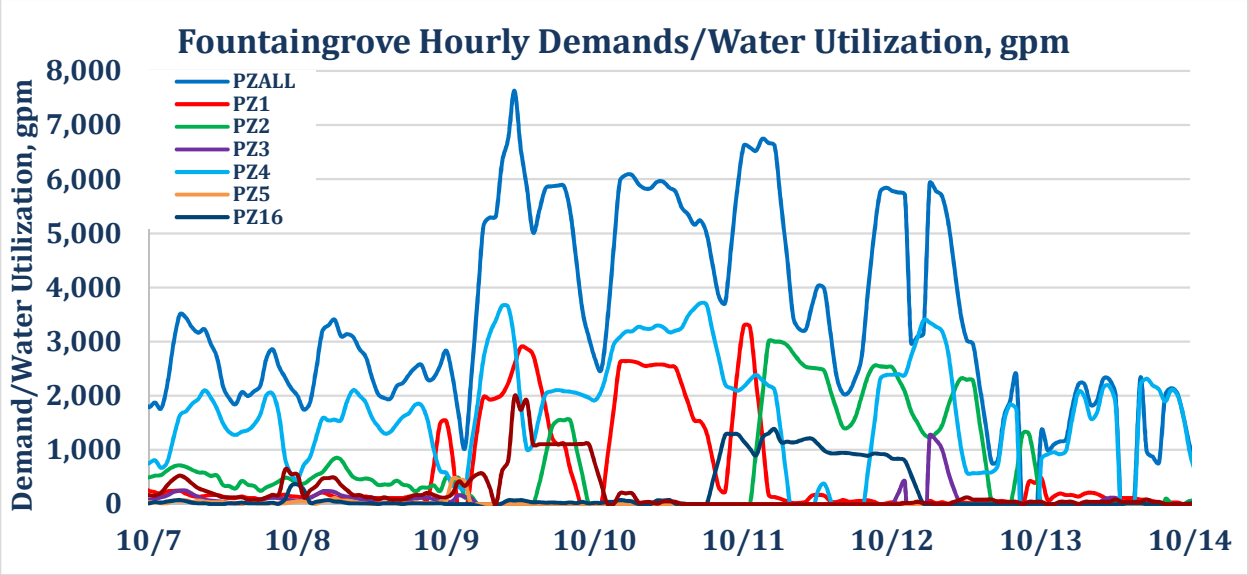


Figure F-3 Fountaingrove Daily Demands (by pressure zone) 10/7 – 10/14, 2017

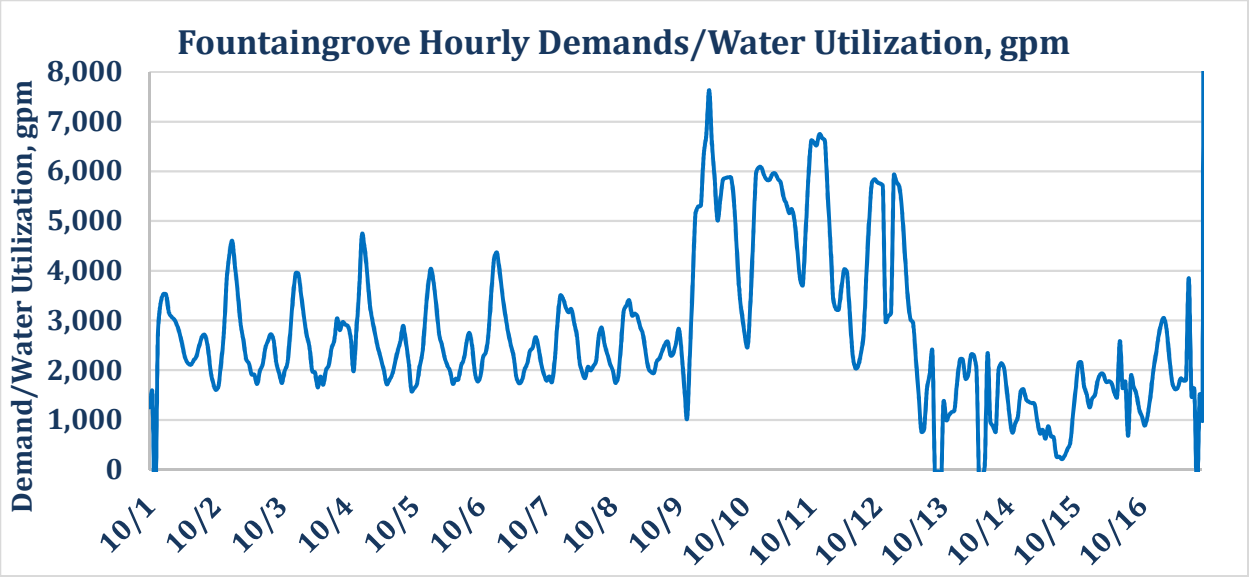
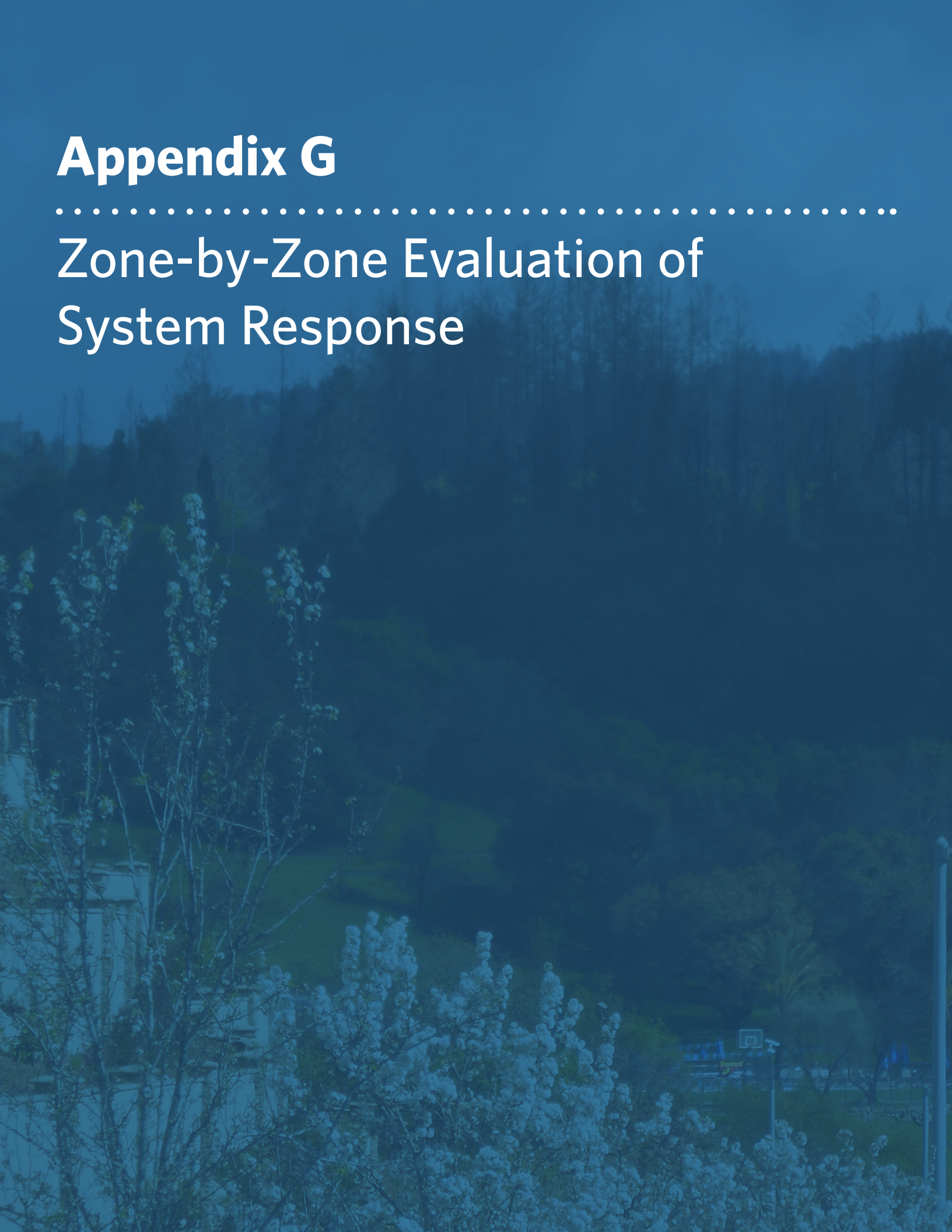


Figure F-4 Fountaingrove Hourly Demands (overall) 10/1 – 10/16, 2017

Appendix G

Zone-by-Zone Evaluation of System Response



Appendix G. Zone-by-Zone Evaluation of System Response

SCADA data was reviewed and compiled in a series of to review the system response to the fire on a zone-by-zone basis. The available data provided recorded values for flow rates at facilities, tank levels, and system pressures. During the time of the fire and afterwards, much of the SCADA recorded values were erroneous as evidenced by repeated consistent unreasonable values or were unreported in the SCADA system due to partial system outage. This was caused by the widespread power outage and damage due to the fire. In many cases, the data for tanks was not available but the pressures at facilities were available. In these instances, it can be inferred from the pressures what the level in the tanks were because the tanks set the hydraulic grade line (HGL) in the zones and the pressures and tank levels follow the same trend. To compare and make these inferences, the system pressures need to be converted to the HGL, which incorporates the facility elevation, as do the tank levels. This conversion was performed and the results are shown in the graphs provided below. The graphs present the following information for two days before the fire through October 12th, when Water Department distribution system operational efforts had provided a significant recovery to the water distribution system operations:

- Tank levels, as HGL, are shown in blue (if there is one tank in a zone) and red (when there are two tanks in a zone).
- Pressures at the discharge of pumping stations, as a HGL, are shown in green and purple
- Pressures at the suction of pumping stations, as a HGL, when available, are shown in dotted green and dotted purple
- Bottom of the tanks, as a HGL, are show in dotted black (if there is one tank) and dotted gray (if there is a second tank)
- Inflow into the pressure zone (pumping from the booster pump station that provides supply to the zone) is shown in the orange series with values represented on the secondary y-axis for flow rate
- When repeating unreasonable values, zero values, or no values were found, due to outage or "frozen" data, they were removed from the figures for legibility.

A few of the key notes gathered from a review of the zone-by-zone evaluations are provided following each of the figures.

PRESSURE ZONE R17

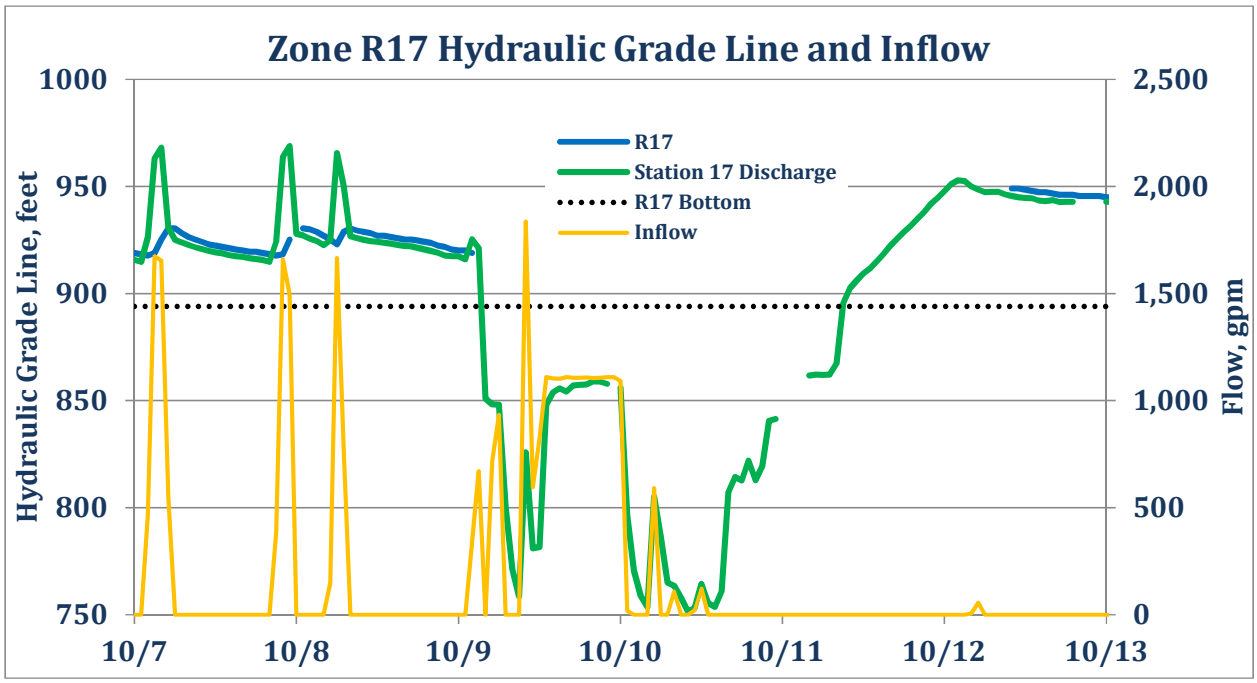


Figure G-1 Pressure Zone R17 – System Response Evaluation

- SCADA data for Tank R17 froze at 3 AM on October 9th.
- As the Tank R17 HGL follows closely with the Station 17 discharge HGL, it can be inferred that the Tank R17 emptied rapidly around 3 AM on the 9th.
- It can be inferred that Tank R17 stayed empty during the remainder of the 9th through the 11th. It appears to have started to fill on the 11th around 9 AM and likely maintained water levels shortly afterwards.
- By the morning of the 12th, the tank would have been operating at normal operating levels as witnessed by the Station 17 discharge HGL.
- Pumping into the R17 Pressure Zone is not shown after the 10th, however, from the discharge HGL, it appears that there was flow going into the zone and it was repressurizing.

PRESSURE ZONE R16

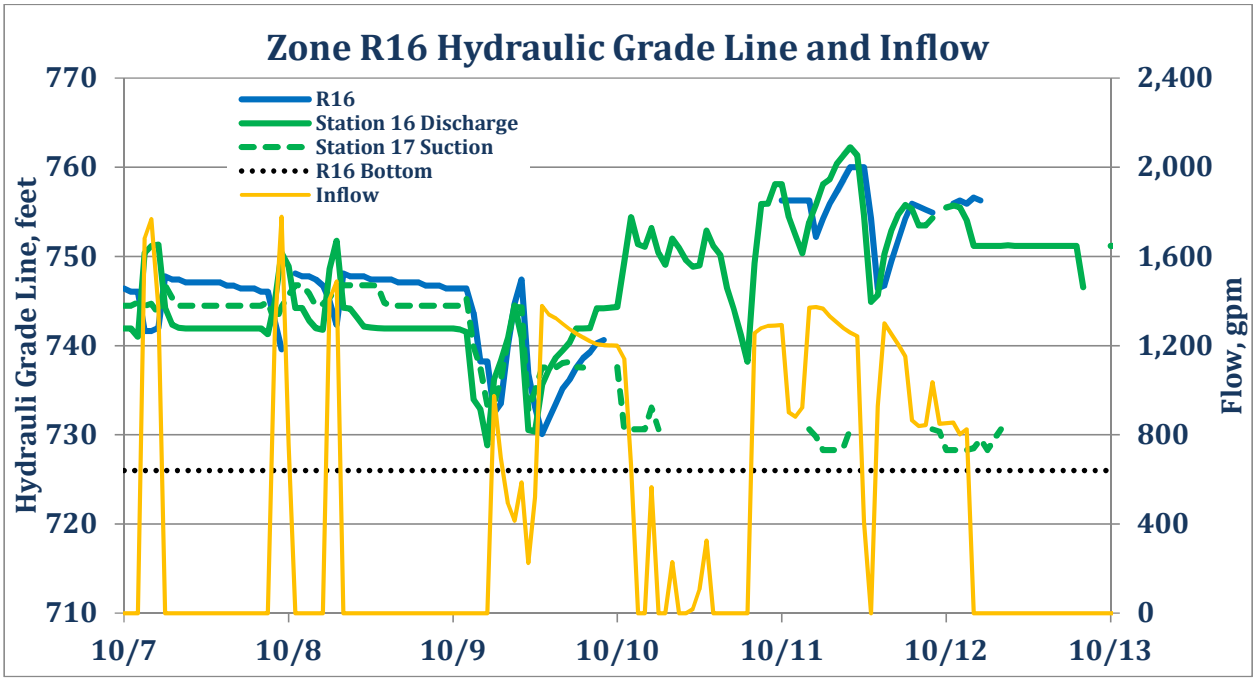


Figure G-2 Pressure Zone R16 – System Response Evaluation

- SCADA data for Tank R16 froze around 10 PM on October 9th. It appears from the Station 16 discharge pressures and the Station 17 suction pressures that the tank never fully emptied (both series are above the R16 bottom HGL)
- Pumping into the zone never stopped for more than a few hours on the 9th except for the early morning hours before 3 AM. Generally it only operated a few hours a day during typical operations that occurred the week prior to the Fire.
- The large difference in the HGL between the Station 16 discharge and the Station 17 suction indicates that there was some significant demand in this small zone.

PRESSURE ZONE R5

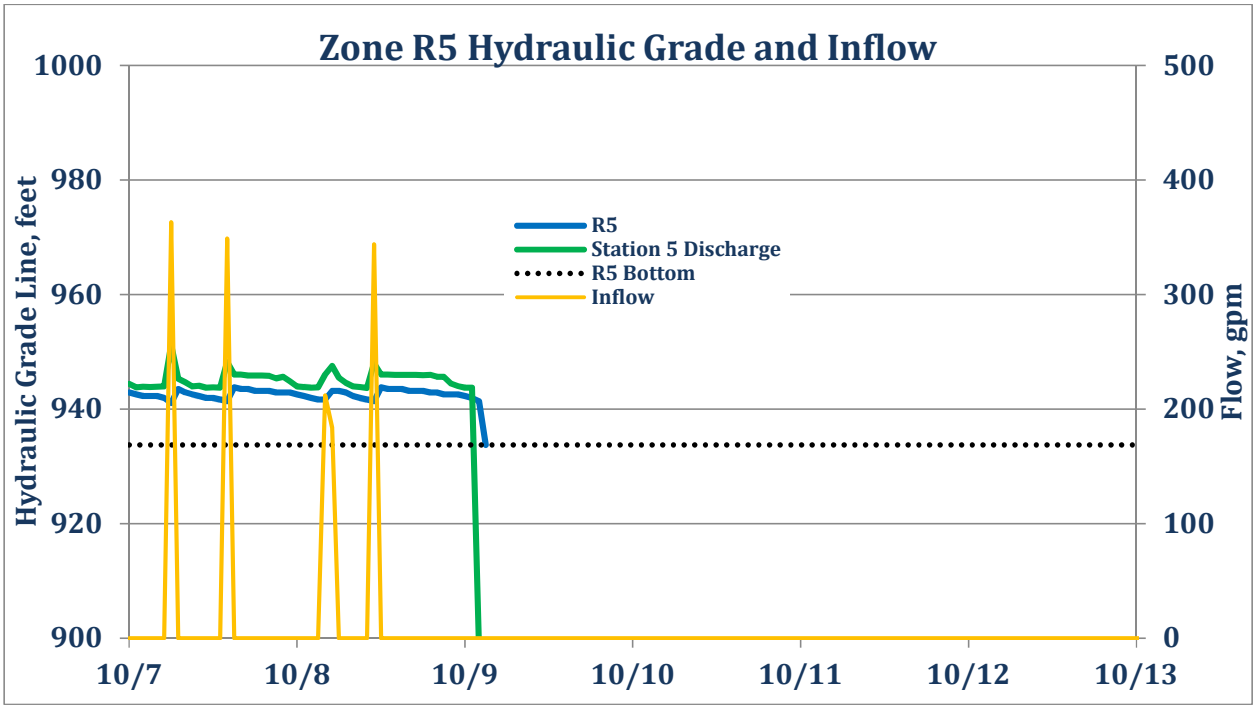


Figure G-3 Pressure Zone R5 – System Response Evaluation

- SCADA data for the tank went out around 3 AM on October 10th.
- No pumping shown into this zone during or after the fire because there was no supply available from Pressure Zone R2. Due to the damage caused by the fire in this zone, there were no customers to supply following the destruction of the property.
- The tank would have emptied immediately at 3 AM on October 10th as seen by the R5 HGL.
- The rapid rate of drain within those first hours indicates that if it had been full at the start of the fire, it would have been empty within the same time-frame depending on the number of openly flowing services.
- This facility was not returned to service as quickly as the other zones since there were no longer homes threatened by the fire. Additionally, the ability to maintain water quality after recharging the system was a serious concern for the four remaining connections that would possible need water service.

PRESSURE ZONE R4

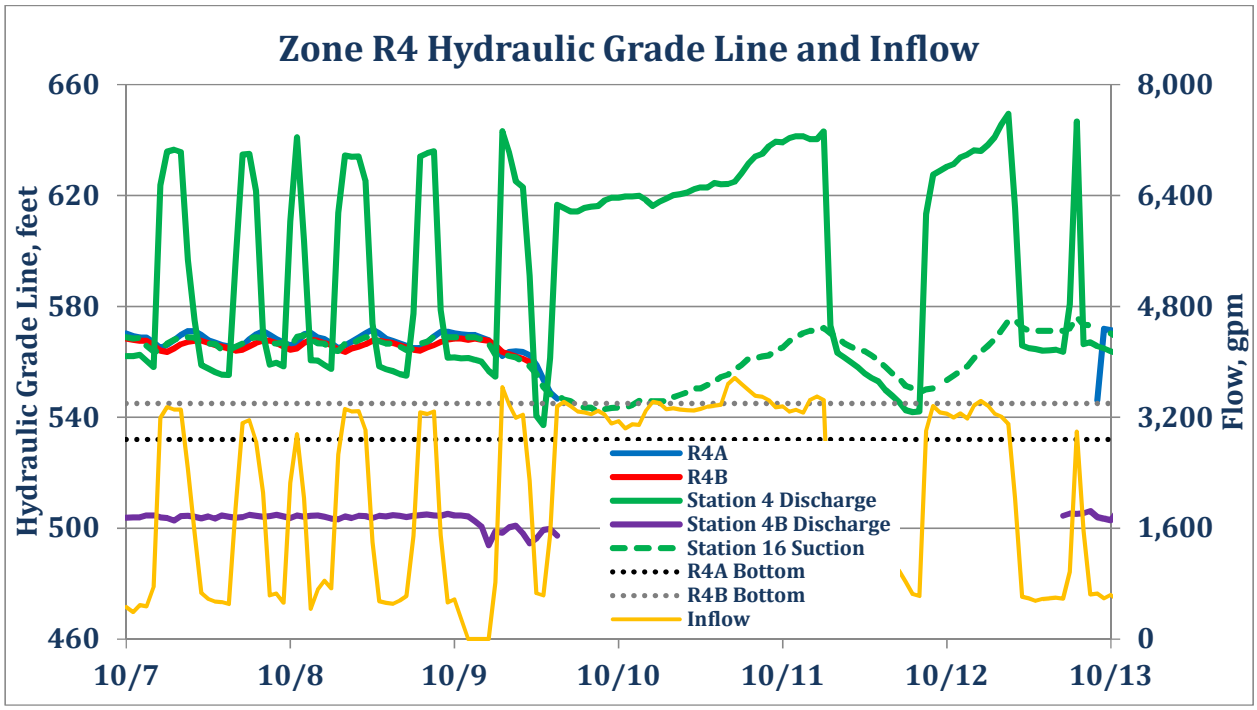


Figure G-4 Pressure Zone R4 – System Response Evaluation

- SCADA for Tank R4A and Tank R4B went out mid-day on October 9th.
- From the Station 16 suction, it can be inferred that Tank R4A maintained water during the entire period and that Tank R4B emptied briefly in the evening of the 9th but was able to be refilled with some water the morning of the 10th.
- There was supply entering the R4 Pressure Zone during all hours prior to the fire, during the fire, and after during recovery.

PRESSURE ZONE R3

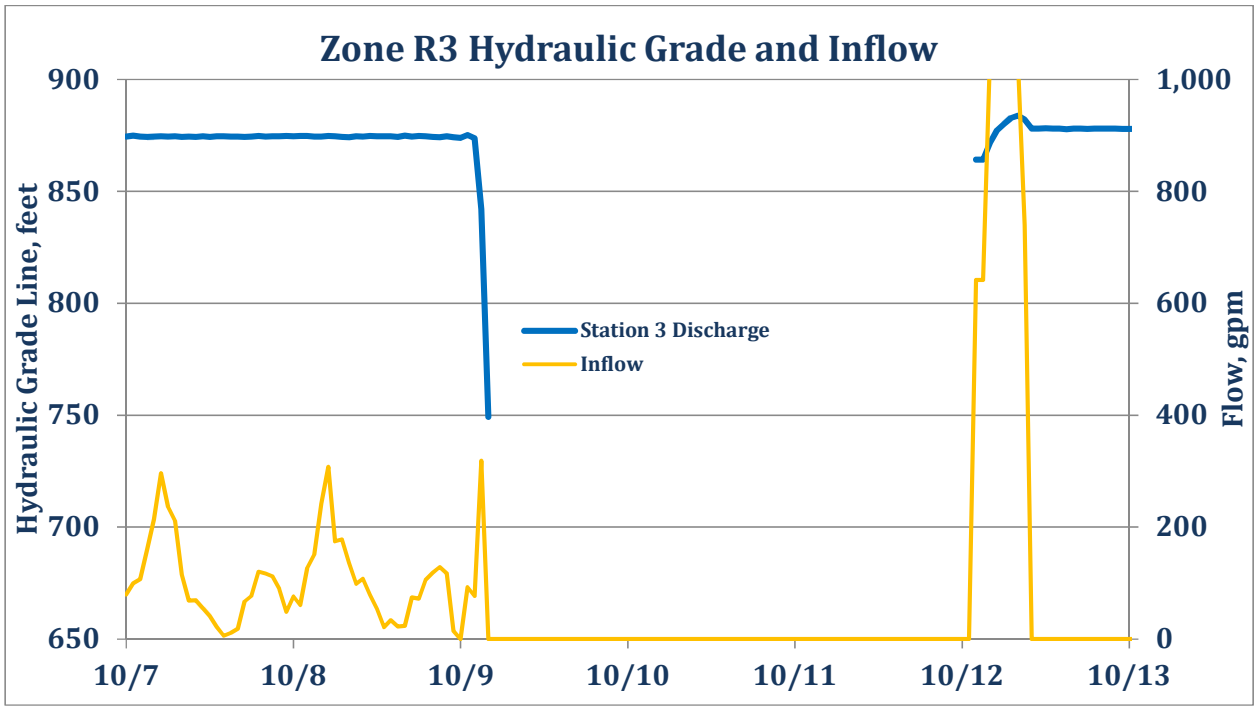


Figure G-5 Pressure Zone R3 – System Response Evaluation

- Tank R3 was out of service for seismic retrofits, as described in the TM.
- Pumping into the R3 Pressure Zone stopped around 3 AM on the 9th. This was likely due to the lack of suction pressure in the lower zone from which it pumps.
- Pumping into the R3 Pressure Zone resumed on the morning of the 12th. Sufficient suction pressure in the R2 Pressure Zone was required before the pumping could resume.

PRESSURE ZONE R2

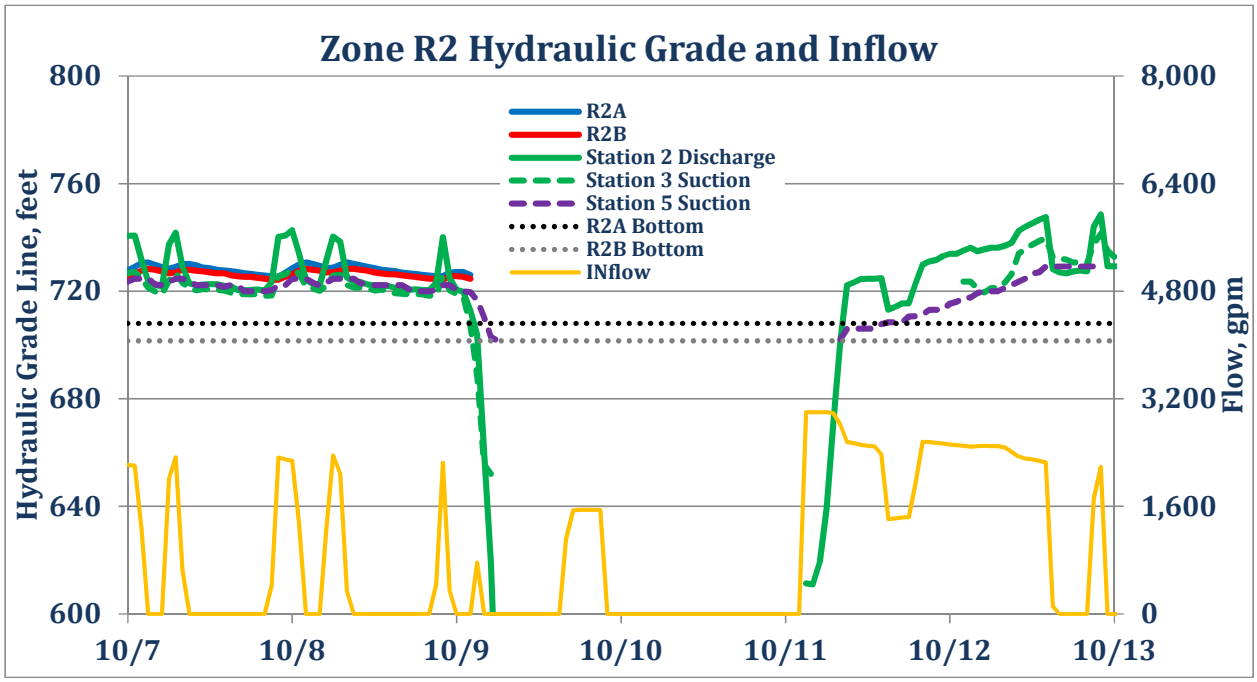


Figure G-6 Pressure Zone R2 – System Response Evaluation

- SCADA data for the tanks went out around 2 AM or 3 AM on October 9th.
- From Station 3 suction HGL, Station 5 suction HGL, and Station 2 discharge HGL, it can be inferred that Tank R2A emptied first, likely between 4 AM and 5 AM and Tank R2B emptied shortly thereafter.
- Attempts to fill the tanks were ongoing through the entire period, however the enormous demand caused by the open fire and service lines was preventing this.
- Early in the morning of the 11th, the pressure began to stabilize in the R2 Pressure Zone. Tanks look to have contained water by noon and continued to fill until they were at normal operating levels by mid-day on the 12th.

PRESSURE ZONE R1

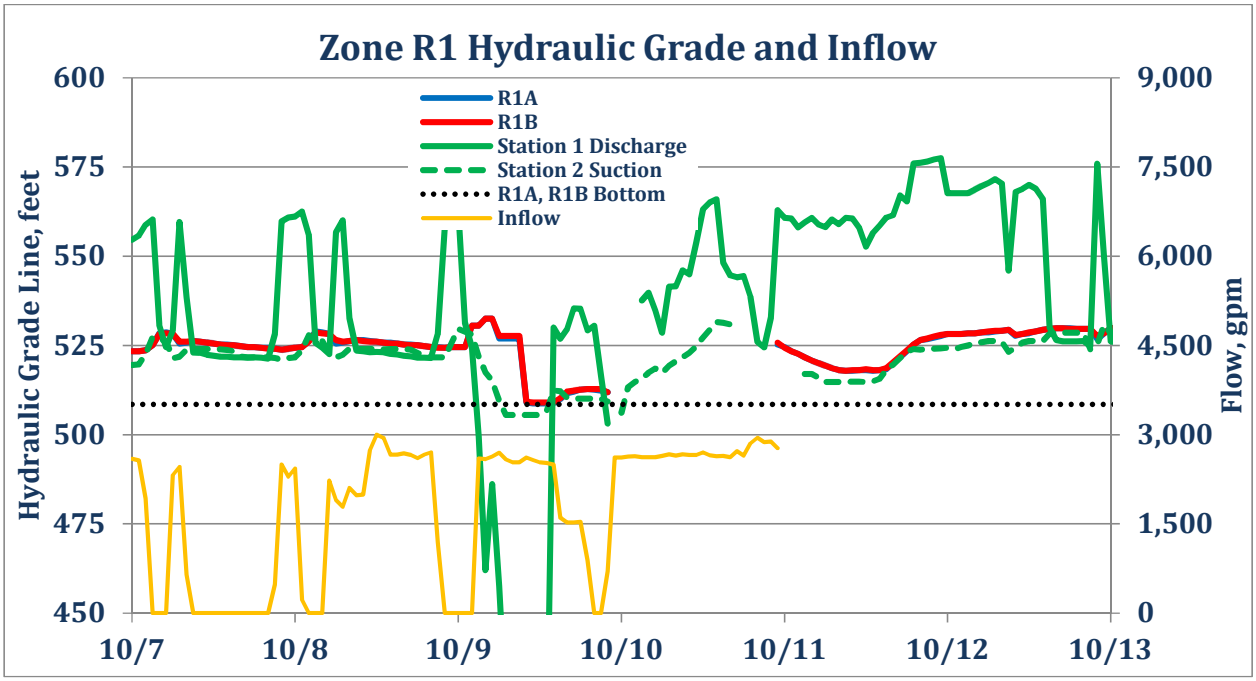


Figure G-7 Pressure Zone R1 – System Response Evaluation

- SCADA data for tanks went out around 11 PM on October 9th.
- Tanks were without water from around 10 AM or 11 AM to approximately 1 PM on the 9th. The remainder of the time they contained water. Attempts to fill these tanks were ongoing but until the openly flowing service lines were closed, the demand outpaced the pumping capacity.
- Pumping data for Station R1 stopped recording at mid-night on the 11th. However, from the Station 1 discharge HGL it appears that it was continuously pumping into the zone. Additional pressure was requested and granted from SCWA on the morning of the 9th which improved the ability to pump.