TECHNICAL MEMORANDUM

DATE: February 16, 2012

TO: Danielle DuGre, P.E., City of Santa Rosa
    Steve Allen, P.E., City of Santa Rosa

CC: Glen Wright, P.E., City of Santa Rosa

FROM: Irene Suroso, P.E., R.C.E. #70771

REVIEWED BY: Gerry Nakano, P.E., R.C.E. #29524

SUBJECT: Existing Water System Analysis – Fire Flow Evaluation in the High Severity Zones

This technical memorandum (TM) summarizes the findings and conclusions of West Yost Associates’ (West Yost) technical evaluation of the ability of the City’s existing water system to provide required fire flows and pressures to the high fire severity zones identified by the City’s Fire Department. This TM also presents a summary of the capital improvements identified by West Yost to meet the minimum required 1,500 gpm fire flow at a minimum required 20 psi system residual pressure in the high fire severity zones.

For the hydraulic analyses, two operational conditions at the City’s tanks and pump stations were evaluated to determine the operational condition that resulted in the most constrained fire flow availability. The operational condition that resulted in the lowest fire flow availability was then used to determine the capital improvements required to increase the fire flow to a minimum of 1,500 gpm while maintaining the minimum required 20 psi system residual pressure.

INTRODUCTION

In 2011, the City requested that West Yost evaluate the fire flow availability in the City’s Hillside Pressure Zones, specifically in the high fire severity areas identified by the City’s Fire Department. Figure 1 presents the high fire severity areas identified by the City’s Fire Department within the City’s Hillside Pressure Zones. As shown on Figure 1, the high fire severity areas are located in the following City Hillside Pressure Zones:

- Fountain Grove Pressure Zones (R1 and reduced R1, R2 and reduced R2, and R3)
- Montecito Pressure Zones (R4 and reduced R4, R16, and R17 and reduced R17)
- Skyfarm Pressure Zone (R5)
- Rincon Pressure Zones (R7 and R8)
- Bennett Pressure Zones (R9 and reduced R9 and R10)
The Hillside Pressure Zones have storage tanks located in each zone that contains fire flow storage volume, except for R15. The size of most storage tanks in the City’s Hillside Pressure Zones is small, and will not be able to accommodate a 1,500 gpm fire flow for multiple hours. Table 1 presents the storage tank volume for each Hillside Pressure Zone and the total hours that each storage tank can provide supply during a 1,500 gpm fire flow event.

<table>
<thead>
<tr>
<th>Pressure Zone</th>
<th>Tank Volume, MG</th>
<th>Hours Available to Serve 1,500 gpm Fire Flow with Tank 100% Full</th>
<th>Hours Available to Serve 1,500 gpm Fire Flow with Tank 50% Full</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1 (Tanks R1A and R1B)</td>
<td>1.00</td>
<td>11.1</td>
<td>5.6</td>
</tr>
<tr>
<td>R2 (Tanks R2A and R2B)</td>
<td>2.50</td>
<td>27.8</td>
<td>13.9</td>
</tr>
<tr>
<td>R3</td>
<td>0.50</td>
<td>5.6</td>
<td>2.8</td>
</tr>
<tr>
<td>R4 (Tanks R4A and R4B)</td>
<td>2.50</td>
<td>27.8</td>
<td>13.9</td>
</tr>
<tr>
<td>R5</td>
<td>0.30</td>
<td>3.3</td>
<td>1.7</td>
</tr>
<tr>
<td>R6</td>
<td>4.00</td>
<td>44.4</td>
<td>22.2</td>
</tr>
<tr>
<td>R7</td>
<td>2.00</td>
<td>22.2</td>
<td>11.1</td>
</tr>
<tr>
<td>R8</td>
<td>0.75</td>
<td>8.3</td>
<td>4.2</td>
</tr>
<tr>
<td>R9 (Tanks R9A, R9B and R9C)</td>
<td>5.50</td>
<td>61.1</td>
<td>30.6</td>
</tr>
<tr>
<td>R10</td>
<td>0.20</td>
<td>2.2</td>
<td>1.1</td>
</tr>
<tr>
<td>R11</td>
<td>1.15</td>
<td>12.8</td>
<td>6.4</td>
</tr>
<tr>
<td>R12 (Tanks R2A and R2B)</td>
<td>1.50</td>
<td>16.7</td>
<td>8.3</td>
</tr>
<tr>
<td>R13</td>
<td>0.10</td>
<td>1.1</td>
<td>0.6</td>
</tr>
<tr>
<td>R14</td>
<td>0.10</td>
<td>1.1</td>
<td>0.6</td>
</tr>
<tr>
<td>R16</td>
<td>0.25</td>
<td>2.8</td>
<td>1.4</td>
</tr>
<tr>
<td>R17</td>
<td>0.75</td>
<td>8.3</td>
<td>4.2</td>
</tr>
</tbody>
</table>

(a) Does not include system maximum day demand.

Based on discussion with City staff, hydraulic model runs were to be evaluated under two storage tank level conditions. These hydraulic model runs include evaluating available fire flow when the storage tank level is at 90 percent of the tank overflow level, and when the storage tank level is near empty, requiring the pump station providing water to fill this tank to be operating. When the storage tank level is 90 percent, the pump station that serves the same zone is assumed to be offline.
HYDRAULIC RESULTS

Hydraulic analyses were conducted under existing maximum day demand conditions. The available fire flow results were simulated at the model nodes where actual hydrants are located. However, the hydraulic model developed in 2007 doesn’t include 100 percent of the actual hydrants in the City Hillside Pressure Zones. Based on discussion with the City staff, West Yost added additional nodes in the smaller Hillside Pressure Zones to represent 100 percent of actual hydrants. However, for the larger Hillside Pressure Zones, as discussed and agreed to by City staff, West Yost only added approximately 80 percent of the actual hydrants into the hydraulic model. These hydrants represent hydrants located at the highest elevation or furthest away from major transmission mains. The hydraulic model results are discussed in the following sections.

Hillside Pressure Zones Storage Tank Level at 90 percent and Booster Pump Station is Offline

Figure 2 presents the currently available fire flow results under a system condition where the storage tank levels in the Hillside Pressure Zones are 90 percent full, and the booster pump stations are offline. As presented on Figure 2, the existing water system with the tank level at 90 percent in the Hillside Pressure Zones R4, R6, R9, R13 and R17 could not provide 1,500 gpm fire flow demands while maintaining a required minimum 20 psi system residual pressure.

Results also indicated that the existing system in the Aqueduct Zone within Oakmont area (A8) could not meet 1,500 gpm fire flow demands. This area is mostly served from 6-inch or 8-inch diameter pipelines through system check valves that convey water from Sonoma County Water Agency (SWCA) into the City’s existing system. Fire flow deficiencies in this area were mainly observed on 6-inch diameter dead-end pipelines that are undersized.

The fire flow deficiencies in the Hillside Pressure Zones R6, R9 and R13 are a result of dead-end pipelines, and the fire flow deficiency in R11 is located near the R11 storage tank site. These areas were not included in the evaluation to determine required improvements to meet 1,500 gpm fire flow demands because: 1) there is no potential for providing system looping to these dead-end areas or tank site; or 2) there are nearby hydrants that can be used to supplement and to meet the 1,500 fire flow demand requirement.

Hydraulic results for R4 and R17 indicated that the existing water system with the tank level at 90 percent full and no pump station operating is not adequate to meet the required 1,500 gpm fire flow demands. Because these two pressure zones also have booster pump stations, West Yost evaluated the capacity of the existing pump station to provide 1,500 gpm fire flow demands when the tank is nearly empty. The results are described in the Hillside Pressure Zone Storage Tank Level near Empty with Booster Pump Station Online Section.

Hillside Pressure Zone Storage Tank Level near Empty with Booster Pump Station Online

Figure 3 presents the available fire flow results simulated with the storage tank level at near empty and the booster pump station operating. Under this system condition, there is no flow from storage tank into each of the Hillside Pressure Zones.
As shown on Figure 3, the existing water system with fire flow demands to be served from the booster pump station could not provide 1,500 gpm fire flow demands in Pressure Zones R4, R6, R8, R9, R11, R13, R14 and R17. The available fire flow deficiencies in Pressure Zones R6, R8, R9 and R11 are related to either the undersized dead-end pipelines or due to high elevations near the storage tank site; consequently, West Yost did not evaluate the system improvements required to meet the minimum 1,500 fire flow demands in these areas.

To meet 1,500 gpm fire flow demands in Pressure Zones R4, R13, R14, R16 and R17, West Yost evaluated the pumping capacity at each pump stations that supplies flow to these pressure zones. Table 2 presents the existing pumping capacity at Pressure Zones R4, R13, R14, R16 and R17.

<table>
<thead>
<tr>
<th>Pump Station</th>
<th>Total Existing Pumping Capacity, gpm</th>
<th>Maximum Day Demand, gpm</th>
<th>Total Maximum Day Demand(a), gpm</th>
<th>Total Demand During Maximum Day Demand plus 1,500 gpm Fire Flow, gpm</th>
<th>Sufficient Existing Pumping Capacity to Provide 1,500 gpm Fire Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>S4</td>
<td>5,450</td>
<td>905</td>
<td>1,196</td>
<td>2,696</td>
<td>Yes</td>
</tr>
<tr>
<td>S13</td>
<td>2,175</td>
<td>26</td>
<td>60</td>
<td>1,560</td>
<td>Yes</td>
</tr>
<tr>
<td>S14</td>
<td>2,100</td>
<td>34</td>
<td>34</td>
<td>1,534</td>
<td>Yes</td>
</tr>
<tr>
<td>S16</td>
<td>1,120</td>
<td>25</td>
<td>291</td>
<td>1,791</td>
<td>No</td>
</tr>
<tr>
<td>S17</td>
<td>1,650</td>
<td>266</td>
<td>266</td>
<td>1,766</td>
<td>No</td>
</tr>
</tbody>
</table>

(a) Calculated based on cascaded demand of each pressure zone, for instance, Pump Station S4 existing maximum day demand requirement of 1,196 gpm equals to the summation of the maximum day demands in Pressure Zones R16 and R17.

The following sections discuss the pumping evaluation and the hydraulic model simulation results for Pressure Zones R4, R16, R17, R13 and R14.

**Pressure Zones R4, R16 and R17**

As shown on Table 2, the total existing pumping capacity at Station R4 is adequate to provide the 1,500 gpm fire flow; however, Pumping Stations S16 and S17 are not adequate to meet the minimum fire flow requirement. Pressure Zone R16 conveys water to Pressure Zone R17 through pump station S16. Therefore, the pumping capacity at Station S16 includes the total maximum day demands in Pressure Zones 16 and 17. The pumping deficiency at Station S16 is 671 gpm and the pumping deficiency at Station S17 is 116 gpm.

As illustrated on Figure 3, the available fire flow demands at some hydrants in Pressure Zone R4 are less than the 1,500 gpm minimum requirement. Although Station S4 has the capacity to deliver the 1,500 gpm fire flow under maximum day demand condition, the accumulated head losses through the existing 12-inch diameter pipelines along Del Rosa Avenue, Osage Avenue and Alta Vista Avenue, and the existing 14-inch diameter pipelines along Farmers Lane causes the water system to be inadequate to deliver 1,500 gpm fire flow demands at 20 psi system residual pressure to the highest hydrant in Pressure Zone R4. Although, the replacement of these existing 12-inch and 14-inch diameter pipelines to 16-inch diameter pipelines would reduce head losses and increase the resultant fire flow demands in Pressure Zone R4, the required pipeline construction along Farmers Lane will be extremely difficult and is not preferable by the City.
Therefore, the City requested West Yost evaluate an alternate solution. This alternate solution was to use the Proctor Pump station to provide fire flow to Pressure Zone 4. The Proctor Pump Station is currently not being operated. It is supplied by two Proctor Tanks that are also currently not operated. These tanks float off the City’s Aqueduct Zone, and the total storage capacity of these tanks is 5.2 MG. Proctor Pump Station has a total pumping capacity of 2,600 gpm which is adequate to supply the 1,500 gpm fire flow demand requirement.

Figure 4 presents the simulated available fire flow in Pressure Zone 4 from the hydraulic model run with the Proctor Pump Station and the replacement of the 12-inch diameter pipelines to 16-inch diameter pipelines (approximately 2,342 lf) configurations. The results indicate that utilizing the Proctor Pump Station and upsizing the existing 12-inch diameter pipeline could provide the 1,500 gpm fire flow demands while maintaining 20 psi system residual pressure in Pressure Zone R4. The capital cost estimate for this improvement is estimated in the Capital Improvement Cost Section of this TM.

For Pressure Zones R16 and R17, West Yost evaluated the total hydraulic head required for the pump to provide a required minimum 20 psi system residual pressure at the highest hydrant in Pressure Zones R16 and R17. Results indicate that the existing total dynamic head at Stations S16 and S17 are inadequate to serve 20 psi residual pressure at the highest hydrant elevation locations in Pressure Zones R16 and R17 due to accumulated pipeline head loss. Using the hydraulic model run, West Yost estimated the required total dynamic head for stations S16 and S17 to deliver a 1,500 gpm fire flow while maintaining 20 psi system residual pressure. Table 3 provides the summary of this evaluation.

Based on these data, West Yost reran the hydraulic model with pump improvements at Stations S16 and S17. Pump Station 16 was simulated in the hydraulic model with a pumping capacity of 1,000 gpm and a total dynamic head (TDH) of 243 feet at each pump, and pumps at Station 17 were simulated in the hydraulic model with a pumping capacity of 1,000 gpm with a TDH of 220 feet at each pump. Hydraulic results indicated these pump improvements could deliver 1,500 gpm fire flow while maintaining 20 psi system residual pressure at the highest hydrant. Figure 5 presents simulated available fire flow under these pump improvement conditions.

<table>
<thead>
<tr>
<th>Table 3. Total Dynamic Head and Highest Hydrant Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump Station</td>
</tr>
<tr>
<td>S16</td>
</tr>
<tr>
<td>S17</td>
</tr>
</tbody>
</table>

(a) Estimated based on hydraulic model run which includes pipeline headlosses.

After presenting these hydraulic results and required improvements for Pressure Zones R16 and R17 to the City staff, due to City concerns regarding extremely difficult construction conditions for the proposed pipeline replacement project, the City requested that West Yost evaluate an alternate option. This option would provide the fire flow in Pressure Zone R17 through the emergency pump station S18, which is supplied by Pressure Zones R3, R2 and R1. Currently, the
City has storage capacity and pumping capacity in Pressure Zones R2 and R1. However, Station S3 does not have the pumping capacity to provide the 1,500 gpm fire flow to Pressure Zone R17 as presented on Table 4. West Yost also identified a pipeline restriction along Fountaingrove Parkway, east of Fir Ridge Drive. This existing pipeline, approximately 606 lineal feet (lf), is a 10-inch diameter pipeline. To deliver 1,500 gpm demand from Station S3 to Station S18, this existing 10-inch pipeline has to be replaced with a 12-inch diameter pipeline. Figure 6 presents the available fire flow in Pressure Zone R17 under this proposed supply configuration.

<table>
<thead>
<tr>
<th>Pump Station</th>
<th>Total Existing Pumping Capacity, gpm</th>
<th>Maximum Day Demand, gpm</th>
<th>Total Maximum Day Demand(a), gpm</th>
<th>Total Demand during Maximum Day Demand plus 1,500 gpm Fire Flow, gpm</th>
<th>Sufficient Existing Pumping Capacity to Provide 1,500 gpm Fire Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>5,700</td>
<td>127</td>
<td>867</td>
<td>2,367</td>
<td>Yes</td>
</tr>
<tr>
<td>S2</td>
<td>4,000</td>
<td>538</td>
<td>740(b)</td>
<td>2,240</td>
<td>Yes</td>
</tr>
<tr>
<td>S3</td>
<td>1,200</td>
<td>296</td>
<td>432(c)</td>
<td>1,932</td>
<td>No</td>
</tr>
<tr>
<td>S18</td>
<td>1,600</td>
<td>0</td>
<td>266</td>
<td>1,766</td>
<td>No</td>
</tr>
</tbody>
</table>

(a) Calculated based on cascaded demand of each pressure zone, for instance, Pump Station Ss existing maximum day demand requirement of 1,196 gpm equals to the summation of the maximum day demands in Pressure Zones R1, R2, R5 and R3.
(b) Includes Pressure Zone R5 maximum day demand of 37 gpm.
(c) Includes Pressure Zone R17 maximum day demand of 266 gpm.

The upgrade of Pump Station S3 and the replacement of the existing 10-inch pipeline to a 12-inch diameter pipeline would also provide an alternate supply solution for providing fire flow in Pressure Zone R4 without the pipeline replacement along Del Rosa Avenue, Osage Avenue and Alta Vista Avenue. Based on discussion with City staff, the construction along Del Rosa Avenue will be difficult and is not preferable by the City.

This alternate fire flow supply solution includes operating the City’s bypass pressure regulator stations located at Pump Stations S17 and S16. The City needs to operate Pump Station S18 to move flow from the upgraded Pump Station S3 into Pressure Zone R17 which will continually flow through the bypasses at Stations S17 and S16 to Pressure Zone R4. Under this alternate supply configuration, the City also needs to operate the Proctor Pump Station, S20, to supplement the fire flow demand in Pressure Zone R4, so flow is actually being provided from two different source areas.

West Yost ran the hydraulic model under this alternate supply configuration to determine the fire flow availability in Pressure Zone R4. Results indicate that this alternate supply configuration could meet the 1,500 gpm fire flow demands while maintaining the required 20 psi system pressure. Only a few areas which are located on dead-end pipelines could not meet the 1,500 gpm fire flow demand requirement during maximum day demand conditions. The hydraulic results for the available fire flow under this alternate supply configuration for Pressure Zone R4 is presented on Figure 7.
Pressure Zones R13 and R14

Table 2 shows that Stations S13 and S14 have sufficient existing pumping capacity to meet maximum day demand plus a 1,500 gpm fire flow demand. However, based on hydraulic results, the system could not provide 1,500 gpm fire flow demands while maintaining the required minimum 20 psi system residual pressure at hydrants located in these pressure zones.

In Pressure Zone R13, the hydrants that could not meet the 1,500 gpm fire flow are located on an existing 6-inch diameter dead-end and long pipeline, approximately 1,994 lf. The accumulated head loss on this existing pipeline causes the fire flow deficiency. To meet the 1,500 gpm fire flow demand while maintaining the 20 psi system residual pressure, about 876 lf of the existing 6-inch diameter pipeline is required to be upsized to an 8-inch diameter pipeline.

Most hydrants located in Pressure Zone R14 could not meet the required 1,500 fire flow while maintaining 20 psi system residual pressure. Because the pump station, S14, has the flow capacity, West Yost evaluated the total dynamic head at this station. Based on hydraulic model runs, West Yost identified the required total dynamic head at Station S14 to deliver 1,500 gpm fire flow demand at 20 psi system residual pressure, and it is presented on Table 5.

<table>
<thead>
<tr>
<th>Pump Station</th>
<th>Pump Station Elevation, feet</th>
<th>Total Dynamic Head, feet</th>
<th>Highest Hydrant Elevation, feet</th>
<th>Required Total Dynamic Head at the Pump Station to Deliver 1,500 gpm Fire Flow Demand at 20 psi Residual Pressure (a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S14</td>
<td>807</td>
<td>210</td>
<td>970</td>
<td>235</td>
</tr>
</tbody>
</table>

(a) Estimated based on hydraulic model run which includes pipeline head losses.

With the pipeline improvement in Pressure Zone R13 and the pump improvement in Pressure Zone R14, the hydraulic model was rerun. Results indicated the system could provide the 1,500 gpm fire flow demand while maintaining 20 psi system residual pressure. Figure 8 presents the simulated available fire flow at the required minimum 20 psi system residual pressure.

Required Improvements

This section summarizes the improvements required by pressure zone to meet the minimum 1,500 gpm fire flow demand during maximum day demand condition while maintaining a required minimum 20 psi system residual pressure.

Pressure Zone R4

- Alternate 1
  - Operate Proctor Pump Station and Proctor Tanks
  - Replace 2,342 lf of existing 12-inch diameter pipeline along Del Rosa Avenue, Osage Avenue and Alta Vista Avenue with a 16-inch diameter pipeline
• Alternate 2 (Recommended Alternative)
  — Replace pumps at Station S3
  — Replace 606 lf of existing 10-inch diameter pipeline along Fountaingrove Parkway, east of Fir Ridge Drive with a 12-inch diameter pipeline

Pressure Zones R16 and R17

• Alternate 1
  — Replace pumps at Station S17
  — Replace pumps at Station S16

• Alternate 2 (Recommended Alternative)
  — Replace pumps at Station S3
  — Replace 606 lf of existing 10-inch diameter pipeline along Fountaingrove Parkway, east of Fir Ridge Drive with a 12-inch diameter pipeline

Pressure Zone R13

• Replace 876 lf of existing 6-inch diameter pipeline, east of Station S13, with an 8-inch diameter pipeline

Pressure Zone R14

• Replace pumps at Station S14

CAPITAL IMPROVEMENTS COSTS

The probable construction cost for each improvement was calculated based on data supplied by manufacturers, published industry standard cost data and curves, construction costs provided by the City, and construction costs previously estimated by West Yost for similar facilities with similar construction cost indexes. The City provided West Yost the pipeline unit cost of $600 per lineal feet which is based on the City’s Unit Cost that includes all pipeline cost and roadway repair cost.

Table 6 presents the construction cost to meet the 1,500 gpm fire flow requirement in Pressure Zones R4, R16 and R17. The construction cost for Pressure Zones R16 and R17 include pump replacements (Alternate 1) at Station S16 and S17. The total pump replacement construction cost is $3.48M. The total construction cost to replace the existing 12-inch diameter pipeline with a 16-inch diameter pipeline in Pressure Zone R4 is $2.04M.

Table 7 presents the construction cost to meet the 1,500 gpm fire flow requirement in Pressure Zones R4, R16 and R17 under the City’s requested alternate supply (Alternate 2 (Recommended Alternative)) to provide fire flow demand in Pressure Zones R4 and R17 through Station S18. The construction cost for upgrading Station S3 is $1.74M and construction cost to replace pipeline along Fountaingrove Parkway is $0.53M.
<table>
<thead>
<tr>
<th>Improvement Type</th>
<th>Improvement Description</th>
<th>Pressure Zone</th>
<th>Quantity</th>
<th>Estimated Construction Cost</th>
<th>CIP Cost (includes mark-ups)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pump Station Upgrade CIP</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S16 Booster Pump Station 4.32 mgd at S16</td>
<td></td>
<td>R16</td>
<td>1 L.S.</td>
<td>$1,196,385</td>
<td>$1,735,000</td>
</tr>
<tr>
<td>S17 Booster Pump Station 4.32 mgd at S17</td>
<td></td>
<td>R17</td>
<td>1 L.S.</td>
<td>$1,196,385</td>
<td>$1,735,000</td>
</tr>
<tr>
<td><strong>New Pipeline and Pipeline Replacement CIP</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R4 Pipeline Replacement 16-inch diameter pipeline (from 12-inch diameter pipeline)</td>
<td></td>
<td>R4</td>
<td>2,342 lf</td>
<td>$1,405,232</td>
<td>$2,038,000</td>
</tr>
</tbody>
</table>

| **Total**                                            |                                                  |               |          |                              | $5,508,000                  |

(a) Pipeline Unit Cost is based on City's Unit Cost which includes all pipeline cost and roadway repair cost.
(b) Pump Station Costs shown are presented in November 2011 dollars based on an ENR CCI of 9173 (20-City Average).
(c) Costs include mark-ups equal to 45 percent (General Contingency: 20 percent; Design and Planning: 10 percent; Construction Management: 10 percent; and Program Administration: 5 percent).
(d) Total rounded to nearest $1,000.
<table>
<thead>
<tr>
<th>Improvement Type</th>
<th>Improvement Description</th>
<th>Pressure Zone</th>
<th>Quantity</th>
<th>Estimated Construction Cost</th>
<th>CIP Cost (includes mark-ups)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pump Station Upgrade CIP</strong></td>
<td>S3 Booster Pump Station 2.88 mgd at S3</td>
<td>R3</td>
<td>1</td>
<td>$1,196,385</td>
<td>$1,735,000</td>
</tr>
<tr>
<td></td>
<td>Pump Station CIP Subtotal</td>
<td></td>
<td></td>
<td></td>
<td>$1,735,000</td>
</tr>
<tr>
<td><strong>New Pipeline and Pipeline Replacement CIP</strong></td>
<td>R3 Pipeline Replacement 12-inch diameter pipelines (from 6-inch and 12-inch diameter pipelines)</td>
<td>R3</td>
<td>606</td>
<td>$363,600</td>
<td>$527,000</td>
</tr>
<tr>
<td></td>
<td>Pipeline CIP Subtotal</td>
<td></td>
<td></td>
<td></td>
<td>$527,000</td>
</tr>
<tr>
<td></td>
<td><strong>Total Capital Improvement Cost</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>$2,262,000</strong></td>
</tr>
</tbody>
</table>

(a) Pipeline Unit Cost is based on City's Unit Cost which includes all pipeline cost and roadway repair cost.  
(b) Pump Station Costs shown are presented in November 2011 dollars based on an ENR CCI of 9173 (20-City Average).  
(c) Costs include mark-ups equal to 45 percent (General Contingency: 20 percent; Design and Planning: 10 percent; Construction Management: 10 percent; and Program Administration: 5 percent).  
(d) Total rounded to nearest $1,000.
Table 8 presents the construction cost to meet the 1,500 gpm fire flow requirement in Pressure Zones R13 and R14. The construction cost to replace pump at Station S14 is $1.51M. The Construction cost to replace the existing 6-inch diameter pipeline in Pressure Zone R13, near Station S13 is $0.76M.

The summary of all probable construction cost of system improvements to meet 1,500 gpm fire flow requirement in each Hillside Pressure Zones is presented on Table 9.
<table>
<thead>
<tr>
<th>Improvement Type</th>
<th>Improvement Description</th>
<th>Pressure Zone</th>
<th>Quantity</th>
<th>Estimated Construction Cost</th>
<th>CIP Cost (includes mark-ups)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S14 Booster Pump Station</td>
<td>5.62 mgd at S14</td>
<td>R14</td>
<td>1</td>
<td>$1,509,935</td>
<td>$1,510,000</td>
</tr>
<tr>
<td>R13 Pipeline Replacement</td>
<td>8-inch diameter pipeline (From 6-inch diameter pipeline)</td>
<td>R13</td>
<td>876</td>
<td>$525,600</td>
<td>$762,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Total Cost</td>
<td>$2,272,000</td>
</tr>
</tbody>
</table>

(a) Pipeline Unit Cost is based on City's Unit Cost which includes all pipeline cost and roadway repair cost.
(b) Pump Station Costs shown are presented in November 2011 dollars based on an ENR CCI of 9173 (20-City Average).
(c) Costs include mark-ups equal to 45 percent (General Contingency: 20 percent; Design and Planning: 10 percent; Construction Management: 10 percent; and Program Administration: 5 percent).
(d) Total rounded to nearest $1,000.
Table 9. Total Dynamic Head and Highest Hydrant Elevation

<table>
<thead>
<tr>
<th>Pressure Zone</th>
<th>Pipeline Upgrade</th>
<th>Pump Replacement</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>To meet 1,500 gpm fire flow in Pressure Zone R4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R4</td>
<td>✓</td>
<td></td>
<td>$2.04M</td>
</tr>
<tr>
<td>Alternative 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(The recommended improvements for this alternative is identical to Alternative 2 for Pressure Zones R16 and R17)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R3</td>
<td>✓</td>
<td>✓</td>
<td>$2.26M</td>
</tr>
<tr>
<td>To meet 1,500 gpm fire flow in Pressure Zones R16 and R17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternate 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R16</td>
<td></td>
<td>✓</td>
<td>$1.74M</td>
</tr>
<tr>
<td>R17</td>
<td></td>
<td>✓</td>
<td>$1.74M</td>
</tr>
<tr>
<td>Subtotal</td>
<td></td>
<td></td>
<td>$3.48M</td>
</tr>
<tr>
<td>Alternate 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(The recommended improvements for this alternative is identical to Alternative 2 for Pressure Zone R4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R3</td>
<td>✓</td>
<td>✓</td>
<td>(a)</td>
</tr>
<tr>
<td>To meet 1,500 gpm fire flow in Pressure Zones R13 and R14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R13</td>
<td></td>
<td>✓</td>
<td>$0.76M</td>
</tr>
<tr>
<td>R14</td>
<td></td>
<td>✓</td>
<td>$1.51M</td>
</tr>
</tbody>
</table>

(a) The recommended improvements for this alternative are identical to Alternative 2 for Pressure Zone R4 and the total cost for these improvements is listed in Alternative 2 for Pressure Zone R4.

CONCLUSIONS

The results of hydraulic analyses of various system configurations are summarized below. Based on the fire flow evaluation in the City’s Hillside Pressure Zones, there are 4 pressure zones that could not meet the minimum required 1,500 gpm fire flow demand while maintaining the required minimum 20 psi system residual pressure. These pressure zones are R4, R17, R13 and R14. The fire flow deficiency in these zones are either resulted from accumulated head losses on downstream pipeline that convey water from the pump station into the City’s water system or from lower head on the pumps that serve these pressure zones.

Based on hydraulic simulated results, West Yost identified pipeline and pump improvements for these pressure zones. West Yost also evaluated the probable cost estimate for each improvement. The improvements to meet the minimum required 1,500 gpm fire flow demand for Pressure Zones R4, R17, R13 and R14 are described as follow:

- For Pressure Zone R4 and Pressure Zone R17
  - Replace pumps at Station S3. The recommended total capacity of the new pump station is 3,000 gpm (currently, Station S3 only have 2 pumps).
  - Replace 606 lf of existing 10-inch diameter pipeline along Fountaingrove Parkway, east of Fir Ridge Drive with a 12-inch diameter pipeline.
- Pressure Zone R13
  — Replace 876 lf of existing 6-inch diameter pipeline, east of Station S13, with an 8-inch diameter pipeline.

- Pressure Zone R14
  — Replace pumps at Station S14 with a total dynamic head of approximately 235 feet.

The total capital costs for the identified system upgrades discussed in this TM is $4.53M.
FIGURE 1
City of Santa Rosa
Fire Flow Availability Evaluation

HIGH FIRE SEVERITY AREAS

LEGEND
High Fire Severity Areas Code

Hillside Pressure Zones:

0 5,500 2,750
Scale in Feet

City of Santa Rosa Fire Flow Availability Evaluation

HIGH FIRE
SEVERITY AREAS

LEGEND
High Fire Severity Areas Code

Hillside Pressure Zones:
All Hillside tank levels were at 90 percent full.

Legend:
- Available Fire Flow at 20 psi
  - Less than 1,500 gpm
  - Greater than 1,500 gpm
- Pumps
- SCWA Tanks
- Existing Pipelines
- SCWA Aqueduct
- Tanks
- High Fire Severity

FIGURE 2
City of Santa Rosa
Fire Flow Availability Evaluation
AVAILABLE FIRE FLOW AT 20 PSI
TANK LEVEL AT 90 PERCENT FULL AND PUMP STATIONS ARE OFFLINE
Most hydrants that have available fire flow less than 1,500 gpm are located on dead-end pipeline.

Notes:
- Proctor pumps were operated.
- S4 pumps were not operated.
- R4A and R4B tank levels were at 10 percent full (assume no flow).

Legend:
- Available Fire Flow at 20 psi
  - Less than 1,500 gpm
  - Greater than 1,500 gpm
- Pumps
- Pipeline Replacement (from 12-inch to 16-inch diameter)
- SCWA Tanks
- SCWA Aqueduct
- High Fire Severity
- Existing Pipelines

**FIGURE 4**
City of Santa Rosa
Fire Flow Availability Evaluation
AVAILABLE FIRE FLOW AT 20 PSI
TANK LEVEL AT 10 PERCENT FULL FOR R4 PRESSURE ZONE
(with Proctor Pump Station and Pipeline Replacement)
Available Fire Flow at 20 psi
- Less than 1,500 gpm
- Greater than 1,500 gpm

Legend
- SCWA Tanks
- Existing Pipelines
- SCWA Aqueduct
- High Fire Severity
- Existing Pump
- Upgraded Pump

Notes
1. S16 and S17 pumps were operated.
2. R16 and R17 tank levels were at 10 percent full (assume no flow).

FIGURE 5
City of Santa Rosa
Fire Flow Availability Evaluation
AVAILABLE FIRE FLOW AT 20 PSI
TANK LEVEL AT 10 PERCENT FULL FOR R16 AND R17 PRESSURE ZONES
(Alternate 1 - with Pump Replacement)
FIGURE 6
City of Santa Rosa
Fire Flow Availability Evaluation
AVAILABLE FIRE FLOW AT 20 PSI
TANK LEVEL AT 10 PERCENT FULL FOR R16 AND R17 PRESSURE ZONES
(Alternate 2 - with Supply from S18 and S3 Pump Replacement)
Most hydrants that have available fire flow less than 1,500 gpm are located on dead-end pipeline.

Notes:
1. Proctor pumps were operated.
2. R4A and R4B tank levels were at 10 percent full (assume no flow).
3. S3 pumps were upgraded and operated.
4. S18 pumps were operated.

Legend:
- Available Fire Flow at 20 psi
  - Less than 1,500 gpm
  - Greater than 1,500 gpm
  - SCWA Tanks
- Pumps
- Pipeline Replacement (from 10-inch to 12-inch diameter)
- SCWA Aqueduct
- High Fire Severity
- Existing Pipelines
- SCWA Aqueduct
- Upgraded Pump

FIGURE 7
City of Santa Rosa
Fire Flow Availability Evaluation
AVAILABLE FIRE FLOW AT 20 PSI
TANK LEVEL AT 10 PERCENT FULL FOR R4 PRESSURE ZONE
(with S3 Pump Upgrade, R3 Pipeline Replacement and Proctor Pump Station)
FIGURE 8
City of Santa Rosa
Fire Flow Availability Evaluation
AVAILABLE FIRE FLOW AT 20 PSI
TANK LEVEL AT 10 PERCENT FULL FOR R13 AND R14 PRESSURE ZONES
(with Pump and Pipeline Improvements)

Notes:
1. S13 and S14 pumps were operated.
2. R13 and R14 tank levels were at 10 percent full (assume no flow).

LEGEND
Available Fire Flow at 20 psi
- SCWA Tanks
- High Fire Severity
- Less than 1,500 gpm
- Greater than 1,500 gpm
- Existing Pipelines
- Pipeline Replacement
- SCWA Aqueduct
- Existing Pump
- Upgraded Pump

Scale in Feet
0 500 1,000

Scale in Feet
0 500 1,000