WEST YOST ASSOCIATES
Consulting Engineers

TECHNICAL MEMORANDUM

DATE: March 30, 2010 Project No.: 418-02-07-22

TO: Jack Bond, City of Modesto, Project Manager

FROM: Charles Duncan, Project Manager

SUBJECT: City of Modesto's 2008 Water System Engineer's Report
Evaluation of the Existing and Buildout Water System for the Grayson Outlying Service Area (Grayson TM)

In the mid 1990's the City of Modesto (City) acquired the former Del Este Water System, which included the communities of Grayson, Hickman, and Del Rio, the City of Waterford, and a portion of the City of Turlock. The City now manages, operates and maintains these five outlying water service areas. As a component of the City's Engineer's Report, the City has requested West Yost Associates (WYA) to provide an individual hydraulic assessment of each of these separate systems. The hydraulic evaluation of the Town of Grayson (Grayson) water system is addressed in this technical memorandum.

1.0 SUMMARY

The hydraulic assessment included three system components and the ability to serve current and buildout demands: groundwater pumping capacity; storage capacity; and distribution system needs. In addition, water supply requirements at buildout were evaluated; additional demands at buildout are minimal and do not require a change in the proposed facility plan.

1.1 Pumping Capacity

The system assessment evaluated the adequacy of existing production wells to meet current water demands for two conditions: Peak Hour; and Maximum Day plus fire flow conditions. Peak hour and Maximum Day demand were calculated as 456 gallons per minute (gpm) and 201 gpm, respectively.

The system was reviewed with all wells and booster pumps producing, and with the largest well out of service (i.e., reliable pumping capacity). The reliable pumping capacity is sufficient to meet Peak Hour demand conditions. Standby pumps are recommended at Well 274 and Booster Pump #1 to ensure a reliable supply. The booster pump station is limited by the ability of the well pumps to provide enough supply to maintain the minimum tank level, approximately 4 feet. A new well is required to provide additional supply. An additional two 50 HP pumping units are required at the Tank 9 booster station to meet Maximum Day plus fire flow demand conditions.

1.2 Storage Capacity

The storage capacity assessment evaluated total storage and peaking capacity requirements based on three criteria: operational storage; fire storage; and emergency storage. Operational storage was established as 0.25 x Maximum Day demand. Fire flow demand was established as 1,500 gpm for a 2-hour duration. Emergency storage was established as 1.00 x the average day demand. Available storage at the tank and from groundwater production provides sufficient storage for the Grayson water system.

1.3 Existing System

The City has established a minimum requirement of 40 pounds per square inch (psi) of system pressure to meet Peak Hour demand, and 20 psi of residual pressure, measured at the flowing hydrant, to meet Maximum Day plus fire flow demands. Also, head loss should remain below 7 feet per 1,000 feet (ft/kft) of distribution piping, and velocity should be not greater than 7 feet per second (fps).

WYA developed the system hydraulic model using MWH Soft's H_2ONET software. Model inputs included pipe, junctions, wells, tanks, and pumps. Additional information about the hydraulic model is provided in Attachment A.

The hydraulic model indicates that the existing supply system, comprised of two operational wells, a 0.22 million gallon (MG) storage tank, and associated distribution system is sufficient to meet peak flow conditions. However, the system cannot maintain a minimum 20 psi residual system pressure during a simulated Maximum Day plus fire flow demand condition. To correct these existing system deficiencies, the City must install a new production well capable of producing approximately 400 gallons per minute (gpm), and replace 4,600 feet of existing small diameter pipeline with new 8-inch diameter pipeline. Our evaluation indicates that a backup generator should also be installed for the new well, Well 274, and Booster Pump #1 to ensure reliable service.

Recommended capital improvements to the existing Grayson water system are listed below, and anticipated to cost approximately $4.63M, as detailed in Table 8 of this TM.

- Construct new 400 gpm production well with standby generator to meet fire flow demands
- Install a standby generator at existing Well 274
- Install a standby generator at existing Booster Tank #1
- Construct 4,600 linear feet of upsized pipeline to convey fire flow

1.4 Buildout System

The existing Grayson water system is approximately 75 percent built out. There is approximately 30 acres of remaining development within Grayson to reach buildout conditions. This additional development is anticipated to increase the Grayson service area demands by approximately 0.11 mgd (76 gpm) to a total of 0.27 mgd (185 gpm). With the completion of the facility recommendations discussed above, no additional capital improvements are required for buildout of the Grayson system.

2.0 INTRODUCTION

In 2002, the City contracted with WYA to provide engineering services to assist in the development and calibration of a water system hydraulic model for the Grayson water system. Using the methodology described in Attachment A of this TM, WYA developed a hydraulic network analysis model of the Grayson water distribution system to allow computer simulations of various demands and flow conditions. The developed hydraulic model was used to evaluate the following demand conditions:

- Maximum day,
- Peak hour, and
- Maximum day plus fire flow.

In order to create a hydraulic network analysis model representative of the Grayson water system, WYA completed the steps listed below:

- Used shapefiles exported from the City of Modesto's Geographical Information System (GIS) and existing hard copy maps to develop the hydraulic model.
- Verified with City Operations staff that the converted hydraulic model system configuration (pipeline sizes, alignments, connections, and other facility sizes and locations) is representative of the current Grayson water system.
- Evaluated 2002 water demands by land use type to ensure proper distribution of demands in the hydraulic model.

In accomplishing these tasks WYA worked closely with City Engineering and Operations staff to obtain and review the following: as-built drawings and maps to confirm pipeline sizes, material, age, locations and alignments; and land use and available metered data.

Since the development and calibration of the hydraulic model in 2002, there have been no significant developments or changes to the Grayson water system infrastructure. However, leak detection and associated repairs of water mains in 2005 resulted in a significant decrease in system demands. The 2002 model has been updated to reflect the decrease in the demands. This TM presents the updates performed, model results, and recommended facility improvements.

This memo is organized as follows:

- Service Area
- Existing Water System
- Grayson Hydraulic Model
- Existing Water Supply System Evaluation & Recommendations
- Buildout Water Supply System Evaluation & Recommendations

3.0 SERVICE AREA

The Town of Grayson is located approximately 14 miles west of the City of Modesto along County Road J16 (Grayson Road) as shown on Figure 1. The Grayson water system serves approximately 1,100 residents and encompasses a service area of approximately 120 acres. This service area is primarily residential and is considered 75 percent developed. The Grayson water service area was originally provided with water service by the Del Este Water Company; in the mid 1990's, the City of Modesto acquired the Del Este system and began providing water service to Grayson.

The remaining development area within the Grayson water system is located primarily in the northern and southern regions of the service area. A small amount of remaining development will be infill.

4.0 EXISTING WATER SYSTEM

The Grayson water system includes two wells, one 0.22 MG tank (City Tank 9), and approximately 16,000 linear feet of pipeline. Existing Grayson pipelines vary in size from 4-inches to 10-inches in diameter and are comprised of welded steel and polyvinylchloride (PVC) pipe. The entire water system was metered in 2003.

There are no interconnections with other systems and there are no nearby water utilities with potential for interconnection.

4.1 Wells

The Grayson water system is solely supplied by groundwater. There are currently two existing wells that are operational. Groundwater is disinfected by chlorine addition at the wellhead, and then pumped into Tank 9. Tank 9 discharges the disinfected groundwater directly into the distribution system (see Figure 1 for locations).

Well characteristics are summarized in Table 1.

Table 1. Well Characteristics[(a)]

Well No.	Address	History Pump Data			Well Construction Details							Total Depth
		Year Drilled	Rated Pump Capacity (at 60 psi), gpm	Rated Hp	Standby Power	Treatment System	Casing Diameter (inches)	Gravel Packed	Depth of Annular Seal (ft)	Casing Depth (ft)	Perforated From/To	
274	8820 Charles	1967	321	20	No	No	14/12	No	NP[(d)]	168	146-168	168
295	8415 Yamamoto Way (Grayson Park)	1989	835	75	Yes	GAC[(b)]/ IX[(c)]	18/16	No	108	332	156-192, 252-328	336

(a) Based on information provided by the City.
(b) GAC = Granulated Activated Carbon
(c) IX = Ion Exchange Treatment
(d) NP = Not provided by the City

Pump efficiency tests were performed on both wells in October 2007. Results of these tests are presented in Table 2 and Table 6.

Table 2. Well Pump Test Results

Well No.	Date Tested	Motor HP	Measured Flow, gpm	Static Level, ft[(a)]	Pumping Level, ft[(a)]	Discharge Pressure, psi	Water HP
274	10/12/07	20	375	18	29	50	14
295	10/12/07	50	600	22	57	58	29

(a) Static and Pumping Levels indicate depth to water measurements from reference point elevations.

Table 3 provides a summary of the total monthly groundwater production of each individual well in 2008, and Figure 2 provides a graphical summary of this data.

Table 3. Summary of Grayson Service Area Monthly Production in 2008[a]

Month	Well 274		Well 295	
	Gallons	MG	Gallons	MG
January	2,401,206	2.40	1,853,875	1.85
February	2,182,256	2.18	1,701,416	1.70
March	2,836,178	2.84	2,279,202	2.28
April	3,106,652	3.11	2,473,171	2.44
May	3,510,827	3.51	2,725,892	2.73
June	3,880,070	3.88	2,930,051	2.93
July	4,227,551	4.23	3,129,240	3.13
August	4,472,373	4.47	3,367,469	3.37
September	4,116,327	4.12	3,238,032	3.24
October	3,639,096	3.64	2,847,034	2.85
November	2,891,921	2.89	2,254,168	2.25
December	2,826,122	2.83	2,196,233	2.20
Subtotals	40,090,579	40.09	30,995,781	31.00

[a] Data provided by the City of Modesto on September 4, 2009, from the file "monthly well flow totals 2002 to present.xls".

4.2 Unaccounted-for-Water

For the past few years, the City of Modesto has been monitoring water demands for the 270 connections (primarily residential) that comprise the Grayson water system. The average system water losses amount to 12 percent in 2006, which is a significant decrease from 38 percent measured in 2004. The City estimates that the detection of leaks and associated water main repairs completed in 2005 have reduced water demands and production by almost 40 percent. The City has decided to assume an average unaccounted-to-water (UAFW) of 15 percent for the Grayson water system, with a goal to achieve an UAFW rate of between 8 to 10 percent.

The Grayson original high UAFW rate was probably the result of two factors: 1) unauthorized water use (water theft), and 2) leakage from aging steel distribution pipelines. The City's capital improvement program, which replaced these steel pipelines, addressed one of these issues. It is recommended that the City of Modesto further investigate this issue of unauthorized water deliveries through the implementation of additional studies and investigations.

4.3 Wellhead Treatment

Wellhead treatment facilities are currently in use at Well 295. To reduce elevated levels of nitrates in the groundwater produced from this well, the City has installed granulated activated carbon (GAC) and ion exchange (IX) wellhead treatment systems. The ion exchange treatment system replaced an existing electro-dialysis system during the first quarter of 2004, in an effort to increase production for the Grayson service area.

Water from Well 274 also exceeds the maximum allowable concentration level of 45 mg/L for NO_3. However, there are currently no wellhead treatment facilities at this well. Therefore, water is pumped from Well 274 and is combined with water from Well 295 prior to ion exchange treatment to reduce nitrate concentrations below the maximum allowable level. The combined water is then stored in Tank 9 prior to being discharged into the distribution system. The hydraulic capacity of the wellhead treatment process at Well 295, combined with the associated process wastewater discharge permit, controls the maximum production rate.

4.4 Storage and Pumping Facilities

The Grayson Service Area includes one tank that is located on the same site as Well 295, at 8415 Yamamoto Way. Tank 9 is an at-grade steel tank. Therefore, all storage must be pumped into the distribution system.

Tank 9 was constructed in the early 1990's and is well maintained. The minimum allowable tank level is 4 feet to provide adequate suction head for the tank booster pump. This level control results in an operating range of 15.5 feet and available storage of 0.16 MG. Tank characteristics are shown in Table 4.

Table 4. Tank Characteristics

Tank	Supply Source	Base Elevation[a], ft	Diameter, ft	Height, ft	Overflow Level, ft	Gross Volume, MG[b]
9	Wells 274 & 295	56	42	22	19.5	0.22

(a) Base elevation estimated using available digital topographic map.
(b) Available storage volume is 0.16 MG due to a minimum operating tank level of 4 feet and operating range of 15.5 feet.

The pump station at Tank 9 includes two 50 hp booster pumps – one duty and one backup. There is also a backup generator at this site to provide service in the event of a power outage. Under Maximum Day plus fire flow conditions, the station’s pumping capacity is limited by the need to maintain a minimum tank level to provide adequate suction head for the tank booster pumps, and by discharge pumping limitations.

4.5 Pipelines

General knowledge of the Grayson pipeline main locations and material type was gained through discussion with City Operations staff. Pipelines within the portion of the service area generally north of Minnie Street are comprised of 8-inch and 10-inch diameter PVC. The remainder of the service area distribution pipelines are comprised of a rectangular grid of smaller diameter steel mains (believed to be unlined), installed during the 1950's and 1960's. The perimeter of the grid on the north, west, and south consists of 6-inch diameter pipe. The remainder of the grid consists of 4-inch diameter pipe. An 8-inch diameter PVC transmission main is dedicated to transporting water from Well 274 to Tank 9 (see Figure 1).

5.0 GRAYSON HYDRAULIC MODEL

In 2002, WYA developed a hydraulic model of the Grayson water service area using MWH Soft's H_2ONET hydraulic modeling software. This model has been updated to reflect 2006 demands and well characteristics. The model represents the current system infrastructure, which has not changed since 2002. A summary of assumptions, criteria, and model components is included in Attachment A of this TM.

6.0 EXISTING WATER SUPPLY SYSTEM EVALUATION AND RECOMMENDATIONS

6.1 Overview

This section presents findings from the hydraulic evaluation of the Grayson existing water distribution system and its ability to meet the City of Modesto's recommended water system operational criteria under existing demand conditions. The existing water distribution system was evaluated under the following demand scenarios:

- Maximum Day Demand
- Peak Hour Demand
- Maximum Day Demand Plus Fire Flow

6.2 Potable Water Demands

Average day potable water demands and peaking factors for the existing Grayson system were estimated and allocated based on the methodology described in Attachment A. Based on production data provided by the City of Modesto from 2003 through 2007, Table 5 shows the peaking factors used to estimate Maximum Day and Peak Hour demands. The Maximum Day peaking factor was developed based on a 5-year average from 2003 through 2007. The Peak Hour peaking factor was developed based on a 2-year average from 2006 through 2007.

Table 5. Water Demand Peaking Factors

Demand Condition	Peaking Factor[a]	2006 Demands	
		Mgd	gpm
Average Day	--	0.16	109
Maximum Day	1.85 x Average Day	0.29	201
Peak Hour	4.19 x Average Day	0.66	456

[a] Based on available Tank 9 water production data for the Grayson service area. Peaking factors were provided by the City as Max-Day Peak Factor.xls on 7/31/08 and Peak-hour tabulation - Outlying Areas.xls on 8/1/08.

6.3 Pumping Capacity Evaluation

The Grayson service area is supplied exclusively by groundwater. The system includes two existing production wells that feed Tank 9 (Wells 274 and 295), as well as wellhead treatment and disinfection facilities. Tank 9 is located at grade; therefore, the stored water is pumped into the distribution system. Operation of the booster pumps is alternated to equalize wear and maintain a sufficient tank level. Each pump is equipped with a variable frequency drive motor; the pumps are never operated simultaneously. Available stand-by power at the site is capable of supporting Well 295, the treatment facility, and one booster pump concurrently. Wells are tested on an “as-needed” basis by City operations staff and/or Pacific Gas and Electric Company.

The two water distribution booster pumps at Tank 9 each have a design capacity of 715 gpm. Recent field testing of the pumping capacity of these booster pumps was conducted in August 2007. The booster pumps were recorded to pump at a capacity of 450 gpm each.

Table 6 provides a summary of recent pump flow testing for each operational well and information on the pumps at the booster pump station. The table indicates a total existing supply capacity of 1000 gpm and distribution capacity of 900 gpm. However, for water supply planning purposes, this groundwater supply (groundwater pumping capacity) and distribution supply must be reduced to account for a well or a distribution pump that is out of service at any given time due to mechanical breakdowns, maintenance or other operational issues. This reduced pumping capacity is defined as the Reliable Pumping Capacity.

For water supply planning purposes, the City has defined Reliable Pumping Capacity as the system’s groundwater (or distribution) pumping capacity with the largest well out of service.

Due to the configuration of the system, the booster pump station at Tank 9 controls flow into the distribution system. However, under high demand conditions (especially under a fire flow condition concurrent with a Maximum Day demand condition), the booster pump station is limited by the ability of the well pumps to provide enough supply to maintain the minimum tank level, approximately 4 feet. Therefore, a supply deficiency exists. A new well is required to provide additional supply. Alternatively, changing out the pump at Well 295 may provide additional capacity. However, the new well is also needed to meet fire flow demands, as discussed below, and the new well will provide an additional supply source for operational flexibility and reliability. Therefore it is recommended that a new well instead of a replacement pump be installed to provide the additional supply. An additional two 50 HP pumping units are also required at the Tank 9 booster station to meet Maximum Day plus fire flow demand conditions. The fire flow analysis assumed that the new well and the booster station would both be used to meet fire flows in the system.

As shown on Table 6, the current total Reliable Pumping Capacity of 450 gpm (with either of the booster pumps out of service) is sufficient to meet existing Maximum Day or Peak Hour demands of 201 gpm and 456 gpm, respectively. While the Reliable Pumping Capacity of 450 gpm is approximately 1% less than the Peak Hour Demand of 456 gpm, it is within an acceptable margin for the purposes of this analysis. However, if Well 274 fails, then Tank 9 may drain down to below the minimum pumping level. Therefore, standby pumps are recommended at all the pumps to improve reliability during a power outage.

Table 6. Summary of Existing System's Pumping Facilities[(a)]

Well Pump Name	Efficiency, percent	Standby Power	Hp	Existing Capacity, gpm[(a)]	Existing Maximum Day Demand, gpm	Existing Peak Hour, gpm
274[(b)]	62	No	20	400	--	--
295[(b)]	39	Yes	50	600	--	--
Booster Pump #1	NP[(c)]	No	50	450	--	--
Booster Pump #2	NP[(c)]	Yes	50	450	--	--
Total Capacity[(d)]				450	201	456
Total Reliable Capacity[(e)]				450	201	456

(a) Based on pump capacity testing from August 2007. Pump tests conducted by City operations staff.
(b) Because of water quality issues, both Well 295 and 274 are used only to fill Tank 9.
(c) NP = Information Not Provided
(d) Based on system configuration – distribution fed only with Tank 9 booster pump station, however, both pumps cannot be operated concurrently due to hydraulic constraints.
(e) Based on normal operation – distribution fed only from a single booster pump at Tank 9.

Based on these recent pump tests, the efficiency of the wells can be improved, and the potential savings in operating costs should be evaluated.

6.4 Storage Capacity Evaluation

Criteria have been defined for determining treated water storage and system peaking capacity needs to meet diurnal operational peaks, fire flows, and emergency conditions. Total storage and system peaking capacity requirements can be evaluated based on the following three components:

- Operational Storage: 25 percent of Maximum Day demand;
- Fire Storage: The required fire flow times the fire flow duration period, as required by the City's Fire Marshall; and
- Emergency Storage: 1 x average day demand.

The existing storage facility (Tank 9) was evaluated to determine whether it has sufficient capacity to provide the required fire, emergency, and operational storage using Grayson's current Maximum Day demand condition. As shown on Table 7, available storage at Tank 9 is sufficient to meet existing City of Modesto storage criteria.

Table 7. Summary of Required Above Ground Storage[(a)]

Storage Component	Component Detail	Storage, MG
Operational	0.25 x max day demand	0.07
Fire	1,500 gpm for 2 hours	0.18
Emergency	1 x average day demand	0.16
Subtotal		0.41
Existing Storage		(0.16)
Groundwater Credit[(b)]	60% reliable production capacity	(0.35)
Total Storage Required		0.00

(a) Data based on the Water Demand Peaking Factors presented in Table 5.
(b) Sixty percent of existing reliable groundwater pumping capacity (without Well 295).

6.5 Existing Distribution System Evaluation

The hydraulic model identified areas of the Grayson existing system in which minimum pressure could not be maintained, or where velocities and/or head losses were found to exceed City of Modesto design standards. A discussion is provided in the following sections.

6.5.1 Peak Hour Demand Conditions

Peak hour demand for the Grayson potable water distribution system under existing conditions is approximately 0.66 mgd (456 gpm). This demand condition was simulated in the hydraulic model, and results indicated that the existing distribution system could reliably deliver these demands under the City's minimum pressure criteria of 40 psi. This analysis also indicated that head losses in existing pipelines met the City's criteria of $\leq$ 7 ft/kft and the velocity criteria of $\leq$ 7 fps. Therefore, since the distribution system pipelines met both criteria, pipelines were not recommended to be rehabilitated or upsized.

6.5.2 Maximum Day Plus Fire Flow Demand Conditions

Fire flows are to be met concurrently with a Maximum Day demand condition while maintaining a minimum residual system pressure of 20 psi, as measured at the flowing hydrant. The fire flow demand for Grayson is 1,500 gpm for a two hour duration. Based on the hydraulic analysis of the Maximum Day plus fire flow demand condition, the Grayson existing water system cannot maintain a minimum residual pressure requirement of 20 psi in the southern half of Grayson's service area (see Figure 3). In addition to the facility improvements discussed above, Figure 4 shows recommended pipeline improvements necessary to ensure minimum system pressures during fire flow conditions.

7.0 RECOMMENDED WATER SYSTEM IMPROVEMENTS

Based on the evaluations completed for the Grayson water system, there is a need for specific water facility improvements throughout Grayson's overall service area. An overview of the recommended facilities is provided on Figure 4. A summary of the recommended improvements is provided below.

7.1 Existing System Improvements

The recommended improvements to the Grayson water system ensure that reliable service can be provided to existing users in a manner that meets the city's system design criteria. These recommendations include the construction of a new well (with a pumping capacity of approximately 400 gpm), a new backup generator at Well 274 and Booster Pump 1, 900 gpm of additional pump capacity at the Tank 9 booster station and 4,600 linear feet of upsized pipelines. Locations of the recommended improvements are shown on Figure 4 and detailed in Table 8 (does not include costs for any well head treatment facilities required to meet water quality standards, if required). The locations of the proposed facilities are for planning purposes only and should be developed further in future pre-design studies. With the completion of these recommendations, residual pressure under fire flow concurrent with Maximum Day demand conditions will meet the 20 psi requirement (see Figure 5).

7.2 Required On-going Rehabilitation Improvements

In addition to the need to construct system improvements to meet current water system demands, the City should plan to repair or replace aging water system infrastructure over time. The decision to repair or replace existing facilities should be based primarily on facility condition. Pipelines that have experienced corrosion but have retained adequate structural integrity may often be repaired instead of replaced. Preventive maintenance is usually more cost effective and less disruptive than replacement, maximizes the useful life of the pipeline, and thereby optimizes lifecycle cost. Pipes that have experienced extensive corrosion and do not have adequate structural integrity should be replaced.

A system-wide condition assessment is also recommended to evaluate existing pipe conditions and to develop a prioritized replacement program. The program may involve internal and external corrosion evaluations to determine when to replace certain pipelines.

8.0 CAPITAL COSTS OF RECOMMENDED IMPROVEMENTS

The estimated probable capital costs for the recommended water system improvements to serve the Grayson existing and buildout condition are presented in Table 8. The capital costs are presented in March 2010 dollars at an Engineering News Record (ENR) construction cost index (CCI) of 9728.17 consistent with San Francisco. The costs include an estimate of 50 percent on the estimated construction cost to account for administration, design, and engineering costs and other contingencies. The costs for the facilities do not include costs for annual operation and maintenance, or costs for acquisition of rights-of-way.

Table 8. Recommended CIP Program for Existing Grayson Water System[a]

CIP ID	CIP Reason	Item	Unit	Quantity	Unit Cost [b] ($)	Cost ($)
		Pipelines				
FF01	Fireflow	Along Minne Street from Tank 9 to Laird Road				
		8-inch	lf	810	101	81,000
FF02	Fireflow	Along Laird Road from Minnie Street to Amelia Street				
		8-inch	lf	700	101	70,000
FF03	Fireflow	Along Stakes and Charles Street From Minnie to Mary Street				
		8-inch	lf	1,640	101	165,000
FF04	Fireflow	Along River Road from Mary Street to Amelia Street				
		8-inch	lf	750	101	75,000
FF05	Fireflow	Along Mary Street from Laird to River Road				
		8-inch	lf	710	101	71,000
		Wells				
	Supply	New Well with 400 gpm pump, backup generator, and SCADA[c]	well	1	1,333,000	1,333,000
		Well Backup Generators				
	Supply	Well 274	mgd	1	133,000 [d]	133,000
	Supply	Booster Pump #1	mgd	1	133,000	133,000
		Tank 9 Booster Upgrade				
		Rehab pump station, add two new units	HP	100	10,220	1,022,000
					Subtotal (Overall Program)	3,083,000
					50% Contingency & Other Costs	1,543,000
					Total Estimated Construction Cost	**4,626,000**

[a] Does not include site specific facilities.

[b] All unit prices presented in SF March 2010 dollars (ENR Construction Index = 9728.17). Unit prices based on combination of cost curves, construction cost guidelines and similar construction projects.

[c] Does not include costs for any well head treatment facilities required to meet water quality standards, if necessary. Includes land acquisition

[d] Backup generator cost estimated at $200,000 per unit, including markup.

9.0 EVALUATION OF BUILDOUT WATER SUPPLY SYSTEM

9.1 Overview

This section presents the hydraulic evaluation of the Grayson water distribution system and its ability to meet City of Modesto's recommended water system operational criteria under buildout demand conditions. The existing water distribution system was evaluated under Maximum Day, Peak Hour, and Maximum Day with concurrent fire flow demands.

9.2 Potable Water Demands

The Grayson water service area is approximately 75 percent built out, and there will be some additional water demands on the system as the vacant areas are developed. The total future potable water demand under average day demand conditions will be 0.27 mgd. Using peaking factors of 1.85 and 4.19, the demands for Maximum Day and Peak Hour are 0.50 mgd and 1.13 mgd respectively.

9.3 Buildout Distribution System Evaluation

The same analyses and calculations that were conducted to evaluate the ability of the system to meet current demands were applied for the analysis of buildout conditions. Based on these analyses, buildout demands can be adequately met with construction of the previously recommended existing system improvements.

LEGEND:

- PARCEL LINES
- SERVICE AREA BOUNDARY
- TANK
- WELL
- 4" PIPELINES & SMALLER
- 6" PIPELINES
- 8" PIPELINES
- 10" PIPELINES OR LARGER

N

0 250 500
SCALE IN FEET

Figure 1

City of Modesto
TOWN OF GRAYSON
WATER DISTRIBUTION SYSTEM

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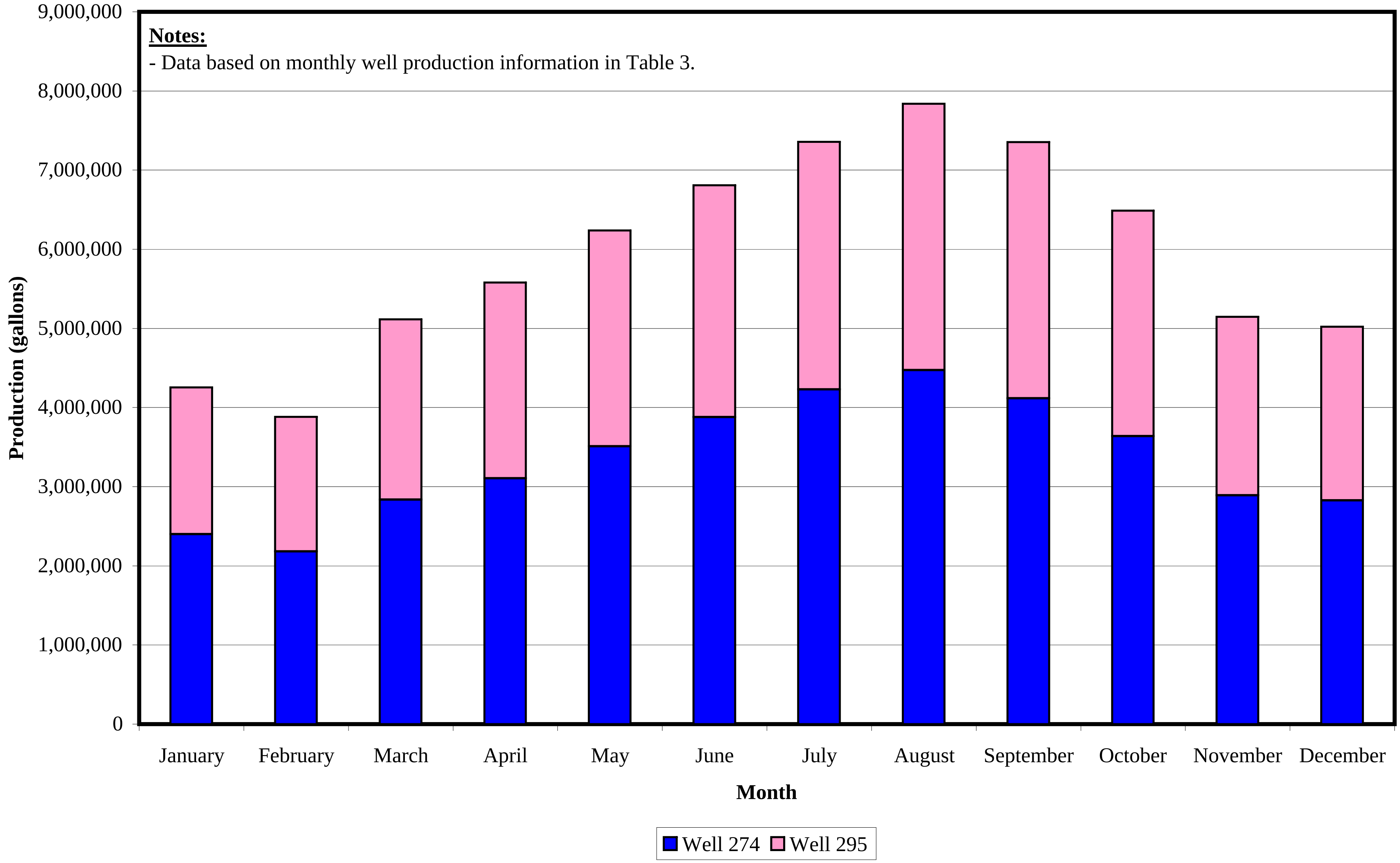
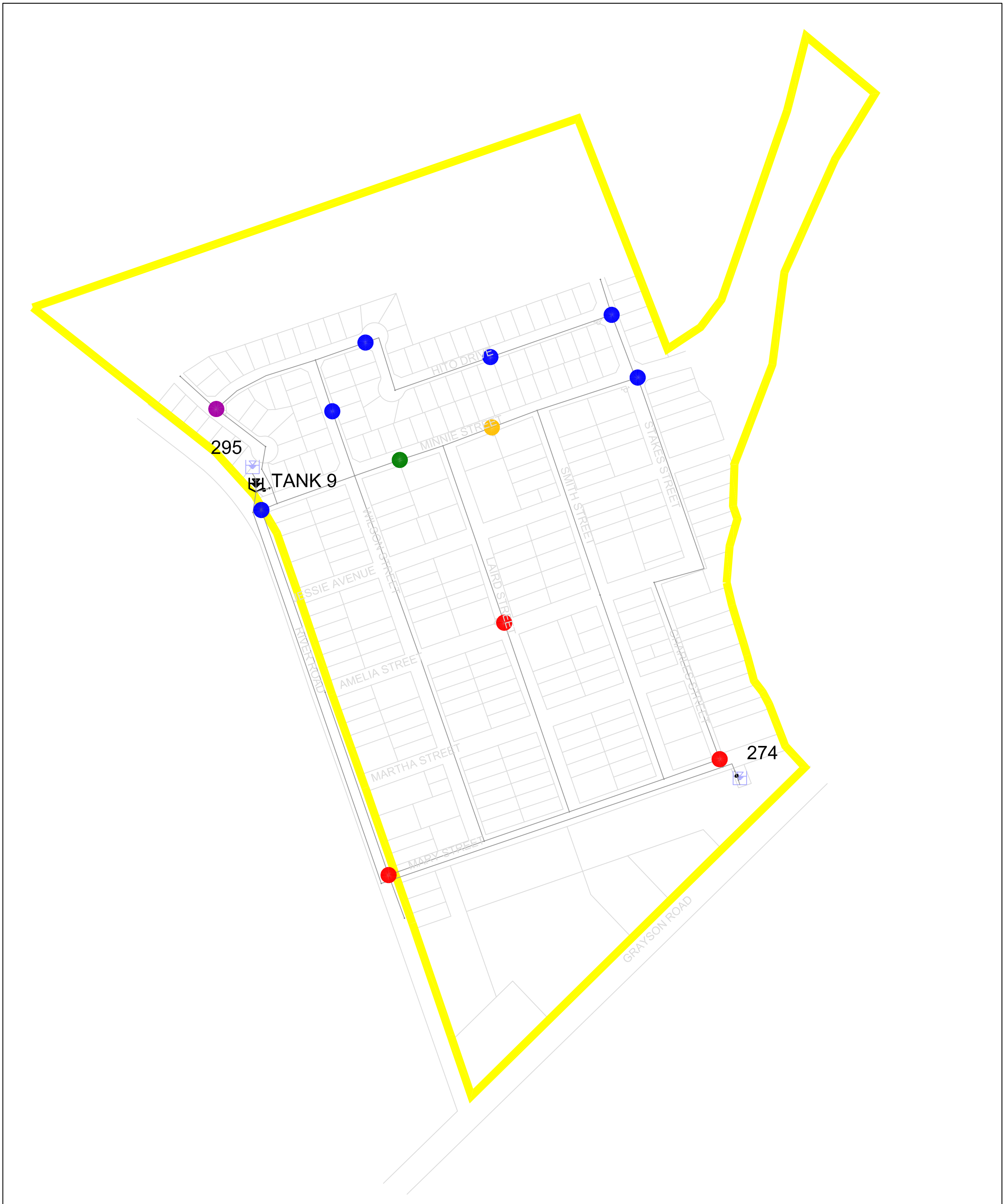
Figure 2. Town of Grayson - Monthly Production by Well (2008)





LEGEND:

STORAGE TANK
CITY WELL
DISTRIBUTION PIPELINE
PRESSURE BELOW 20 PSI
PRESSURE BETWEEN 20 & 30 PSI
PRESSURE BETWEEN 30 & 40 PSI
PRESSURE BETWEEN 40 & 50 PSI
PRESSURE ABOVE 50 PSI

Figure 3

City of Modesto

TOWN OF GRAYSON EXISTING SYSTEM RESIDUAL PRESSURE UNDER MAX DAY PLUS FIRE DEMAND (0.24 MGD)

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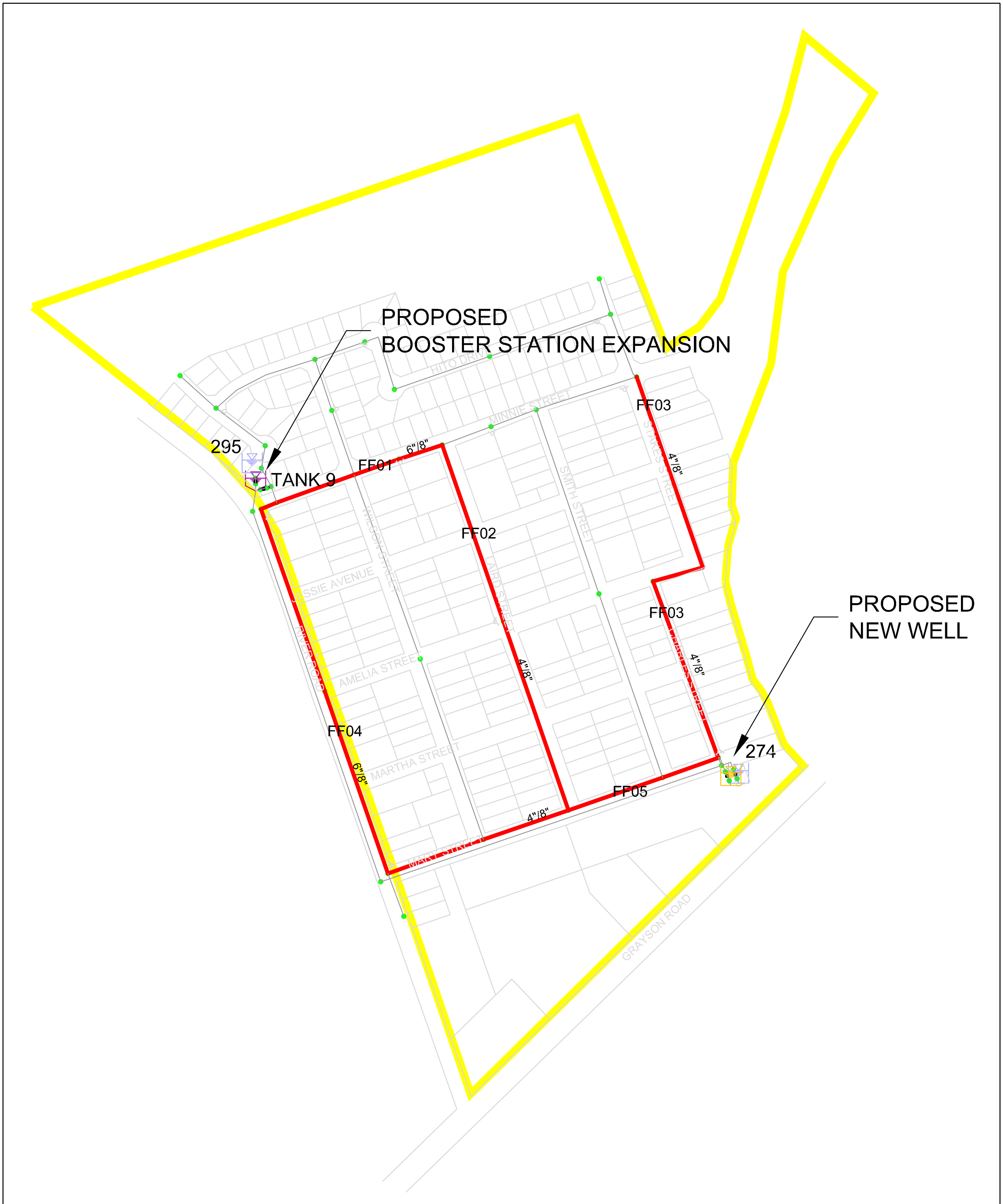

LEGEND:

- STORAGE TANK
- CITY WELL
- RECOMMENDED WELL
- DISTRIBUTION PIPELINE
- 6"/8" RECOMMENDED PIPELINE UPSIZE

0 250 500
SCALE IN FEET

N

Figure 4

City of Modesto
TOWN OF GRAYSON EXISTING SYSTEM RECOMMENDED CIP

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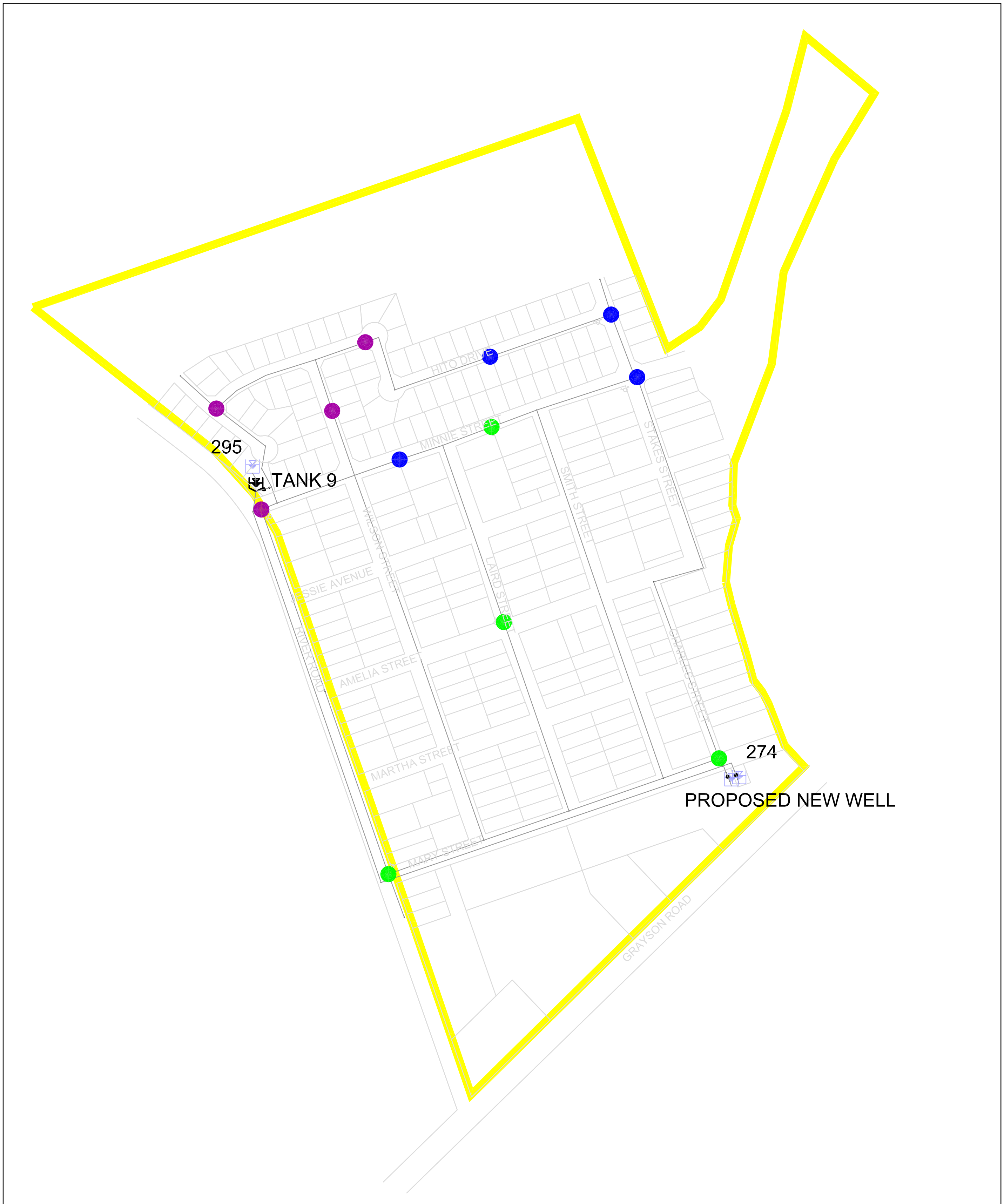

LEGEND:

- STORAGE TANK
- CITY WELL
- DISTRIBUTION PIPELINE
- PRESSURE BELOW 20 PSI
- PRESSURE BETWEEN 20 & 30 PSI
- PRESSURE BETWEEN 30 & 40 PSI
- PRESSURE BETWEEN 40 & 50 PSI
- PRESSURE ABOVE 50 PSI

N

0 250 500
SCALE IN FEET

Figure 5

City of Modesto

TOWN OF GRAYSON EXISTING SYSTEM RESIDUAL PRESSURE UNDER MAX DAY PLUS FIRE DEMAND (0.24 MGD) W/ RECOMMENDED CIP

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ATTACHMENT A

Development of Grayson’s Hydraulic Model

ATTACHMENT A. DEVELOPMENT OF GRAYSON'S HYDRAULIC MODEL

WYA developed a hydraulic model of the Grayson Service Area using MWH Soft's H_2ONET hydraulic modeling software. The distribution system depicted in the City provided AutoCAD file was replicated as pipe, junctions, wells, tanks, and pumps. In 2010, this model was converted to MWH Soft's InfoWater v7.0.

Modeling Assumptions and Criteria

Establishing computer modeling assumptions and criteria was important for the development of the model, calibrating and running the model, and interpreting the results of the computer runs. The assumptions and criteria that were used to develop Grayson's water distribution system hydraulic model are described below:

- A minimum pipe size of 4 inches was modeled.
- Information on pipe length, diameter, material type and age was extracted from the City's existing GIS and hard copy maps.
- Pipe roughness coefficients, "C" values, were assigned based on age and pipe material.
- Pump station piping configurations, performance curves, and motor size information were acquired from "as-built" plans and interviews with City operational staff.
- Pipe length accuracy was assumed to be ±25 feet.
- Ground surface elevations were estimated using available digital topographic maps and surveyed benchmark elevations. Elevations were estimated to the nearest foot where spot elevations were not available.
- The water demands in the model were expressed in gallons per minute (gpm).

Peaking Factors

Maximum day and peak hour demand factors were calculated using data provided by the City of Modesto. The maximum day peaking factor was developed based on a 5-year average from 2003 through 2007, as shown in Table 1. The peak hour peaking factor was developed based on a 2-year average from 2006 through 2007, as shown in Table 2.

Table 1. Maximum Day Demand Peaking Factor

Year	Date	Max Day, gpd	Average Day, gpd	Peaking Factor
2003	06/29/03	428,459	256,183	1.67
2004	07/18/04	337,410	231,975	1.45
2005	07/31/05	389,313	211,335	1.84
2006	07/23/06	335,811	156,758	2.14
2007	07/16/07	378,875	178,168	2.13
Average				1.85

Table 2. Peak Hour Demand Peaking Factor

Year	Date	Peak Hour, gpm	Average Day, gpm	Peaking Factor
2006	07/23/06	380	109	3.49
2007	07/16/07	604	124	4.88
Average				4.19

Model Development

Node elevations were automatically computed using U.S. Geological Survey Digital Elevation Models (DEM). Pipeline were assigned C-factors based on material types and age as indicated by City Operations staff, ranged from 135 to 100.

The water surface elevation for both wells were as modeled as fixed-grade reservoirs, with water surface elevations equal to active water pumping levels as reported in City pump tests. Well pumps modeled with design point curves as presented in Table 3. Flow and head data points are based on observed flow and computed total dynamic head from City pump tests.

Although well 295 has a variable frequency drive, the well is typically operated at a constant speed, pumping into Tank 9.

Table 3. Well Model Characteristics

Well	Diameter, in	Modeled with Design Point Curve	
		Head, ft	Flow, gpm
274	4	144.5	375
295[a]	8	191	600

[a] Well pump has variable frequency drive. Well pumps to Tank 9.

Tank 9 booster pump station also has two pumps (one duty, one standby) with variable frequency drives. The booster pumps were modeled as constant power pumps of 50 horsepower followed by a pressure reducing valve to reduce downstream pressure to a maximum pressure of 55 pounds per square inch (psi) in order to simulate a variable speed pump.

Demand Allocation

MWH Soft H_2ONet and InfoWater allow the definition of multiple demand fields at a single node to represent different use classes or demand types. Because the system is almost fully developed, all demands are allocated in demand field 1.

Existing Demands

Unaccounted-for-Water: The City has determined Unaccounted-For-Water is approximately 15 percent of total production system-wide. The Town of Grayson's unaccounted-for water is approximately 12 percent of total production. Because this unaccounted-for water is probably due to unauthorized water use (water theft) which will be investigated separately, and leakage from old, small diameter steel pipelines that will be replaced as part of the recommended CIP, for purposes of this study unaccounted-for water was assumed to be uniformly lost throughout the distribution system.

Metered Non-residential Customers: While large metered customer loads are typically assigned individually to the closest model node, the Grayson Service Area metered non-residential demand amounts to only approximately 5% of the total, with no significantly large individual accounts. Therefore, metered non-residential consumption was combined and allocated with the residential component.

Metered Residential Customers: The Grayson Service Area is mainly composed of residential land use. Because Grayson is almost fully developed, all parcels were assigned equal demand. The unit demand per parcel is the total consumption (109 gpm average day) divided by number of parcels (270), or 0.40 gpm per parcel. Parcels, and their associated 0.40 gpm demand, were aggregated to the nearest model junction nodes to develop the base Average Day demand set. Maximum Day and Peak Hour (see Table 5 for factors) demand sets were calculated by applying the appropriate factors to the average day demands.

Fire: The Grayson service area has no large industry or dense commercial areas. Therefore, the fire demand of 1,500 gpm for a two hour duration was used for the entire service area.

Future System Demands

Future demands were estimated from planning information provided by the City of Modesto. Because the system is close to fully developed, future demands were estimated and then system demand was uniformly scaled up to incorporate anticipated future demands.

Scenarios

The scenarios modeled are shown in Table 4.

Table 4. Model Scenarios

Scenario	Description	Definition
AD	2006 Average Day Demand Scenario	Model of the 2006 average day demand condition
MD	2006 Maximum Day Demand Scenario	Model of the 2006 maximum day demand condition
MDFF	2006 Maximum Day plus Fire Flow Scenario	Model of the 2006 maximum day demand plus 1,500 gpm fire flow demand condition
PH	2006 Peak Hour Demand Scenario	Model of 2006 peak hour demand condition
EX-CIP	Existing System with CIP Recommendations	Model of 2006 fire flow runs with recommended improvements to meet the minimum design criteria

Data Sets

The Data Sets contained in the model are shown in Tables 5 through 7.

Table 5. Demand Sets

Demand Set	Description	Definition
AD	2006 Average Day Demand Set	Average day demand
MD	2006 Maximum Day Demand Set	Maximum day demand condition
MDFF	2006 Maximum Day w/ Fire Flows	Maximum day demand concurrent 1,500 gpm fire flow demand condition
PH	2006 Peak Hour Demand Set	Peak hour demand condition

Table 6. Pipe Sets

Pipe Set	Description	Definition
EXIST	2006 Existing Infrastructure	Existing system configuration
EX-CIP	Recommended CIP Infrastructure	Recommended system configuration

Table 7. Fire Flow Sets

Fire Flow	Description	Definition
FF1500	1,500 gpm Fire Flow at Fire Hydrant Nodes	This sets up the fire flow analysis at each hydrant node

Verification

The initial assessment was performed prior to field verification of the model in 2002 to provide a preliminary understanding of the system's capacity.

Modeling Element Information

To provide flexibility in modeling various system configurations, each modeling element was assigned a phase number as listed in Table 8 below. Each Phase number corresponds to a system configuration assignment.

Table 8. Phase Numbering

Phase	Configuration
1	Existing System
2	Existing System CIP