CITY OF DUNSMUIR
2015 MASTER WATER PLAN

JOB NO. 204.52

Prepared By:

PACE ENGINEERING
REDDING, CALIFORNIA

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SUMMARY AND RECOMMENDATIONS

I. SUMMARY

Review of the City of Dunsmuir (City) water system consisted of a separate engineering analysis of each of the major components including water supply, storage reservoirs, booster pumping, pressure reducing stations, fire hydrants, and distribution piping. Analysis of the distribution piping was accomplished with the aid of a computer hydraulic model.

A. WATER SUPPLY

The City is supplied water by a number of the Mossbrae Springs at Mossbrae Falls. Currently, the City has a water right to 1.27 million gallons per day (MGD) of water based on an annual maximum 30-day use period. Based on estimated flows during the five-year drought, it appears that the existing spring headworks has an effective maximum daily capacity of about 1.5 MGD and it is estimated that it can be increased to about 1.6 MGD with some additional improvements to the headworks facility. Any future increase in water supply to serve the area north of Dwight Way will probably have to be from wells in the Mott Airport area.

B. WATER TREATMENT

Water from the Mossbrae Springs is of excellent quality and requires no treatment or chlorination at this time. However, existing chlorination facilities are available adjacent to the spring headworks.

Depending upon future regulations, the City might have to begin chlorinating its entire water supply and maintaining a chlorine residual throughout the distribution.

C. WATER STORAGE

The City currently has two water storage reservoirs totaling 1.05 million gallons (MG) of storage. The California Waterworks Standard §64554(a)(1) states that for systems with 1,000 or more service connections, the system shall be able to meet four hours of peak hourly demand (PHD) with source capacity, storage capacity, and/or emergency source connections. Based on the City's current PHD, the required equalizing storage to meet existing California Waterworks Standards is about 0.23 MG. Adding the maximum fire storage of 0.63 MG (3,500 GPM for three hours), the total existing storage requirement is about 0.86 MG.

D. BOOSTER PUMPING

Currently, the City has one booster pump station in the north end of town near Castlerock Water Company, which normally maintains adequate pressures in the Lookout Pressure Zone.

E. WATER DISTRIBUTION SYSTEM

The existing City distribution system consists of approximately 105,000 feet (19.9 miles) of mainline piping from 1-inch to 18-inch diameter. Approximately 80 percent of the distribution system (about 85,000 feet) consist of 4-inch to 18-inch mains. The age of all of the City's pipelines is difficult to determine, however from available records at least 34,000 feet is over 60 years old. For reference, typical steel pipelines have a theoretical useful life of 55 to 75 years depending upon the type of lining and coating used. Most of the existing steel pipelines within the City's distribution system are very near the end of their theoretical useful life. Existing pipelines are shown on Plate 2 at the end of this Plan.

The remaining 20 percent of the distribution system (about 20,000 feet) consist of 1-inch to 3-inch pipelines that are primarily about 40 to 60 years old. In addition, many of these small pipelines in the Shasta Retreat area run down back lot lines and under houses. Due to the limited capacity of these smaller lines they are not shown on Plate 2 at the end of this Plan.

F. FIRE FLOW AND SYSTEM ANALYSIS

Considerable attention was given during the hydraulic analysis to determining the entire water system's adequacy to meet estimated maximum hour demands (MHD) and fire flow requirements at MHD conditions. Water demands for potential fires were based on estimated fire flow requirements typically recommended by the Uniform Fire Code.

The Insurance Service Office (ISO) is the organization responsible for rating community water systems and fire protection facilities. This rating, in turn, affects the fire insurance rates paid in the community. The City of Dunsmuir was last rated in 2015 when the City was given a Class 03/3X rating.

Based upon our hydraulic analyses, significant fire flow deficiencies appear to exist at the following locations:

1. South Dunsmuir Avenue and Elizabeth Street
2. Simpson Avenue and Haven Avenue in Shasta Retreat
3. Dunsmuir High School
4. Dunsmuir Elementary School
5. Patricia Way Subdivision
6. Riverwood Trailer Park on S. 1st Street

The computer model was valuable in determining weaknesses in the system. Using the computer analyses and the Year 2035 growth projections, the location and extent of the deficiencies were determined. Additional analyses were made incorporating improvements necessary to provide supplies and pressures, at the present time and with the future 2035 development. Based on these analyses, a staged plan of improvements has been prepared.

G. FUTURE WATER DEMANDS

In order to determine the required future improvements, it was necessary to project the current water usage. Based on discussions with City staff it was decided to use 0.75 percent as the average annual growth rate in water demand for the next twenty years. It should be emphasized that this is simply a design value and it is contingent in part upon continued residential and commercial growth and potential industrial growth in the City service area.

In the event that actual growth is slower or faster than projected, need for the improvements shown herein should be proportionately shifted in time. The planned growth rate will result in approximately a 16 percent increase in water usage in the next 20 years.

Considerable time was spent in making projections of future water use within small water service areas. Existing water consumption and proposed land use were used in making future flow predictions for 2035 and ultimate development within each of these service areas. Plate 1 at the end of this Plan indicates the boundaries of the overall water service area. Based on this plan, the following total maximum daily demand values were determined.

	2015	2035	Ultimate
MAXIMUM DAILY DEMAND, MGD	0.84	0.97	2.08

The ultimate flow was based on a saturation population of the entire City’s Area of Influence as depicted on Plate 1. It appears that the City's ultimate maximum daily water usage will be almost two and a half times the current demand, which is about 0.84 MGD.

II. RECOMMENDATIONS

A. GENERAL

The proposed major capital improvements necessary to correct existing deficiencies and to meet future increasing water demands are shown on Plate 2 at the end of this Plan. Cost estimates and staging of the general improvements have been developed and are shown in detail in Table 1, under the heading of ESTIMATES OF COSTS. Table 1 is a listing of major improvements needed primarily to overcome existing system deficiencies and to provide for future growth. Many of the improvements in Table 1 may, because of their cost and timing, have to be financed by means of grants, loans or bond issuance.

B. WATER SUPPLY

The City water usage is currently about 0.84 MGD during maximum daily demand and it has an effective supply capacity of 1.5 MGD. By 2035 the estimated maximum daily demand will be about 0.97 MGD with a maximum hourly demand of about 1.58 MGD. Even though a small amount of this projected 2035 demand will be in the area north of Dwight Way, which is planned to be supplied by wells, it is obvious that reservoir equalizing storage in the existing zones will be needed to meet the difference between the 1.5 MGD spring effective capacity and the 1.58 MGD maximum hourly demand. The additional storage capacity is also needed to improve fire flow capabilities.

Based on Lawrence and Associates' evaluation of the potential for developing wells in the vicinity of Mott Airport, it is recommended that the City plan on developing two or three wells to supply the estimated 330 gallons per minute (GPM) ultimate demand in the area north of Dwight Way. A copy of Lawrence and Associates' report is included as an Appendix at the end of this Plan.

C. PRESSURE ZONE

The distribution system pressure zone boundaries are shown on Plate 2. The City topography requires some areas to have higher pressures than are typical seen within water systems. Typical practice is to maintain pressures from 50 to 125 PSI. The City of Dunsmuir average pressures are typically between 40 and 160 PSI under maximum day demand conditions. Under wintertime conditions, pressures may be as high as 180 PSI in high pressure areas. A new pressure zone has been proposed to limit high pressure areas to 140 PSI. Pressures larger than this can be dangerous for City staff and may damage firefighting equipment. This new pressure zone would be located in the southern half of the distribution system and would require the construction of two pressure reducing stations.

D. BOOSTER PUMP FACILITIES

The City maintains a single booster pump station that provides water to the Lookout Reservoir and the Mountain Estates Subdivision. This booster pump station appears to have adequate capacity to supply the Lookout Reservoir. Future demands north of the

Lookout Pressure Zone will be required to provide new well water supply and are not considered in depth within this plan. These wells may be able to moderate use or even replace the booster pump station depending on system configuration.

E. WATER STORAGE

On the basis of volume, the City currently has adequate storage. However, the 0.4 MG Downtown Storage Reservoir Tank is 110 years old and located too low to be utilized without significantly lowering system pressures. Water cannot be discharged from the Downtown Tank until the water pressure in the downtown area is approximately 27 PSI below normal. Thus, the reservoir functions primarily as emergency and fire storage. A new 0.9 MG storage tank is proposed at a higher elevation in order to increase reliability, capacity, and safety of the Downtown Pressure Zone.

H. WATER DISTRIBUTION SYSTEM

As part of this Master Water Plan, an inventory of existing distribution system piping was prepared. The City has historical records for much of their distribution system. These records are updated when improvements are constructed. However, there are no records (e.g. material, age) for many areas within the distribution system. Based on the available records, a theoretical useful life of each pipe was determined; see Table 5 and Table 6. Although many pipes are beyond their theoretical useful life, the need for replacement is dependent upon the pipe's actual condition, which is difficult to ascertain. One indicator of pipe condition is history of leak repairs on various sections of pipeline. Based upon our review with City staff, there are a number of water main sections that require frequent repair and should be replaced as soon as possible. In addition, strengthening of the main distribution system in the Downtown Zone is needed to provide adequate pressures and fire flows in the future. It is envisioned that old undersized steel mains will be replaced with larger mains that will provide adequate fire flows.

It is estimated that most of the Immediate and Near-Term Improvement, shown in red dashed and solid lines, respectively on Plates 2, will be constructed by 2022. It is anticipated that some of the As-Developed mains, shown in green dashed lines, will be needed by 2035.

I. FIRE FLOWS AND SYSTEM

The hydraulic model indicates that both the storage and distribution improvements outlined above will significantly improve fire flows in the system. However, there are several critical locations that require increased fire flow. These locations are identified in Table 13 through Table 16 at the end of this Plan. Improvements associated with increasing fire flow to these locations are shown on Plate 2. Table 1 includes a summary of costs associated with these improvements.

J. ESTIMATES OF COSTS

Due to the poor condition of some of the old steel distribution system; deficiencies in the Lookout Zone supply system; and the need to provide effective equalization storage in the Downtown Zone, the City needs to make a number of improvements by the year 2016. A summary of the Immediate (2015-2016), Near-Term (2017-2022) and As-Developed Improvement costs is shown in Table 1. A more detailed cost breakdown is shown in Table 13 through Table 16 at the end of this Plan.

Immediate Improvements are geared toward replacement of high maintenance water mains and increasing system pressures and fire flows in areas with insufficient pipeline capacity. In addition, Immediate Improvements include new storage within the Downtown Pressure Zone at the proper elevation. The new Downtown Zone storage will make the best use of the available spring supply by using equalizing storage to meet peak demands. Near-Term Improvements address the replacement of the pipelines that are at or beyond their serviceable life.

As the City of Dunsmuir development progresses, continued improvements involving supply, storage, distribution, and control will be required to meet the ultimate system demands.

It is recommended that the City review this 2015 Master Water Plan carefully and, if in agreement, that it be accepted with any corrections or supplements as may be applicable.

Table 1: Cost Estimate Summary

Description		Estimated Project Cost[1]
Current Improvements (2015)[2]		
1	Scherrer Avenue Water Main Replacement	$228,000
2	Upper Blackberry Hill Water Main Replacements	$559,000
3	Willow Street Water Main Replacement	$151,000
4	Bush Street Water Main Replacement	$125,000
5	Butterfly Avenue Water Main Replacement	$129,000
6	Oak Street Water Main Replacement	$29,000
	Total Project Costs:	**$1,221,000**
Immediate Improvements (2016)[3]		
1	S. Dunsmuir Water Main Replacements	$520,000
2	N. Dunsmuir Water Main Replacements	$730,000
3	0.9 MG Downtown Tank Replacement	$3,204,000
4	Scenic Avenue & Needham Avenue Water Main Replacement	$530,000
5	Dunsmuir Elementary School Water Improvements	$460,000
6	River Avenue Water Main Replacement	$490,000
7	Vista Street Water Main Replacement Project	$130,000
8	Butterfly Avenue to Gills Street Water Main Replacement	$390,000
9	Shasta Retreat Water Improvement Project	$580,000
10	Dunsmuir High School Water Improvement Project	$207,000
11	Wood Street Water Main Replacement Project	$135,000
12	S. Sacramento Avenue Water Main Replacement	$255,000
13	S. Dunsmuir Avenue Water Improvement Project	$520,000
14	S. 1st Street Water Improvement Project	$590,000
15	North Sacramento Ave. R.R. Crossing Water Main Replacement	$255,000
16	Downtown Water Improvement Project	$408,000
	Total Project Costs:	**$9,404,000**
Near-Term Improvements (2017 - 2022)[4]		
1	Katherine & Francis Streets	$225,000
2	Hill Street	$128,000
3	Rose & Scherrer Avenue	$159,000
4	Cedar Street	$143,000
5	Pine Street	$149,000
6	Sacramento Street	$602,000
7	Ash Street	$128,000
8	Dunsmuir Avenue & Florence Loop	$629,000
9	Dunsmuir Avenue (Caltrans Right-of-Way)	$870,000
10	Upper Soda Road	$106,000
11	Stage Coach Road	$176,000

Description		Estimated Project Cost[1]
12	Buckboard Lane & McCloud Avenue Road	$152,000
13	Dunsmuir Avenue - Part 1	$780,000
14	Dunsmuir Avenue - Part 2	$430,000
15	Scarlet Way & Shasta View Avenue	$372,000
16	Shasta Street	$221,000
17	Patricia Way & Linda Place	$269,000
	Total Project Costs:	**$5,539,000**
As-Developed		
1	Zone A - 0.8 MG Reservoir	$2,454,000
2	Zone A - Wells (3)	$1,597,000
3	Zone A - 10" and 8" Piping Improvements	$1,673,000
4	Zone B - 8" Piping and PRV Improvements	$814,000
5	Zone C - 8" Piping and PRV Improvements	$1,475,000
	Total Project Costs:	**$8,013,000**

Note:
(1) Estimated Project Cost includes planning, design, project management, contingency and construction costs. Allowance for environmental documentation and right-of-way procurement were included, however these costs are based on a preliminary review of planning level alignments. These costs will vary based on actual alignments. Individual projects can be combined to reduce the indirect project costs.

(2) Current Improvements are projects that are planned for construction in 2015. The order that the Current Improvements are listed in does not indicate project priority.

(3) Immediate Improvements are projects that are planned for construction in 2016. The order that the Immediate Improvements are listed indicates project priority based on the hydraulic model and input from City staff.

(4) Near-Term Improvements are based on pipeline installation date, material and typical design life. Listed projects include pipelines that have and/or will exceed their design life in the next 5 years. City records are incomplete; therefore, it is likely that more pipelines than are listed have/will exceeded their useful life in the next 5 years. As this is a theoretical evaluation, an investigation of maintenance records and/or field verification of pipeline conditions should be made. The order that the Near-Term Improvements are listed in does not indicate project priority.

INTRODUCTION

III. BACKGROUND

A. GENERAL

The City of Dunsmuir is located in Siskiyou County on Interstate 5, approximately 50 miles north of Redding, California. Its water distribution system is owned and operated by the City.

In August of 1989, the City of Dunsmuir purchased the Dunsmuir Water Corporation which had supplied water to the City residences since the early 1900's. The existing water system also provides water service to an area located south of the Dunsmuir City Limits.

Due to known deficiencies in the existing system, as well as anticipated future growth in the north and south areas, the City recognized the need to develop a Master Water Plan for their entire water supply and distribution system.

B. PREVIOUS STUDIES

In 1994, PACE was contracted to analyze the City's water system and prepare the 1994 Master Water Plan. Deficiencies identified within this 1994 Plan that have not been addressed, remain as part of the recommended 2015 Master Water Plan improvements.

C. SCOPE OF WORK

In 2014 the City authorized PACE Engineering to work jointly with City staff to prepare an updated Master Water Plan. This plan reviews the current water system and recommends improvement required over the next 20 years. The plan includes supply, storage, and distribution needs to meet existing and anticipated water demands.

D. RATINGS BY INSURANCE SERVICES OFFICE (ISO)

The ISO rated the fire protection facilities provided by the City in 2015. This organization is responsible for rating fire protection facilities (including water systems), for all communities in the United States; and the assigned rating is used by fire insurance underwriters to determine insurance rates. The lowest rating is a ten with the highest corresponding premium rate, and the highest and best rating is a one. The City received an overall Class rating of 03/3X in 2012, which is a good overall rating.

In 2014 ISO began using a split classification system. The first number is the class that applies to properties within 5 road miles of the responding fire station and 1,000 feet of credible water supply, such as a fire hydrant, suction point, or dry hydrant. The second number is the class that applies to properties within 5 road miles of a fire station but beyond 1,000 feet of a creditable water supply. The “X” after the number in the second classification denotes what was formally classified as a “9.”

In 1980 ISO began using a different rating system which does not penalize a community for not having fire flow capacity in excess of 3,500 gallons per minute. In effect this new rating system, which is described in the ISO Fire Suppression Rating Schedule, June 1980, puts the burden of fire demands in excess of 3,500 GPM on the property owner. No longer will cities and districts be penalized in ISO's rating system for not having capabilities to fight fires in excess of 3,500 GPM. The trend is to force property owners of large buildings to sprinkler their building and thus reduce their fire demand below the 3,500 GPM value. This is accomplished either by County or City Ordinance, or by the result of higher insurance premiums if the building is not sprinklered.

K. ABBREVIATIONS AND TERMS

Certain terms and abbreviations have been used in this Plan for convenience. Definitions are as follows:

AAD	Average Annual Demand
ADD	Average Day Demand. This is the average rate of water usage per day within a year. It can be expressed on an individual basis such as gallons per capita per day (GPCD) or on a community basis in million gallons per day (MGD)
CDPH	California Department of Public Health
CFS	Cubic Feet Per Second
EPS	Extended Period Simulation
GPCD	Gallons Per Capita Per Day
GPHED	Gallons Per Household Equivalent Per Day
GPM	Gallons Per Minute
HE	Household Equivalent
HGL	Hydraulic Grade Line
HP	Horsepower
ISO	Insurance Services Office
KWH	Kilowatt Hours
MDD	Maximum Daily Demand, in GPCD or MGD
MG	Million Gallons
MGD	Million Gallons Per Day. Note: 1 MGD = 694 GPM

MHD	Maximum Hourly Demand, in GPCD or MGD
MMD	Maximum Monthly Demand
MWP	Master Water Plan
MWS	Maximum Water Surface
PRV	Pressure Reducing Valve
PSI	Pounds Per Square Inch
SCADA	Supervisory Control and Data Acquisition
TDH	Total Dynamic Head

IV. EXISTING WATER SYSTEM

A. WATER SUPPLY SYSTEM

The City of Dunsmuir Water System is supplied by the diversion of four of the sixteen springs which are known collectively as Mossbrae Springs. Based on a 1957 license for diversion and use of water issued by the State Water Rights Board, the City currently has water rights to use 1.97 cubic feet per second (CFS) or about 1.27 million gallons per day (MGD) of water based on its annual maximum 30-day use period.

Water from the Mossbrae Springs is collected and discharged to a concrete weir box where the majority of the flow is discharged into the City's 18-inch steel water supply main and the excess overflows to Mossbrae Falls. The springs are located in a remote area along the Sacramento River approximately 0.5 miles north of Castlerock Water Company as shown on Plate 2. The entire Mossbrae Springs system (i.e., all 16 springs) is estimated to have a total yield of about 15 CFS or about 9.6 MGD. Water flows by gravity from the Mossbrae Springs diversion into the City’s water system. A booster pump station near the Castlerock Water Company forces water into the Lookout Pressure Zone on the north end of town.

Based on the September 1993 flow measurements, it appears that the spring supply was capable of providing water at flow rates of at least 1.75 MGD during that month. Historically the spring supply has been able to supply the City's peak hour demand, except for a few occasions. Prior to the 2006 Booster Pump Station improvements, inadequate suction pressure occurred a number of times during the summer of 1992. Therefore, if one assumes that the spring supply was not quite meeting the estimated MHD of 1.55 MGD, then it can be concluded that the effective supply capacity of the existing spring system was approximately 1.5 MGD during those drought conditions.

According to the State Health Department Waterworks Standards, the effective capacity of a spring shall be "the lowest anticipated daily yield, based on adequately supported and documented data". In addition, the standards specify that where the capacity of a source varies seasonally, the source capacity shall be the capacity at the time of MDD. Therefore, for the purpose of this Master Plan, it has been estimated that the effective capacity of the City's existing Mossbrae Springs facilities is about 1.5 MGD.

B. TREATMENT

Water from the Mossbrae Springs is of excellent quality and currently receives no treatment or chlorination from source to consumer. In the late 1970's the water system began to experience positive coliform tests which indicated bacterial contamination. Dye tests performed on the sewage disposal systems of upgradient development indicated positive results in almost all the springs. As a result, chlorination facilities were constructed and put into operation. Soon afterward, the upgradient development was connected to the City's Sewage Collection System. Since that time, there has been no record of the water supply requiring any form of treatment or chlorination. Depending upon the future water regulations, the City might have to begin chlorinating its entire water supply and maintaining a chlorine residual throughout the distribution system.

C. PRESSURE ZONES

Currently there are four pressure zones: the Lookout, Prospect, Shasta Retreat, and Downtown Pressure Zones, which are supplied water from the Mossbrae Springs. The Prospect and Shasta Retreat Pressure Zones are supplied by gravity from the Lookout Zone which is supplied by the existing booster pump station near the Castlerock Water Company. Generally, static pressures vary in the four zones from 30 PSI to 180 PSI as a result of the hydraulic gradeline and ground elevations within the zones. However there are some areas that are outside this range as shown in Table 2. Table 3 summarizes the existing pressure reducing valves used to control system pressures.

Table 2: Pressure Zone Limits

Zone	Existing HGL[1] [Ft]		Future HGL [Ft]		Highest Service							Lowest Service						
					Elevation[2] [Ft]	Pressure [PSI]						Elevation[2] [Ft]	Pressure [PSI]					
						Existing			Future				Existing			Future		
	High	Low	High	Low														
Lookout	2890	2862	2890	2862	2747	62	-	50	62	-	50	2549	147	-	135	147	-	135
Prospect	2793	2782	2793	2782	2619	75	-	71	75	-	71	2469	140	-	135	140	-	135
Shasta Retreat	2640	2640	2640	2640	2558	35	-	35	35	-	35	2386	110	-	110	110	-	110
Downtown																		
Existing	2792	2631	2792	2631	2550	105	-	35	105	-	35	2168	270	-	200	n/a	-	n/a
Future	n/a	n/a	2792	2631	2550	n/a	-	n/a	105	-	35	2280	n/a	-	n/a	222	-	152
Future Southern	n/a	n/a	2543	2531	2441	n/a	-	n/a	44	-	39	2168	n/a	-	n/a	162	-	157
Future Upper Mtn. Estates	n/a	n/a	2945	2942	2850	n/a	-	n/a	41	-	40	2584	n/a	-	n/a	156	-	155
Mott Airport																		
A	n/a	n/a	3500	3490	3400	n/a	-	n/a	43	-	39	3140	n/a	-	n/a	156	-	152
B	n/a	n/a	3230	3225	3140	n/a	-	n/a	39	-	37	3000	n/a	-	n/a	100	-	97
C	n/a	n/a	3100	3095	3000	n/a	-	n/a	43	-	41	2790	n/a	-	n/a	134	-	132

Notes:

(1) HGL is hydraulic gradient elevation under static conditions. This is usually the elevation of the maximum water surface and estimated maximum hour water surface in a reservoir controlling the pressure in the zone. Otherwise, it is set by pressure range at a booster pump station or pressure reducing valve.

(2) Elevation is based on the available U.S. Geological Survey mapping with 3 meter digital elevation model (DEM).

Table 3: Pressure Reducing Valve Inventory

PRV No.	PRV Station Location	PRV Valve			Downstream		Duplex
		Zone Served	Size [in]	Elevation(1)	HGL(2) [ft]	Pressure [PSI]	
1	Shasta View Ave & Wells Ave	Shasta Retreat	4	2,509	2,671	70	Yes
2	Dunsmuir Ave & Prospect Ave	Prospect	8	2,596	2,792	85	Yes
3	Dunsmuir Ave & Prospect Ave	Downtown	8	2,596	2,631	15	-

Notes:

(1) Elevation is based on the available U.S. Geological Survey mapping with 3 meter digital elevation model (DEM).

(2) HGL is the estimated hydraulic gradient setting on the downstream side of the pressure reducing valve. The values given were estimated by using a combination of the USGS DEM, surveyed elevations and pressure readings taken during low flow demands. These values need to be confirmed by a field survey.

D. STORAGE RESERVOIRS

Adequate water storage facilities in a water system are important for a number of reasons. It may be necessary to replace a pumped supply with stored water in the case of a power outage or broken pipeline. Also, it is usually more economical to rely on water from storage rather than expanding water supplies in order to meet the peak hourly demand flows over and above the 24-hour average flow during the MDD. The amount of storage needed to meet these peak demands is normally called equalizing storage. The amount of storage in a water system available for fire demands during the MDD conditions also affects the rating by ISO for fire protection facilities. As shown in Table 4: Water Storage Reservoir Inventory, there are currently two storage reservoirs totaling 1.05 MG in the City system.

The Downtown Reservoir was constructed in about 1905 and rehabilitated with a new gunite liner and composition roof in 1988. Unfortunately, the reservoir was not constructed at an elevation that would allow it to provide equalizing storage during normal maximum hourly demands. In fact, due to its maximum water surface elevation water cannot discharge from the reservoir into the distribution system until the water pressure downtown is about 27 pounds per square inch (PSI) below normal. Thus, the reservoir functions primarily as emergency and fire storage.

The Lookout Reservoir was designed by PACE and constructed in 2006. The need for this reservoir was identified in the 1994 Master Water Plan to provide adequate pressure and fire flows in the Lookout Zone, as well as provide much needed storage.

Table 4: Water Storage Reservoir Inventory

Tank No.	Reservoir Location	Date Constructed	Type	Volume [MG]	Maximum Water Surface Elevation [Ft]	Base Elevation [Ft]	Tank Dimensions		Existing Pressure Zones Served
							Feet of Water	Tank(1) Diameter [Ft]	
1	Downtown	~1905	Conc.	0.4	2538	2526	12	65	Downtown
2	North Dunsmuir	2006	Steel	0.65	2889.5	2861.5	28	63	Lookout
			Total Capacity:	**1.05**					

Note:

(1) Tank diameters are calculated. Calculations are based on tank heights and total volume.

The majority of the water system functions as one pressure zone based on the hydraulic gradeline of the springs. Under static conditions (i.e., no flow) the pressure downtown and in the southern end of the service area would be excessive. Therefore, a pressure relief valve was installed on the pipeline leading to the reservoir to regulate the system pressure. This valve is set to open at approximately 30 PSI which maintains about 120 PSI pressure at City Hall. The hydraulic gradeline of the valve set point is higher than the reservoir maximum water surface elevation. Water vented by this pressure relief valve is released into the reservoir and is subsequently discharged out the reservoir overflow. The flowmeter on the pipeline into the reservoir has been inoperable for some time. Based on past flow measurement information it is estimated that under average daily conditions, about 700 GPM overflows from the reservoir and into the small drainage ditch that flows across town to the Sacramento River. Of course, the overflow rate varies with the water demands in the water system and is shut off altogether when the system demand exceeds the spring supply. A bypass check valve is installed parallel with the pressure relief valve so that water can flow from the reservoir into the water system during extremely high demands or fire flow conditions.

E. DISTRIBUTION BOOSTER PUMP STATIONS

The elevation of the water supply springs is not high enough to provide adequate pressure to the entire City of Dunsmuir service area and a Booster Pump Station was installed decades ago to provide adequate pressure to the Lookout Zone. As part of the improvements required for the first phase of the Mountain Estates Subdivision, the Dunsmuir Water Company required the developer to relocate the booster pump station. In addition, the developer was required to provide a propane-fired, engine-driven pump for emergency backup. Unfortunately, the pump station was relocated to a high point on the 18-inch supply main from the springs where the maximum suction pressure on the booster pumps is only about 8 PSI. This low suction pressure prevented pump operation during periods of high demand. In 2006, both 15-horsepower pumps in the station were replaced with 25-horsepower pumps as part of the Lookout Reservoir Project. In addition, suction piping improvements were made to minimize suction piping friction losses. Since these improvements were installed, the booster pump station has operated without interruption.

F. DISTRIBUTIONS SYSTEM

CONDITION

As part of this Master Water Plan (MWP), an inventory of existing distribution system piping was prepared. The distribution system consists of a network of about 105,000 feet (19.9 miles) of mainline piping from 1-inch to 18-inch diameter. Approximately 80 percent of the distribution system (about 85,000 feet) consist of 4-inch to 18-inch mains. Most of the piping that has been installed in the last 40 years is primarily PVC and should last another 30+ years. Approximately 34,000 feet of distribution system with known pipe diameters is over 60 years old. Of these pipes, 16,000 feet of mains with known material and age are 60 to 70 year old steel lines which have a theoretical useful life of 55 to 75 years depending upon the type of lining and coating provided. Although many of these old steel lines are at or beyond their theoretical useful life, the need to replace them is dependent upon their actual condition, which is difficult to ascertain. Approximately 18 percent of distribution system pipeline material is unknown, as shown in Table 5. One obvious indicator of the condition of pipeline segments with unknown material is the history of leak repairs. Based upon our review with City staff, there are a number of water main sections that require frequent repair and should be replaced as soon as possible. Table 6 summarizes the design life of the existing distribution system.

Table 5: Distribution System Inventory

Material	Length [Ft]	Percent of Known	Percent of Total
PVC	13,000	15%	12%
Cast Iron	29,800	34%	28%
Steel	33,500	39%	32%
Galvanized	5,300	6%	5%
Ductile Iron	3,300	4%	3%
Asbestos Concrete	1,600	2%	2%
Unknown	18,900	N/A	18%
Total:	105,400	100%	100%

The remaining 20 percent of the distribution system (about 20,000 feet) consist of 1-inch to 3-inch pipelines that are primarily about 40 to 60 years old. In addition, many of these small pipelines in the Shasta Retreat area are located down back lot lines and under houses. Since the capacity of the 3-inch and smaller lines is very limited, they are not shown on Plate 2 at the end of this Plan. However, many of these lines need to be upgraded with 6-inch minimum mains in order to provide adequate fire flows.

Table 6: Distribution System Design Life Summary

Material	I.D. [in]	Approx. Ave. Age [Yrs]	Design Life [Yrs]	Ave Remaining Life [Yrs]	Total Length [Ft]
Steel	18	88	65	-23	2,413
Steel	14	87	65	-22	5,613
PVC	12	9	75	66	2,090
Steel	12	88	65	-23	3,420
PVC	10	9	75	66	680
Steel	10	69	65	-4	2,841
Cast Iron	8	45.9	100	54	2,455
Ductile Iron	8	9	75	66	13
PVC	8	23	75	52	4,403
Steel	8	82	65	-17	2,094
Cast Iron	6	60.1	100	40	9,495
Ductile Iron	6	48	75	27	849
PVC	6	15	75	60	4,661
Steel	6	89	65	-24	621
Cast Iron	4	84	100	16	8,677
Galvanized	4	19	65	46	16
PVC	4	7	75	68	97
Steel	4	88	65	-23	3,028
PVC	3	7	75	68	204
Galvanized	2.5	9	65	56	12
Cast Iron	2	88	100	12	76
Galvanized	2	74	65	-9	1,842
Steel	2	61	65	4	1,115
Galvanized	1	41	65	24	234
				Total[1]:	56,714

Note:
1) Design life summary only includes pipes segments with known material and installation year.

EXISTING SYSTEM CAPACITY/ANALYSIS

Considerable attention was given to determining the entire water distribution system's adequacy to meet estimated 2015 MHD and the fire flow requirements at MDD conditions. Potential fire flow supplies at various locations were compared with typical ISO fire flow requirements.

The capacity of a distribution system is generally considered adequate if it can meet the following criteria:

1. Supply all the water necessary to meet consumers' needs during periods of maximum usage (maximum hourly demand), at a reasonable residual pressure, usually not less than 40 PSI and normally not greater than 125 PSI (although higher pressures are often a practical condition up to about 150 PSI).

2. Supply the needed fire flow coincident with reasonable consumers' demands and not drop the pressure below 20 PSI.

To evaluate the distribution system, a computer model of the entire distribution system was prepared utilizing the InfoWater by Innovyze. Nearly all 1-inch and larger pipelines were included in the model. The model of the existing system contained about 651 pipelines and flow demands were assigned to approximately 597 nodes. A file containing all City water meter accounts and addresses was used to distribute demands throughout the model. Simulations were made of the existing water system, including the MHD conditions. Fire hydrant locations were identified throughout the system and analyzed for adequacy.

The distribution system model was first analyzed under 2015 MHD conditions. Analysis of the output pressures, flows, and headloss information provided confirmation of a number of system deficiencies. Because of the relatively low elevation of the existing reservoir, there are two potential operation scenarios during MHD conditions. First, if the spring supply is greater than the MHD requirements, then the hydraulic gradeline in the Low Pressure Zone will be controlled by the pressure relief valve located in front of the reservoir. Under normal conditions the pressure relief valve discharges up to

700 GPM through the reservoir overflow and thus imposes a continuous flow on the distribution system from the springs to about City Hall near Dunsmuir Avenue and Cedar Street that is almost as high as the 2015 maximum hour conditions. Therefore, under this scenario when the maximum hour conditions do occur with adequate spring supply the pressure at City Hall only drops from about 120 PSI to 107 PSI. Similarly, the operating pressure north of City Hall only drops about 2 to 13 PSI. However, the distribution system pressures south of the City limits can drop from 10 to 20 PSI below normal. For example, the operating pressure in the upper reaches of the Blackberry Hill area, east of the Scherrer Avenue bridge across the Sacramento River, might drop from about 75 PSI to about 55 PSI.

Under the second operating scenario, the spring supply is less than the MHD requirements and the system hydraulic gradeline drops until water begins to flow from the reservoir to make up the difference between the supply and the demand. Once this happens, the hydraulic gradeline and pressures in the Downtown Pressure Zone drop by about another 25 PSI, which results in a pressure of about 90 PSI at City Hall. Pressures at the upper reaches of Simpson Avenue drop to less than zero and pressures in the Blackberry Hill area can drop to less than 20 PSI. Although improvements to the booster pump station suction piping have allowed the Lookout Reservoir to remain full and provide supplemental water to the Downtown Pressure Zone, one would expect more frequent periods of reduced pressures as the demands continue to increase due to growth or if the spring capacity should diminish, as it probably did during the past years of drought.

From a high pressure standpoint, the static pressures along the east side of the Sacramento River from the Butterfly Avenue Bridge along S. 1st Street at the Shasta County line range from 130 PSI to about 185 PSI.

Nine potential fire flows were determined at various strategic locations such as at the high school and elementary school, downtown business area, and at the extremities of the system. A comparison of the computer model fire flow, City staff/PACE field tests and 2015 Fire Department field test, is shown in Table 7. In general, the computer model fire flows at a 20 PSI residual were in fairly good agreement with the field hydrant tests except for a few areas where the Fire Department projected flow at 20 PSI did not consider the impacts to adjacent service pressures. It must also be recognized that the Fire Department tests were performed over an extended period of time and it is unknown whether the actual domestic flow conditions were close to the MDD condition for each test.

In general the potential fire flows are the largest in the downtown area where the reservoir can effectively supplement the spring supply and achieve fire flows of between 2,000 to 3,000 GPM. However, the potential fire flows are the lowest at the higher elevations, such as the high school and Simpson Avenue in Shasta Retreat, and at the far extremities of the system such as the south end of Dunsmuir Avenue and the south end of S. 1st Street.

The computer analyses and all proposed improvements will be discussed further in the Section, ANALYSIS AND RECOMMENDED IMPROVEMENTS.

G. FIRE HYDRANTS

The location of the existing fire hydrants is shown on Plates 2 and Figure 10 at the end of this Plan. In general, fire hydrant spacing is good in the City and there are currently about 148 hydrants in the system based on Fire Department records.

H. SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) SYSTEM

The City maintains a SCADA system to monitor the Lookout Reservoir and Booster Pump Station. When the Lookout Reservoir's water surface level falls below a setpoint, the telemetry system is designed to automatically call the Booster Pump Station to run. The telemetry system consists of one remote terminal unit (RTU) at the Lookout Reservoir and one master RTU at the Booster Pump Station.

Table 7: Fire Flow Summary

Test	Year	Computer Simulation Description	Computer Model Fire Flow [GPM][(1)]	Computer Model Design Fire Flow [GPM][(2)]	Field Test Fire Flow [GPM][(3)]	Fire Department Fire Flow [GPM][(4)]	Comments
1	2015	Existing system run at MDD with fire at corner of 2nd & 1st St (Hyd-204)	688	405	550	660	
2	2015	Existing system run at MDD with fire at corner of Dunsmuir Ave & Katherine St (Hyd-101)	1193	1189	1640	1290	
3	2015	Existing system run at MDD with fire at corner of Beverly Way & Allen St (Hyd-167)	1549	1184	2230	1245	
4	2015	Existing system run at MDD with fire at corner of Sacramento Ave & Upper Soda Rd (Hyd-137)	2273	1532	1380	960	
5	2015	Existing system run at MDD with fire at corner of Needham & Gray St (Hyd-137)	2803	2803	2320	2140	
6	2015	Existing system run at MDD with fire at corner of Siskiyou & Hope St (Hyd-110)	1943	1591	4870	3660	
7	2015	Existing system run at MDD with fire at north of Bridge St on Gillis St (Hyd-201)	818	400	N/A	940	The Blackberry Hill area, to the east of Hyd-201, does not have fire hydrants. Simulated fire flow in Blackberry Hill area are significantly below 500 GPM (~20 GPM)
8	2015	Existing system run at MDD with fire at corner of Haven & Simpson Ave (Hyd-124)	319	215	N/A	N/A	The Shasta Retreat area has undersized mains, some of which are located outside the right-of-way.
9	2015	Existing system run at MDD with fire at the south entrance to the Elementary School on Siskiyou Ave (Hyd-118)	1948	1483	N/A	3990	The estimated Fire Department fire flow does not take into account surrounding services that will drop below 20 PSI if fire hydrant supplies maximum available flow

V. FUTURE WATER DEMANDS

A. SERVICE AREA

To determine future water needs for the City of Dunsmuir, it was first necessary to establish physical and political boundaries of the service area. This Plan assumes that the City will ultimately serve most of the area within the proposed Zone of Influence Boundary shown on Plate 1. This boundary was determined primarily on the basis of the current Siskiyou and Shasta County General Plans and discussions with the City staff. Emphasis was given to continued service to lands in Shasta County south of the City limits. The existing City boundary and topography were also taken into account. The areas to the north of the existing Lookout Pressure Zone will be required to provide their own water source. As a result, the northern areas were excluded from this Plan's analysis.

B. POTENTIAL DEVELOPMENTS

City staff has indicated that areas to the north of the Lookout Pressure Zone will be required to provide their own water source. As a result, these areas were excluded from this Plan's analysis.

A review of all parcels within the existing Service Area Boundary identified approximately 175 undeveloped parcels. Many of these are small or irregular-shaped parcels that would be difficult to develop. Based on input from City staff, no specific plans for developing these parcels has been proposed.

C. GROWTH PROJECTION

Based on the current General Plan a growth rate of 0.75 percent was assumed for the next 20 years. Beyond the 20-year planning period, it was assumed that the growth rate of the proposed service area would begin to level off with ultimate development occurring in about 50 years. It should be emphasized that this assumed 20-year growth rate is higher than past long-term growth rates in the area. If the actual growth rate is smaller than 0.75 percent, then improvements designed to accommodate growth for the near-term will be satisfactory for a longer period of time. If the actual growth is greater, then improvements will reach their design capacity sooner than projected.

D. PAST AND PRESENT WATER USAGE

City of Dunsmuir water consumption demands for 2013-2014 were approximately 0.84 MGD maximum day demand (MDD) and 1.36 MGD maximum hour demand (MHD). The current MDD and MHD represent about 56 and 91 percent of the present system's effective supply capacity, respectively. Table 8: Monthly Water Consumption was compiled using the City's water meter billing records. The per service demand rates were determined on a household equivalent (HE) basis. An HE is the water usage of an average residential water user, which was determined by subtracting the water use of the largest users from the total water use and then averaging the remaining water use over the remaining connections. The water use of the major users could then be expressed in HEs. For example, Union Pacific Railroad was equivalent to about 117 HEs. In July 2013 the City had a total of 1,216 metered services which were equivalent to 1,818 HEs. These figures are shown in Table 9.

Approximately 46 unmetered accounts exist within the system. Most of these services are within the Shasta Retreat area. Water consumption for unmetered users was estimated based on typical consumption of similar type metered users.

Table 8: Monthly Water Consumption

User Type	Jul 2013	Aug 2013	Sep 2013	Oct 2013	Nov 2013	Dec 2013	Jan 2014	Feb 2014	Mar 2014	Apr 2014	May 2014	Jun 2014
Residential [MG]:	10.04	10.52	10.10	5.64	3.96	4.19	4.54	3.58	3.23	3.97	5.42	10.50
Commercial [MG]:	4.28	4.76	4.10	2.76	2.26	2.49	2.78	2.26	2.10	2.47	2.29	3.63
Total [MG]:	14.32	15.28	14.20	8.40	6.23	6.68	7.32	5.84	5.33	6.44	7.71	14.13
Total [MGD]:	0.46	0.49	0.47	0.27	0.21	0.22	0.24	0.21	0.17	0.21	0.25	0.47

Table 9: Household Equivalent Determination

No.	Account	Maximum Month [CF]	Maximum Month [GPD]	HEs
1	Union Pacific Railroad	142,500	34,386	117.0
2	Cave Springs Motel	111,300	26,857	91.4
3	City of Dunsmuir, Ball Park	85,000	20,511	69.8
4	City of Dunsmuir, Park	60,800	14,671	49.9
5	City of Dunsmuir	56,800	13,706	46.6
6	Riverwood Estates	26,800	6,467	22.0
7	Riverwood Estates	25,700	6,202	21.1
8	Union Pacific Railroad	23,600	5,695	19.4
9	Lodging Enterprises	23,300	5,622	19.1
10	Riverwood Estates	17,800	4,295	14.6
11	Manfredi's Market	16,900	4,078	13.9
12	Lodging Enterprises Low Flow	15,300	3,692	12.6
13	Dunsmuir Elementary School	14,400	3,475	11.8
14	City of Dunsmuir	12,600	3,040	10.3
15	Private Service	11,200	2,703	9.2
16	Private Service	10,800	2,606	8.9
17	Private Service	10,700	2,582	8.8
18	Dunsmuir Brewery Works	10,000	2,413	8.2
19	Dunsmuir Lodge	9,200	2,220	7.6
20	Private Service	9,100	2,196	7.5
21	Dunsmuir Rec. Dist.	9,000	2,172	7.4
	TOTAL	**702,800**	**169,591**	**577**

Total No. of July 2013 Metered Services =	**1,216**
Total Max Month Metered & Non-Metered Consumption [MG] =	**16.1**
Less Twenty-One Largest Users For Max Month [MG] =	**5.26**
Production For Remainder Services [MG] =	**10.9**
Typical Maximum Month Consumption/Household Equivalent [GPD]=	**294**
Largest July 2013 Metered Users [HEs] =	**577**
Other July 2013 Metered Users [HEs] =	**1,195**
Estimated Flat Rate Users [HEs] =	**46**
Total Number of July 2013 [HEs] =	**1,815**

Average day consumption, citywide, was about 220 gallons per HE per day (GPHED) for 2013-2014. Typical average annual consumption in other metered communities varies from 610 GPHED in the City of Yreka to about 360 GPHED in the City of Weed. The lower consumption in the City of Dunsmuir is probably due to mild summer temperatures, small lot sizes and the relatively steep terrain which results in less irrigation demands.

As shown on Table 10, the ratio of MMD to ADD was 1.3 and demonstrates the relative change in water consumptive use through the year. Actual MDD and MHD are difficult to determine because of the Downtown Reservoir's overflow. This overflow is unmetered and is constantly overflowing. Therefore, it is necessary to use empirical design factors for estimating the maximum daily and maximum hourly demands. Design ratio values of 1.3, 2.1 and 3.4 for maximum month, day, and hour, respectively, selected for use in this plan agree with industry standards.

E. PROJECTED WATER DEMANDS

Table 10: Summary of Design Values in Water System Analysis, is a summary of design parameters used for existing and ultimate system analysis. Values for 2035 were based upon a 0.75 percent annual increase from the 2015 values. The ultimate system values were based upon an assumed full development of the City of Dunsmuir's Zone of Influence as determined by the City and County General Plans. Sloped areas within the Zone of Influence, unsuitable for development (Slope>30%), were removed. The area north of the existing Lookout Pressure Zone was also removed. This region will be required to develop its own water supply (i.e., wells, springs, etc.).

Ultimate development within the City of Dunsmuir's Zone of Influence would result in an estimated average daily demand (ADD) of about 0.99 MGD which is about a 148 percent increase in the current 0.40 MGD ADD. The 2035 ADD with the 0.75 percent growth rate is estimated at 0.62 MGD or about a16 percent increase compared to the 2015 water demands.

Table 10: Summary of Design Values in Water System Analysis

Average Annual Demand [Gal/HE/Day] = 220

Design Ratios	
MMD/ADD =	1.3
MDD/ADD =	2.1
MHD/ADD =	3.4

Description	Year		
	2015	**2035**	**Ultimate(1)**
Household Equivalents	1,815	2,108	10,682
Average Daily Demand [MGD]	0.40	0.46	0.99
Maximum Monthly Demand [MGD]	0.53	0.62	1.32
Maximum Daily Demand [MGD]	0.84	0.97	2.08
Maximum Hour Demand [MGD]	1.36	1.58	3.37
ADD/Equivalent House Service [GPM]	0.15	0.15	0.15
MDD/Equivalent House Service [GPM]	0.32	0.32	0.32
MHD/Equivalent House Service [GPM]	0.52	0.52	0.52

Note:
(1) Ultimate demand does not include service north of the existing service area boundary. This area has an estimated ultimate demand of 2.1 MGD, however it is above the Lookout Pressure Zones HGL.

Projected ultimate water demands for undeveloped areas were determined on a per acre basis based on the current City of Dunsmuir's Zoning and General Plan summarized in Table 11. These values were derived by analyzing current City of Dunsmuir consumption rates.

Table 11: Zoning and General Plan Land Designations

Zoning/ Designation	Source	Unit Density[(1)] [Units/Acre]	Design Demand [Gal/Acre/Day][(2)]
R-1	City of Dunsmuir Zoning Plan	7.92	3,657
R-2	City of Dunsmuir Zoning Plan	15.84	7,314
R-3	City of Dunsmuir Zoning Plan	43.56	20,113
R-4	City of Dunsmuir Zoning Plan	43.56	20,113
C-1	City of Dunsmuir Zoning Plan	8.71	4,023
C-2	City of Dunsmuir Zoning Plan	27.23	12,571
M	City of Dunsmuir Zoning Plan	29.04	13,409
LDR	City of Dunsmuir General Plan	6.00	2,770
MDR	City of Dunsmuir General Plan	12.00	5,541
HDR	City of Dunsmuir General Plan	40.00	18,469
RL	City of Dunsmuir General Plan	0.05	23
GC	City of Dunsmuir General Plan	27.23	12,571
MU-PD	City of Dunsmuir General Plan	0.40	185
SC	City of Dunsmuir General Plan	5.51	2,543
PA	City of Dunsmuir General Plan	0.00	0
OS	City of Dunsmuir General Plan	0.00	0

Notes:
1) Unit density and ultimate demand determined on a parcel by parcel basis.
Density were based on surrounding area Zoning and General Plan designations.
2) Design demand based on unit density and 462 GPD per HE MDD usage.

As indicated herein before the City's current water rights for water from Mossbrae Springs is in the amount of 1.27 MGD on a maximum 30-day (i.e., MMD) use period. The effective capacity of the spring's headworks is estimated at about 1.5 MGD based on the summer 1992 flows, which was at the end of a five-year drought. Therefore, with adequate equalizing storage to meet the maximum hourly demands and additional improvements at the spring's headwork to reduce the minor leakage, it appears that the

City should be able to meet 2035 supply requirements with the existing spring supply and its existing water right. Based on 0.75 percent growth rate the spring supply could meet demand for the next 75 years, excluding areas north of the existing Lookout Pressure Zone.

In January 1994 PACE Engineering retained Lawrence and Associates on behalf of the City to evaluate the potential for developing wells in the vicinity of Mott Airport with yields of 100 gallons per minute (GPM) or more. The Lawrence and Associates' report dated February 17, 1994 indicates that based upon an analysis of the well logs of existing wells and the geology and the hydrology of the area, there is a potential for developing 100 GPM or greater capacity wells provided they are drilled to a depth of approximately 500 feet or to the top of the non-water bearing rocks, whichever comes first. Based on the 21 well logs that were available, well yields vary from 5 to 236 GPM and average 35 GPM. The second highest yield was 100 GPM. The Lawrence and Associates' report is included at the end of this Master Plan in the Appendix.

The ground elevation at Mott Airport is about 630 feet above the elevation of the Mossbrae Springs headworks, while the groundwater level at Mott Airport is only about 200 feet below the ground. Thus, from a pumping power cost standpoint it would be much more expensive to pump spring water to the Airport than to pump the local groundwater. Therefore, based on Lawrence and Associates' findings that the potential for 100 GPM wells does exist in the Mott Airport area and the high cost of pumping spring water, it is recommended that two or more wells be developed to meet the ultimate maximum daily demand of the service area north of the existing Lookout Pressure Zone.

F. WATER STORAGE DEMANDS

It is usually more economical and reliable to provide stored water for the supply needed during: 1) fire demands, 2) peak demands in excess of maximum daily demand, and 3) in the event of an emergency short loss of the usual source of supply such as power outage or damage to a major supply main. The required storage in a typical water system is a function of three quantities as follows (see Table 12):

1. Equalizing storage is the amount of water needed over and above the maximum daily demand rate to satisfy peak demands of the day. This is often found to be between 15 and 20 percent of the maximum daily demand and has been assumed to be 20 percent for design purposes herein.

2. Fire storage is usually based on the theoretical amount that could be used to combat a major fire in the high value districts. Insurance Services Office (ISO) recommends fire storage be a function of computed fire demands. ISO recommendations could be for up to 3,500 GPM. It is our understanding the buildings requiring higher flows would not be counted against the community water system if ISO were to rate the system. It seems impractical to design the entire water system to meet every possible fire demand, which can change with building reconstruction, sprinkler installation, or building demolition. A 2,500 GPM fire flow for two hours has a corresponding storage quantity of 0.30 MG and has been used herein as the bare minimum design value for commercial/industrial areas. Fire storage capable of meeting ISO's 3,500 GPM capacity for three hours in commercial/industrial areas has a corresponding storage requirement of 0.63 MG. Future large buildings having fire flow demands in excess of about 2,000 GPM should be encouraged to be sprinklered, which reduces the fire demand flow.

3. Emergency storage is the amount of water necessary to continue service in the event of power failure or some other failure of the supply system. This is usually assumed to be the maximum daily demand rate times some interval of time such as might occur during a power outage. Six hours is normally used. However, where supply system failures are uncommon, it seems unreasonable to imagine a major fire coincident with both a supply failure and with a period of water consumption equal to the maximum daily demand. For this reason, the City of Dunsmuir desirable storage will be the equalizing storage plus the larger quantity of either the ISO fire storage or emergency storage.

Table 12 summarizes the City's existing and proposed storage demands until ultimate buildout. Note that minimum storage demand is composed of equalizing and emergency storage or minimum fire storage, whichever is greater. Desirable storage, on the other hand, is composed of equalizing storage and ISO fire storage or emergency storage, whichever is the greater.

The City currently has two reservoirs, the 0.65 MG Lookout Reservoir and the 0.40 MG Downtown Dunsmuir Reservoir. The Downtown Dunsmuir Reservoir is located in the Downtown Pressure Zone at an elevation which makes it virtually ineffective for use as equalizing storage. This reservoir does function to provide emergency and fire flow storage for the downtown area and the area to the South. However, because of the distribution system hydraulics, a significant portion of the existing service area north of the I5 bridge across the Sacramento River is either out of water or has very low water pressure whenever water is being withdrawn from the Downtown Dunsmuir Reservoir.

It is also recommended that an 0.80 MG reservoir be constructed in the future to serve the Mott Airport Zones and that a 0.15 MG reservoir be built to serve the Upper Mountain Estates area when that development occurs. In addition to serving Mountain Estates area, the proposed 0.15 MG reservoir will provide storage for increased demands within the Downtown Pressure Zone.

Table 12: Storage Requirements

Year	MDD [MGD]	Equal Storage(1) [MG]	Emergency Storage(2) [MG]	Fire Storage(3) [MG]	Desirable Storage [MG]	Surplus Storage(4) [MG]	Comments
Existing Lookout Zone							
2015	0.04	0.01	0.01	0.30	0.31	0.33	Exist 0.65 MG
2035	0.05	0.01	0.01	0.30	0.31	0.33	-
ULT.	0.38	0.08	0.10	0.30	0.38	0.48	Add 0.15 MG
Existing Prospect Pressure Zone							
2015	0.09	0.02	0.02	0.30	0.32	0.01	-
2035	0.11	0.02	0.03	0.30	0.32	0.01	-
ULT.	0.10	0.02	0.03	0.30	0.32	0.16	-
Existing Shasta Retreat Pressure Zone							
2015	0.05	0.01	0.01	0.63	0.64	0.09	-
2035	0.06	0.01	0.01	0.63	0.64	0.59	-
ULT.	0.07	0.01	0.02	0.63	0.64	0.73	-
Existing Downtown Pressure Zone							
2015	0.67	0.13	0.17	0.63	0.76	-0.35	Exist. 0.4 MG
2035	0.78	0.16	0.19	0.63	0.79	0.12	Replace W/ 0.9 MG
ULT.	1.52	0.30	0.38	0.63	0.93	0.13	-
Proposed Downtown Pressure Zone							
2015	0.46	0.09	0.12	0.63	0.72	-	-
2035	0.53	0.11	0.13	0.63	0.74	-	-
ULT.	1.14	0.23	0.28	0.63	0.86	-	-
Proposed Southern Pressure Zone							
2015	0.21	0.04	0.05	0.30	0.34	-	-
2035	0.24	0.05	0.06	0.30	0.35	-	-
ULT.	0.38	0.08	0.09	0.30	0.38	-	-
TOTAL							
2015	0.85	0.16	0.20	-	-	-	Exist 1.05
2025	0.93	0.19	0.23	-	-	-	1.55
ULT.	2.00	0.40	0.50	-	-	-	1.65

Note:

(1) Equalization storage based on 20% of MDD.

(2) Emergency storage based on 25% of MDD.

(3) 0.3 MG storage based on 2,000 GPM fire flow for 2 hours. 0.63 MG storage based on 3,500 GPM fire flow for 3 hours.

(4) Surplus storage includes surplus from upstream pressure zones.

G. DISTRIBUTION SYSTEM DEMANDS

As future development occurs, a goal of the City should be to obtain a grid system of suitable diameter mains so that reasonable fire flows can be provided throughout the City. However, not all pipelines that will be needed are shown. A skeletal layout of future water mains is shown on Plate 2. In general, 6-inch and larger pipes have been added based upon existing development plans and those envisioned for ultimate development. Pipeline improvements shown on Plate 2 are in one of four categories:

1. Planned 2015 (Current): Pipelines planned for construction in 2015. These pipelines are needed to correct existing deficiencies (such as looping dead end mains, meeting fire demands or replace defective mains). These improvements are shown in Table 13 of the Master Plan and are designated on Plate 2 by dashed red lines and circled numbers at each end of the pipeline reach or at the needed reservoir, well, or other facility.

2. Proposed Immediate: Similar to the planned 2015 improvements, but slated for construction in 2016, these improvements are shown in Table 14 of the Master Plan and are designated on Plate 2 by solid red lines and circled numbers at each end of the pipeline reach or at the needed reservoir, well, or other facility.

3. Proposed Near-Term: Pipelines needed to replace existing lines that are at or beyond their serviceable life based on available records. These improvements should be constructed between 2017 and 2022 and are shown in Table 15 of the Master Plan and are designated on Plate 2 by a yellow highlighted solid black lines and circled numbers at each end of the pipeline reach or at the needed reservoir, well, or other facility.

4. Proposed As-Developed: Pipelines needed to serve new development (and possibly at the same time provide for future growth) are shown as dashed green lines. Many of these lines shown on Plate 2 are uncertain at this time especially where they are providing supplies to undeveloped perimeter areas. In these cases, the locations shown should be considered to be “conceptual” or "typical”. Costs for these improvements are shown in Table 16.

Because of the age of the distribution system, the City should develop a routine meter maintenance program. This program should include periodic review of meter installations to determine if the meter is recording flows accurately, as well as review of the site to determine if upgrading or replacement is desirable because of meter age, ease of reading, better drainage, etc. Records including date of installation, date last tested, accuracy, and condition should be recorded for later use.

It would be desirable to check large meters (2-inch and larger) about once every two years and smaller meters at least every 10 to 15 years. The larger meters have the potential for greater loss of revenue should they not be measuring the flow accurately. The program should start in the older portions of the system and progress to the more recent areas. In addition, the City should consider installing meters on the existing unmetered services.

H. PRESSURE ZONES

Pressure zone boundaries and upper elevation limits are also shown on Plate 2. Normally, pressures of about 50 to 125 PSI should be maintained in a distribution system. However, as a matter of practicality, these limits are often stretched to about 40 to 150 PSI. Pressure below 20 PSI does not meet the California Department of Health Services standards unless the user is informed of the limits of pressure and is in agreement with such limitations.

Currently there are only four pressure zones, the Lookout, Prospect, Shasta Retreat, and Downtown Pressure Zones. As discussed hereinbefore, the portion of the Shasta Retreat Area that is on the west side of the Sacramento River is in the Shasta Retreat Pressure Zone and suffers from low pressure during periods of high demand and low fire flow problems.

The elementary school on Siskiyou Avenue is in the Downtown Pressure Zone and has to booster pump water to its upper playing fields. By extending the Siskiyou Avenue water main from Timber Drive to the elementary school, it would be possible to move the school into the Lookout Pressure Zone, thus increasing the normal operating pressure and fire flow potential.

Future pressure zones include the Upper Mountain Estates Zone, the three Mott Airport Zones (A, B, and C), which will be needed when development occurs in those areas, and the Southern Zone.

The water system indicated for the Mott Airport Zones are based on industrial development at the Airport and the associated 3,500 GPM fire flows. It was assumed that development south of the Airport would be residential with 1,000 GPM fire flow requirements. The schematic layout of the water system for the Airport assumes that up to three new deep wells may be required to meet the estimated 330 GPM ultimate development maximum daily demand for Zones A, B, and C. It is proposed that all three wells be located in Zone A so they can pump into the new reservoir. Water would be fed from Zone A into Zones B and C via pressure reducing stations so that only one reservoir would be required to serve all three zones.

Under wintertime conditions, when water demands are at their lowest, pressures may be as high as 180 PSI along S. 1st Street in the southern portion of the Downtown Pressure Zone. Pressures have been kept high in the area to force water through inadequately-sized pipe in the Blackberry Hill Area. Pipeline capacity improvements to the Blackberry Hill area should help to increase area pressures. Pressures in excess of 150 PSI are of concern for older infrastructure commonly found in this area. Pipelines under excess pressure are more prone to leaks, are dangerous for City staff to maintain, and may damage firefighting equipment during firefighting activities. A new Southern Pressure Zone would curtail these excessive pressures to 150 PSI. Three new pressure reducing stations would be required to form a new Southern Pressure Zone.

With these pressure zone changes, pressure in the City of Dunsmuir system should generally be in the 40 to 150 PSI range. Only under conditions of very high demand or in a few special cases are pressures found to be outside this range. Refer to Table 2 in the Section PRESSURE ZONES for a listing of current and future pressure limits.

Six pressure reducing valves (PRVs) and two check valves will be used in the future in order to accomplish the ultimate pressure zone plan. As mentioned previously, the addition of PRVs to form a Southern Pressure Zone would help to limit extreme pressures at the southern end of the distribution system. Because these changes will decrease the normal pressures, existing users in affected areas should be notified that their private service PRVs may need to be adjusted.

I. FIRE FLOWS AND SYSTEM ANALYSIS

As with the existing water system, the ultimate supply, storage, and distribution system's adequacy to meet various water demands and fire flows was analyzed.

A computer model was developed consisting of 838 pipes, representing the ultimate system including storage tanks, the Mossbrae Springs and booster pump stations. Approximately 700 nodes, or demand points, were distributed through the service area based upon the projected land use categories.

Figures 1 through 6 summarize the 2015 and Ultimate Model computer MDD analysis results. In general, the existing system, which was based on a system supply of 1.5 MGD of flow from Mossbrae Springs, maintains residential pressures above 40 PSI in most cases during MHD simulation; however, in a few places (at the higher elevations) residual pressures were between 35 and 40 PSI. The ultimate model, which incorporates all of the proposed 2015 and 2035 Model capacity and fire flow improvements shows similar results.

As shown in Table 7, nine different fire flows were simulated under existing 2015 MDD and ultimate MDD conditions. The proposed master plan of improvements significantly increased the fire flow capability of the water system, but it does not appear feasible to meet the estimated ISO fire flows in the South Dunsmuir area near Elizabeth Street, at the elementary school, or at the Riverwood Trailer Park on 1st Street because of the increased system demands at ultimate development and the high cost of upgrading long sections of water mains. Therefore, it is recommended that the City encourage all future commercial or institutional development in these areas to install fire sprinkler systems.

J. COST ESTIMATES

Estimates of the both Near-Term and As-Developed Improvements costs are summarized in Table 1. Table 15 and Table 16 provide a more detailed breakdown of these costs at the end of this Plan.

V. ANALYSIS AND RECOMMENDED IMPROVEMENTS

A. GENERAL

The first step in analysis of the water system was to compare the capacity of the existing facilities against recommended capacities based on current engineering design criteria. Next, the facilities were analyzed under future conditions based on projected growth and corresponding system demands. Deficiencies were noted and various solutions examined. Finally, the recommended improvements needed to provide the required capacity for the next 20 years of growth were prioritized in a timetable and constitutes the Master Plan of Improvements. The improvements are shown in the ESTIMATES OF COST section of this Plan, and on Plate 2 at the end of the text.

B. SUPPLY

As discussed earlier, spring supplies are normally rated on the basis of the minimum flows on record during the maximum demand period. The City is supplied water by a number of the Mossbrae Springs at Mossbrae Falls. Currently, the City has a water right to 1.27 MGD of water based on an annual maximum 30-day use period. This right exceeds the estimated ultimate maximum month water demand. The existing spring headworks have an estimated effective maximum daily capacity of about 1.5 MGD. The capacity of the spring exceeds the estimated 2035 MDD demand of 1.32 MGD. However, the spring capacity is less than the estimated ultimate MDD of 2.08 MGD. As demand approaches the City's full water right, the City should pursue additional spring rights and increase the capacity of its headworks. As an alternative, the City could develop wells. However, the cost of well development and pumping make acquisition of addition spring rights the preferred alternative.

C. TREATMENT

The City does not treat the Mossbrae Springs supply as it is of excellent quality. For a short period in the late 1970s the water system experienced positive coliform tests which indicate bacterial contamination. At that time chlorination facilities were constructed and put into temporary operation. Since then, chlorine has not been added to the water as part of typical operations. No additional treatment is recommended at this time.

D. PRESSURE ZONES

Since the 1994 Master Water Plan, the City has made some significant changes to the pressure zone boundaries. Plate 2 shows the pressures zone boundaries and their hydraulic grade lines. These changes include the addition of the Lookout Reservoir and the creation of the Prospect and Shasta Retreat Pressure Zones. The City topography requires some areas to have higher pressures than are typically seen within water systems. Typical practice is to maintain pressures from 50 to 125 PSI. The City of Dunsmuir's average pressures are typically between 40 and 160 PSI under maximum day demand conditions. Under wintertime conditions, pressures may exceed 180 PSI in some pressure areas. New pressure reducing stations have been proposed to limit high pressure areas to 150 PSI. Pressures larger than this can be dangerous for City staff and may damage firefighting equipment. This new pressure zone would be located in the southern half of the distribution system and would require the construction of three pressure reducing stations.

1) <u>LOW PRESSURE AREAS</u>

a. Blackberry Hill Area in the Downtown Pressure Zone:

This area is bound on the west by S. 1st Street, on the east by Fourth Street, on the south by Mican Street and on the north by Hilltop Street. The area is elevated above the surrounding services and served by mains with diameters ranging from ¾ inch to 2 inch. The limited capacity of the mains and elevation of services results in pressures significantly below 40 PSI.

Based on the hydraulic model, increasing main sizes in the area will help to eliminate low pressures during periods of high demand. However, adequate fire flows cannot be obtained in this area of the distribution system without significant improvements (e.g., tank, booster pump station, out of zone main, etc.).

b. Shasta Retreat Pressure Zone

This area extends west from Dunsmuir Avenue, down Simpson Avenue and across the Sacramento River. The development of a Shasta Retreat

Pressure Zone significantly increased pressures in the area, however pressures are still low in the upper regions of the area. Based on the hydraulic model, increasing main sizes in the area will help to eliminate low pressures during periods of high demand.

c. High School Area in the Downtown Pressure Zone

This area is located west of Interstate 5 along High School Road. The High School area is located in an elevated area adjacent to the existing Downtown Zone Reservoir. This reservoir is too low in the system, and as a result it continuously overflows. Although the overflow volume is not measured, it is estimated to be to 700 GPM. For the purposes of a hydraulic evaluation, the overflow can be thought of as a continuous 700 GPM demand adjacent to the High School. Any capacity or fire flow improvements will be of minimum effect until the overflow is stopped. Based on the hydraulic model, replacing the existing reservoir with a reservoir at the higher elevation would eliminate overflow, improve both local pressures and fire flows, and help meet the system's 2015 and future storage requirements.

2) HIGH PRESSURE AREAS

a. Southern Areas in the Downtown Pressure Zone:

The high pressure areas can be found in two areas separated by the Sacramento River. The first is the area west of the river from Katherine Street south along Dunsmuir Avenue. The second is the area east of the river from the Bush Street bridge south along Butterfly Avenue and along S. 1st Street, excluding the Butterfly Hill area. Both of these regions see pressures from 130 to 180 PSI. During low demand periods, such as the winter season, pressures may increase to as high as 200 PSI in lower areas. These pressures are above those typically seen in water systems. In addition, the existing overflow at the Downtown Zone Reservoir helps to limit pressures in the high pressure areas. Once this Downtown Zone Reservoir is replaced with a higher reservoir, pressures will increase in the southern portion of the system. As a result, the proposed high pressure improvements should be constructed in conjunction with the new Downtown Zone Reservoir.

In order to protect the existing infrastructure a new Southern Pressure Zone should be created. The formation of a new zone would require that three PRV stations be constructed. Two PRV stations would create the Southern Zone along the east side of the river. One PRV station would be installed at the Bush Street Bridge and the other at the S. 1st Street bridge. The third PRV would installed at the corner of Dunsmuir Avenue and Katherine Street along the west side of the river.

The increased pressure from the proposed Downtown Zone Reservoir and the proposed Blackberry Hill capacity improvements should negate any pressure losses in the Blackberry Hill Area that would typically be associated with installing a PRV.

FUTURE PRESSURE ZONES

a. Northern Dunsmuir Region above Lookout Pressure Zone:

   Future pressure zones including the Upper Mountain Estates Zone and the three Mott Airport Zones (A, B, and C) will be needed when development occurs in those areas. The water system indicated for the Mott Airport area is based on industrial development at the Airport and the associated 3,500 GPM fire flow. It was also assumed that development south of the Airport would be residential with 1,000 GPM fire flow requirements. The schematic layout of the water system for the Airport assumes that up to three new deep wells may be required to meet the estimated 330 GPM ultimate development maximum day daily demand for Zones A, B and C. It is proposed that all three wells be located in Zone A so they can pump into a new reservoir. Water would be fed from Zone A and into Zone B and C via PRV stations so that only a single reservoir would be required to serve all three zones.

   With these new pressure zones, pressure in the City of Dunsmuir system should generally be in the 40 to 150 PSI range. Only under conditions of very high demand or in a few special cases are pressures found to be outside this range. Refer to Table 2 for a listing of current and future pressure limits.

E. BOOSTER PUMPING FACILITIES

Since the previous 1994 Master Water Plan, the existing Lookout Pressure Zone booster pump station underwent capacity improvements. These improvements appear to be adequate to keep the Lookout Reservoir relatively full during 2015 MDD. Because the Downtown Pressure Zone is fed by the Lookout Zone during periods of high demand, the addition of a new larger Downtown Zone Reservoir would limit the need for increased pumping capacity within the Lookout Pressure Zone.

F. STORAGE RESERVOIRS

The existing Lookout Reservoir is in good condition and has adequate capacity to serve the Lookout Pressure Zone. The addition of a 0.15 MG reservoir will be needed to serve the Upper Mountain Estates area, once developed. As the area north of the existing Lookout Pressure Zone develops, a new 0.8 MG storage will be required. See FUTURE PRESSURE ZONES discussion.

The Downtown Pressure Zone is served by both the Lookout and Downtown Reservoirs. However, the 0.4 MG Downtown Reservoir is below the hydraulic gradeline of the Downtown Pressure Zone. As a result, the Downtown Reservoir continuously overflows and is not utilized until the significant pressure drops are seen in the Downtown Zone. A new 0.9 MG Reservoir should be constructed to replace the 100-year-old existing reservoir. A new Downtown Reservoir would increase pressures and fire flows throughout the Downtown Pressure Zone.

G. DISTRIBUTION SYSTEM

REPLACEMENT OF DETERIORATED STEEL PIPELINES

As discussed previously, the distribution system consists of about 105,000 feet (19.9 miles) of mainline piping from 1-inch to 18-inch diameter pipeline, excluding individual service lines. Approximately 34,000 feet of distribution system with known pipe diameters is over 60 years old. Of these pipes, 16,000 feet of mains with known material and age are 60- to 70-year-old steel pipes which have a theoretical useful life of 55 to 75 years depending upon the type of lining and coating provided. It can be expected that the City will experience increasing frequency of leak repairs in the future, leading to eventual replacement of the pipelines.

Table 1 indicates the estimated replacement cost of the steel water mains, excluding services. Since the service lines are probably also steel of a similar age, one can expect that they will need replacement also. Based on the typical bid prices received on water main replacement projects, one can expect the service line replacement to add another 40 percent to the construction cost on those mains that have services at typical residential lot spacing.

Replacement construction costs will vary depending upon the type of existing roadway surface that will have to be excavated and replaced, the type of soils to be excavated and other site specific conditions. As the old undersized steel supply mains are replaced in the future, it would be desirable to upgrade them with larger PVC mains, where needed, to improve fire flows. It is also recommended that replacement mains be located in public rights-of-way wherever possible to improve access for maintenance.

The City should maintain a log of the date, type, and condition of the pipe for all repairs made to the existing steel mains as well as the remainder of the distribution system so it can be determined which areas are in the worst condition and need to be replaced first. This type of data will also be valuable in applying for possible grant and loan funding. It is also recommended that a corrosion survey be conducted on the 18-inch supply main from Mossbrae Springs to determine its condition and whether addition of a cathodic protection system is warranted to increase its useful life.

H. FIRE HYDRANTS

The location of existing fire hydrants is shown on Plate 2 at the end of this Plan. In general, fire hydrant spacing is good in the City. There are currently about 148 hydrants in the system based on fire department records. The need for new fire hydrants, beyond replacing old and unserviceable hydrants, is not anticipated.

I. FIRE PROTECTION

While the Master Plan evaluation identifies fire flow deficient areas, recommended improvements will not correct all deficient areas. This is primarily due to the limitation in available funding to implement these improvements, and secondarily, the difficultly in spreading costs to the overall user base predicated upon benefit. In addition, due to the variability in required fire flow throughout the City, the distribution system was evaluated against the typical residential fire flow of 1,000 GPM. Figures 1 through 6 show the existing fire hydrants throughout the system and the locations in which fire flows are currently less than 1,000 GPM. Therefore even though these Figures may show fire flows as being adequate, there could be a facility in proximity which requires a higher fire flow than 1,000 GPM.

As part of the Master Plan, PACE and City staff performed a review of field fire flow tests in order to: 1) compare the result of the City fire department's testing efforts; 2) use as a tool for calibrating the City's hydraulic model.

The hydraulic model indicates that both the storage and distribution improvements outlined in the proceeding section will improve system fire flows. However, there are several critical locations that require increased fire flows. These locations include the high school and elementary school. Fire flow improvements are shown on Plate 2. Table 1 includes a summary of the costs associated with these improvements. The fire flow improvements shown on Plate 2 focus on increasing pipe sizes in key locations currently restricting fire flows to critical locations.

J. SUPERVISORY CONTROL AND DATA ACQUISTION (SCADA) SYSTEM

Currently there is limited need for a SCADA system because the City of Dunsmuir maintains a fairly simple gravity-fed system. The Lookout Reservoir and Booster Pump station are the only sites monitored by the City's existing SCADA system. The SCADA system should be expanded to include any new reservoirs that are constructed. In addition, the City may want to consider adding monitoring of flow, pressure and open/close status of its PRV stations in the future.

VI. ESTIMATES OF COST

A. BASIS

Pipeline and other facility costs were determined on the basis of previous projects competitively bid in the northern California area. It should be noted that these estimates are based, in many instances, on extremely preliminary information. For example, at the report stage it is often difficult to determine whether a new main will require pavement replacement or how much utility interference will be encountered. These costs cannot be properly evaluated until final design. Consequently, the estimates in this Plan may vary considerably from the actual cost for a particular project.

For future or delayed work, an allowance for construction cost increases must be considered. Historically, construction costs have increased at an average rate of about 4 percent per year for the last 50 years. However, in the last 4 to 5 years, construction costs have been relatively stagnant due to current economic conditions. Therefore, it is recommended that the City inflate the cost estimates in this Plan annually based on the Engineering News Record Construction Cost Index, which is continuously updated to reflect current economic trends.

In order to obtain total project costs, construction contingencies and indirect costs were added to the construction costs. Construction contingencies are usually assumed to be 10 percent of the construction costs. Indirect costs include engineering, administration, and legal costs. All of these combined usually amount to about 20 percent. The total of the above was taken at 30 percent. This figure may vary considerably depending on the complexity of the work. Where bonding or other loans are involved, costs for interest during construction and other finance costs (such as bond discounts, legal and bond counsel fees, and reserve funds) should be added in the preparation of the financial plan.

B. IMPROVEMENT COSTS

The project cost for each of the proposed improvements are shown in Table 1 and Table 13 through Table 16 at the end of the text. The improvements are listed in categories of Current, Immediate, Near-Term, and potential Long-Term Improvements.

Current Improvements consist of the sections of water main replacement that will be constructed in 2015. These improvements replace deteriorating pipes and increase hydraulic capacity.

The Immediate Improvements address the major problem associated with the ineffectiveness of the existing Downtown Zone Reservoir. A new Downtown Zone Reservoir will provide adequate storage at the proper elevation so that equalizing storage from the reservoir can be used to satisfy the difference between the maximum hourly demand and the maximum daily demand. A new reservoir will also greatly increase the system reliability and fire flow capabilities in the Downtown Zone. In addition, the creation of the new Southern Zone will solve the existing high pressure problems in the southern portion of the existing Downtown Zone. Development of a new Southern Zone will be required, not only to address existing high pressures, but also to moderate increased pressures resulting from the new higher Downtown Zone Reservoir elevation. The list of Immediate Improvements will require substantial engineering and construction costs, but should be completed as soon as possible.

Near-Term Improvements address the aging infrastructure that is beyond its useful life. Currently, City staff spends significant amounts of time repairing leaks. Often times, these leaks are found adjacent to previous repairs and require custom-made repair clamps. Given the large amount of leaks found and repaired by City staff, not all leaking lines can be included in the Near-Term Improvements. A review of areas requiring recurring repairs was made with the help of City staff. The staff helped to identify areas that merited inclusion in the list of Immediate Improvements.

Potential Near-Term Improvements include the eventual replacement of the old steel mains and services as they continue to deteriorate. It is not possible to evaluate the condition of each section of the water system at this time without performing extensive field testing. The longevity of the steel piping is controlled by factors such as the type and thickness of the steel piping installed, the type of coating, the corrosiveness of the soil and normal operating pressure.

Considering the magnitude of the potential replacement costs addressed in both the Immediate and Near-Term Improvements, the City has contracted with PACE

Engineering, Inc. to develop a Rate Study that should be finished shortly after the release of this Master Water Plan. This Rate Study will address the financial consideration and the cost to customers to replace the majority of the old steel line in the next 20 to 30 years.

Preliminary cost estimates are included for an initial phase of a water system at Mott Airport so the City will have an "order of magnitude" estimate of the cost of those possible future improvements.

Table 13 through Table 16 describe the general improvements shown on Plate 2 at the end of this Plan, except for some where it has been recommended that replacement mains be upgraded in size to meet the ultimate demands. The total estimated project cost (excluding financing costs) of the Current and Immediate Improvements are $1,221,000 and $9,404,000, respectively, while the total estimated project cost of the Near-Term Improvements is $5,539,000. The City has received funding through the U.S. Department of Housing and Urban Development's Community Development Block Grant (CDBG) Program to finance the Current Improvements. It is anticipated that financing of the Immediate and Near-Term Improvements will be obtained through loans and/or grants provided by either U.S. Department of Agriculture's Rural Development (RD), California Department of Public Health's Safe Drinking Water State Revolving Fund (SDWSRF) or Integrated Regional Water Management (IRWM) Grant Program. It is suggested that the City continue to explore the possibility of a combination grant and low interest loan from other Federal and State agencies for financing the Immediate and Near-Term Improvements.

COST ESTIMATES

Table 13: Cost Estimates – Current Improvement Projects

Description	Ident. Points	Estimated Project Cost (Aug 2015 Dollars)	Comments
CURRENT IMPROVEMENTS (2015) - FUNDED BY CURRENT CDBG GRANT			
Scherrer Ave. Water Main Replacement	8 - 12	$228,000	The current Scherrer Ave. main is aged and undersized resulting in poor flows along Scherrer Ave. and downstream down S. 1st St. to the Wastewater Treatment Plant. This project replaces the existing 4" and 8" main, improving flows throughout the southern portion of the City.
Upper Blackberry Hill Water Main Replacements	4 - 9	$559,000	The existing Blackberry Hill Areas main's size range from 3/4" to 2". These mains are undersized and beyond their serviceable life. This project replaces the existing mains with 6" to 8" mains, which will increase the system's capacity in the area.
Willow St. Water Main Replacement	22 - 23	$151,000	The Willow St. main (circa 1941) has met its serviceable life. This undersized main is prone to leaks and poses a significant risk to the community if it were to have a break. Its current location, on the hillside, makes access and maintenance difficult. This project replaces the existing line with a larger line within the roadway.
Bush St. Water Main Replacement	17	$125,000	This project replaces the Bush St. main which has been one of the most problematic mains within the City's water system (I.e., frequent leaks and significant man hours).
Butterfly Ave. Water Main Replacement	14 - 17	$129,000	The Butterfly Ave. water main is undersized and has exceeded its serviceable life. This project will replace the existing 4" main (circa 1926) with an 8" main, greatly improving flows along Butterfly Ave.
Oak St. Water Main Replacement	16	$29,000	The Oak St. water main between Shasta Ave. and Dunsmuir Ave. is undersized resulting in poor flows in the area. This project will replace the existing 4" water main with an 8" water main, greatly improving flows in the area.
	Total Project Cost:	**$1,221,000**	

Table 14: Cost Estimates – Immediate Improvement Projects

Rank	Description	Ident. Points	Estimated Project Cost (Aug 2015 Dollars)	Comments
IMMEDIATE IMPROVEMENTS (2016) - EXPECTED TO BE FUNDED WITH PROP. 84 GRANT THROUGH IRWM				
1 - S. Dunsmuir Water Main Replacements				
	Lower Blackberry Hill	5 - 8	$520,000	Replace leaking and undersized mains along S. 2nd Street (between Bridge St. and Marion St.), Marion St., 3rd St., and Welsh St. This project will replace the existing 2" water mains with 6" water mains providing increased capacity to meet demand and provide improved fire suppression in the area with new fire hydrants. Also funds remainder of CDBG - funded project.
2 - N. Dunsmuir Water Main Replacements				
	N. Dunsmuir Ave. & Prospect Ave.	36 - 40	$730,000	Replace the leaking mains along Prospect Ave. and Dunsmuir Ave., both of which have exceeded their serviceable life. Relocates Dunsmuir Ave. mains into the right-of-way from under homes and businesses along the west side of Dunsmuir Ave.
IMMEDIATE IMPROVEMENTS (2016) - TO BE FUNDED BY OTHER FUNDING SOURCES				
3 - 0.9 MG Downtown Tank Replacement				
	0.9 MG Tank and Pressure Reducing Stations	7, 12, 17 & 22-24	$3,204,000	The existing 0.4 MG Downtown Tank is too low to be utilized without significant pressure losses in the Downtown Pressure Zone. Replacing the Downtown Tank (circa 1905), with a new 0.9 MG Tank at a higher elevation will provide the City with the water storage it needs at a higher elevation. This will improve pressures and allow the Tank to be utilized as equalization storage during high demand periods and fire storage during emergency events.
4 - Scenic Ave. & Needham Ave. Water Main Replacement				
	10" PVC Main w/ Class "A1" Backfill	37 - 40	$530,000	Replace the leaking mains along Scenic Ave. and Needham Ave., both of which have exceeded their serviceable life.
5 - Dunsmuir Elementary School Water Improvements				
	8" PVC Main w/ Class "A1" Backfill & PRV Station	32 - 35	$460,000	This project will extend the Siskiyou Ave (ending at Forest Ln.) main south through the Dunsmuir Elementary School and connect to the existing main serving the school. Installing a Pressure Reducing Station will move the School into the higher Lookout Pressure Zone, improving the area's fire flow.
6 - River Avenue Water Main Replacement				
	8" PVC Main w/ Class "A1" Backfill	25 - 28	$490,000	River Ave. residents have experienced poor flow due to the aged existing undersized 4" and 2" mains. This project will replace the existing main with an 8" main, improving capacity and fire suppression in the area.
7 - Vista Street Water Main Replacement Project				
	6" PVC Main w/ Class "A1" Backfill	20	$130,000	The current Vista St. main is undersized resulting in poor flow and decreased pressures. Replacing the main with a larger pipeline will alleviate the problem.

Rank	Description	Ident. Points	Estimated Project Cost (Aug 2015 Dollars)	Comments
8 - Butterfly Avenue to Gills St Water Main Replacement				
	8" PVC Main w/ Class "A1" Backfill	10 - 14	$390,000	The Butterfly Ave. to Gills St. water main is undersized and has exceeded its serviceable life. This project will replace the existing 4" main (circa 1927) with an 8" main, improving capacity in the southern portion of the City.
9 - Shasta Retreat Water Improvement Project				
	8" PVC Main w/ Class "A1" Backfill	34 - 38	$580,000	The Shasta Retreat Area has been plagued with low pressure problems and old, leaky mains. This project will replace the current 6" fire main, and 4" domestic main with one 8" water main to boost flows in the area and eliminate the leaky mains.
10 - Dunsmuir High School Water Improvement Project				
	6" PVC Main w/ Class "A5" Backfill	18 - 22	$207,000	The High School has experienced poor pressures and poor flows due to not only its elevation but also the existing mains serving the school. This project will replace the existing water main from Willow Street, greatly improving flows to the school; however, the poor pressure problem will continue to persist until the Downtown Tank can be replaced to a higher elevation.
11 - Wood Street Water Main Replacement Project				
	6" PVC Main w/ Class "A1" Backfill	11	$135,000	The current Wood St. main is undersized resulting in poor flow and decreased pressures. Replacing this main with a larger pipeline will alleviate the problem.
12 - S. Sacramento Avenue Water Main Replacement				
	8" PVC Main w/ Class "A5" Backfill	15 - 17	$255,000	The current S. Sacramento Ave. water main from Bush St. to Branstetter is an aged undersized 4" main which restricts flow along Sacramento Ave. as well as flow crossing the Bush St. Bridge and flow going down Scherrer Ave. to cross the Bridge St. Bridge. To improve flow along Sacramento Ave. and the parts of the City east of the Sacramento River, the project would replace the 4" main with an 8" main.
13 - S. Dunsmuir Avenue & Woodward Lane Water Improvement Project				
	10" PVC Main w/ Class "A5" Backfill & 8" PVC Main w/ Class "C" Backfill	1 - 3	$520,000	S. Dunsmuir Ave. experiences poor flow due to the existing undersized 4" main serving the area. This project will extend the 8" water line along Francis St. southward to Dunsmuir Ave., looping the system in the area, and replacing the existing 4" main in S. Dunsmuir Ave. with a 10" main, improving capacity in the area.
14 - S. 1st Street Water Improvement Project				
	8" PVC Main w/ Class "A5" Backfill	2 - 8	$590,000	Southeast Dunsmuir's distribution system is undersized and lacks looping. Residents experience decreased pressures during peak demands and during fire events. This project replaces the existing 6" and 2" mains between Bridge St. and Welsh Ln, with an 8" main that will extend south and tie into the system at the intersection of S. 1st St. and S. 2nd St. looping the system and improving capacity in the area.

Rank	Description	Ident. Points	Estimated Project Cost (Aug 2015 Dollars)	Comments
15 - North Sacramento Ave R.R Crossing Water Main Replacement				
	8" PVC Main w/ Class "A1" Backfill	28	$255,000	The main along the north end of Sacramento Ave at the railroad crossing is prone to breaks and is a maintenance problem for City staff as it crosses under the Union Pacific right-of-way. This project will replace the pipeline, eliminating both the leaks and the man hours required to fix this problematic main.
16 - Downtown Water Improvement Project				
	8" PVC Main w/ Class "A1" Backfill	15 - 16	$408,000	The downtown water mains starting on Dunsmuir Ave. just north of Oak St. going south to Branstetter St, then east to Sacramento, and finally south again to Scherrer are undersized and act as a bottleneck for water flowing to the south of town. To eliminate this bottleneck and improve flow in the area and south of town, this project would replace the existing aged 6" and 4" water mains with 8" mains.
		Total:	**$9,404,000**	

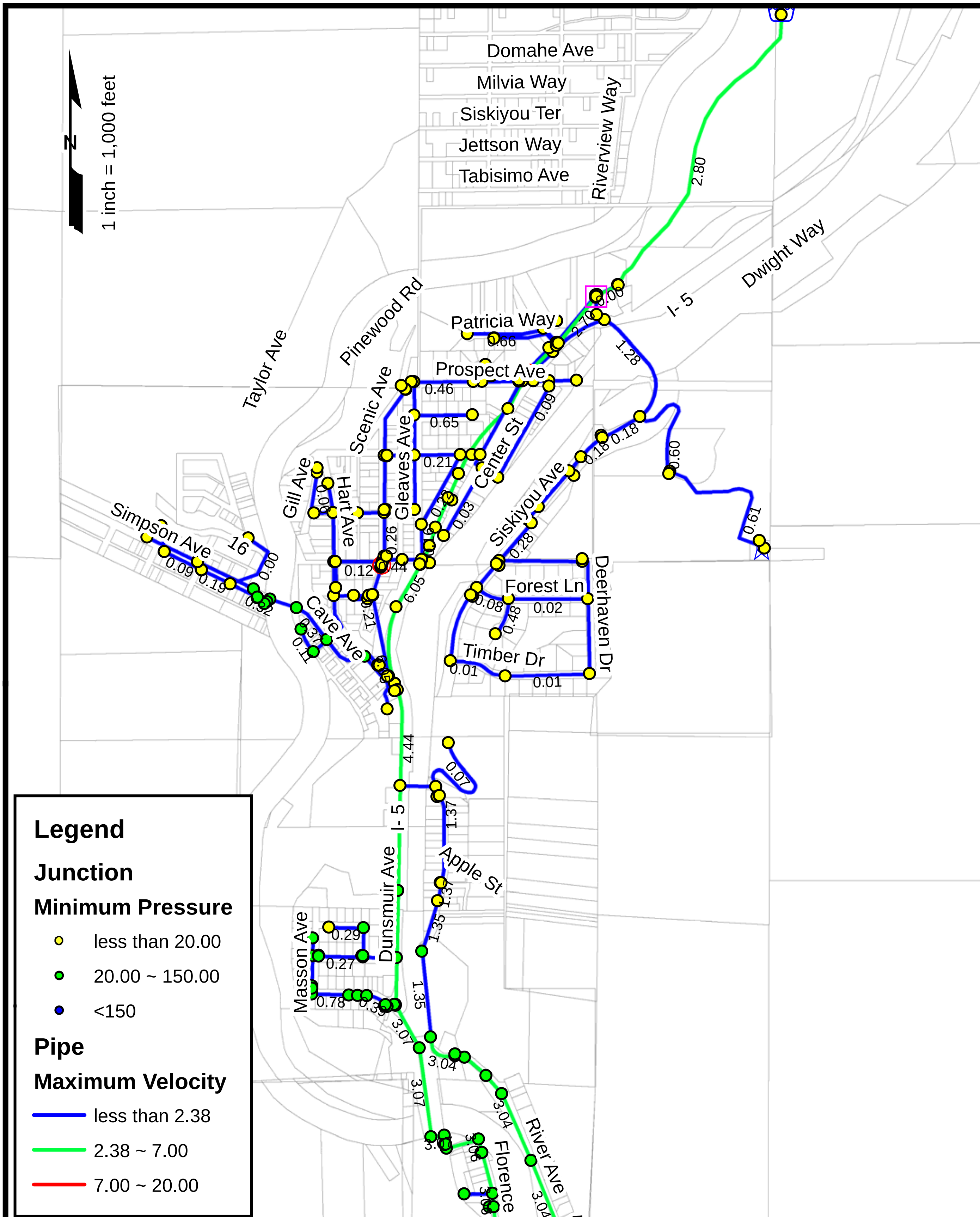
Table 15: Cost Estimates – Near-Term Improvement Projects

Description	Ident. Points	Estimated Project Cost (Aug 2015 Dollars)	Comments
Near-Term Improvements (2017 - 2022)			
Katherine & Francis Street			
8" PVC Main w/ Class "A1" Backfill	6 - 7	$225,000	
Hill Street			
6" PVC Main w/ Class "A1" Backfill	11	$128,000	
Rose & Scherrer Avenue			
6" PVC Main w/ Class "A1" Backfill	13	$159,000	
Cedar Street			
6" PVC Main w/ Class "A1" Backfill	19	$143,000	
Pine Street			
8" PVC Main w/ Class "A1" Backfill	21	$149,000	
Sacramento Street			
6" PVC Main w/ Class "A1" Backfill	17 - 26	$602,000	
Ash Street			
6" PVC Main w/ Class "A1" Backfill	26	$128,000	
Dunsmuir Avenue & Florence Loop			
14" PVC Main w/ Class "A1" Backfill	27 - 29	$629,000	
Dunsmuir Avenue (Caltrans Right-of-Way)			
14" PVC Main w/ Class "A5" Backfill & Bridge Crossing	29 - 30	$870,000	
Upper Soda Road			
8" PVC Main w/ Class "A1" Backfill	28	$106,000	
Stage Coach Road			
6" PVC Main w/ Class "A1" Backfill	30	$176,000	
Buckboard Lane & McCloud Avenue Road			
6" PVC Main w/ Class "A1" Backfill	31	$152,000	
Dunsmuir Avenue - Part 1			
14" PVC Main w/ Class "A1" Backfill	30 - 33	$780,000	
Dunsmuir Avenue - Part 2			
14" PVC Main w/ Class "A1" Backfill	33 - 36	$430,000	
Shasta View Avenue & Scarlet Way			
10" PVC Main w/ Class "A1" Backfill	33 - 37	$372,000	
Shasta Avenue			
6" PVC Main w/ Class "A1" Backfill	39 - 41	$221,000	
Patricia Way & Linda Place			
6" PVC Main w/ Class "A1" Backfill	41 - 42 - 44	$269,000	
	Total:	**$5,539,000**	

Table 16: Cost Estimates – As-Developed Improvement Projects

Description	Ident. Points	Estimated Project Cost (Aug 2015 Dollars)	Comments
As-Developed			
Zone A: Reservoir			
0.8 MG Reservoir	51	$2,454,000	
Zone A: Wells			
3 Wells	49, 50 & 52	$1,597,000	
Zone A: Pipeline Improvements			
10" and 8" PVC Main w/ Class "A1" Backfill	48 - 52	$1,673,000	
Zone B: Pipeline amd PRV Improvements			
8" PVC Main w/ Class "A1" Backfill and PRV Station	47 - 48	$814,000	
Zone C: Pipeline amd PRV Improvements			
8" PVC Main w/ Class "A1" Backfill and PRV Station	46 - 47	$1,475,000	
	Total:	**$8,013,000**	

Figures



PACE ENGINEERING
REDDING, CALIFORNIA

CITY OF DUNSMUIR

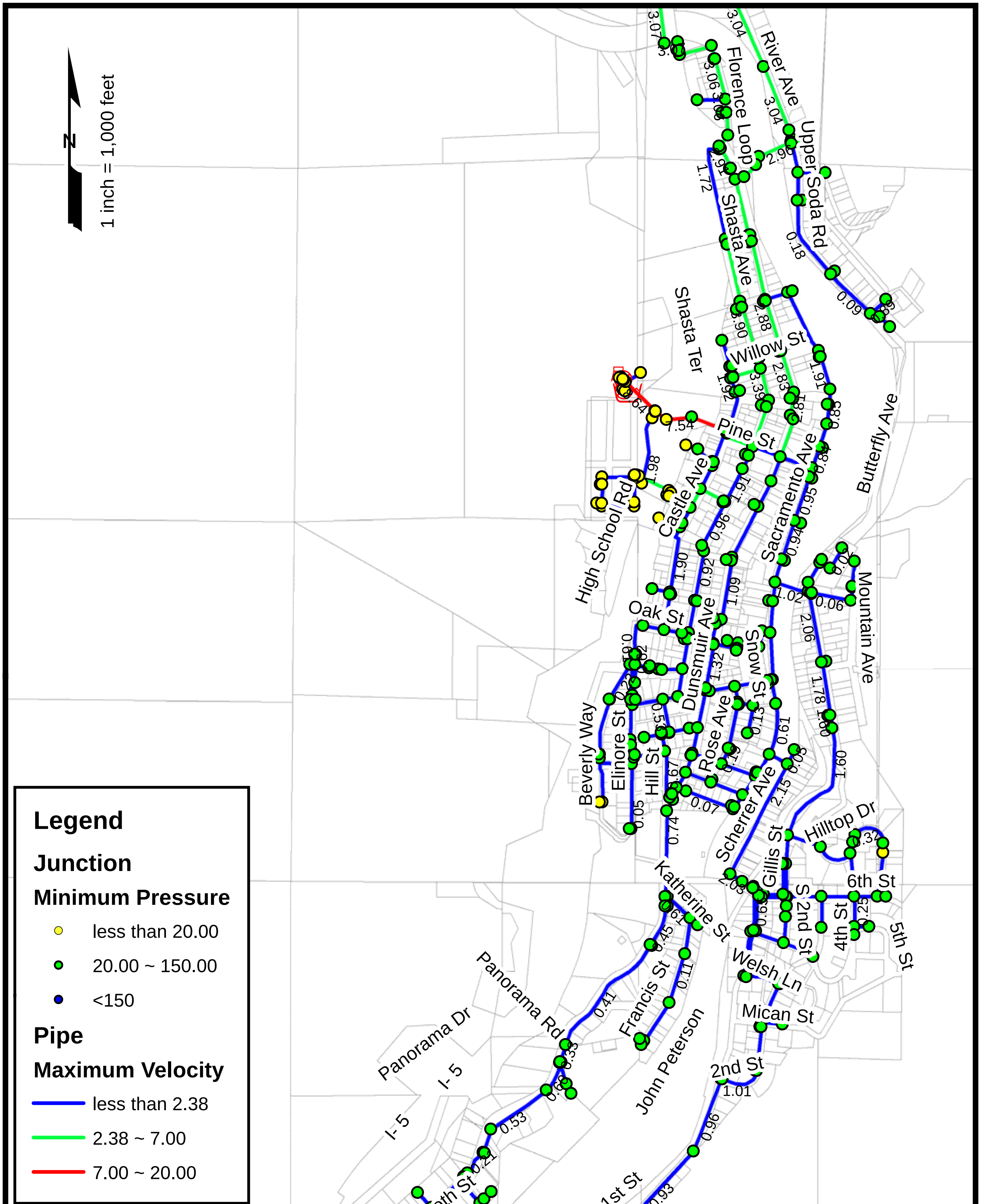
2015 MASTER WATER PLAN

2015 MODEL RESULTS

FIGURE 1

DATE 7/15

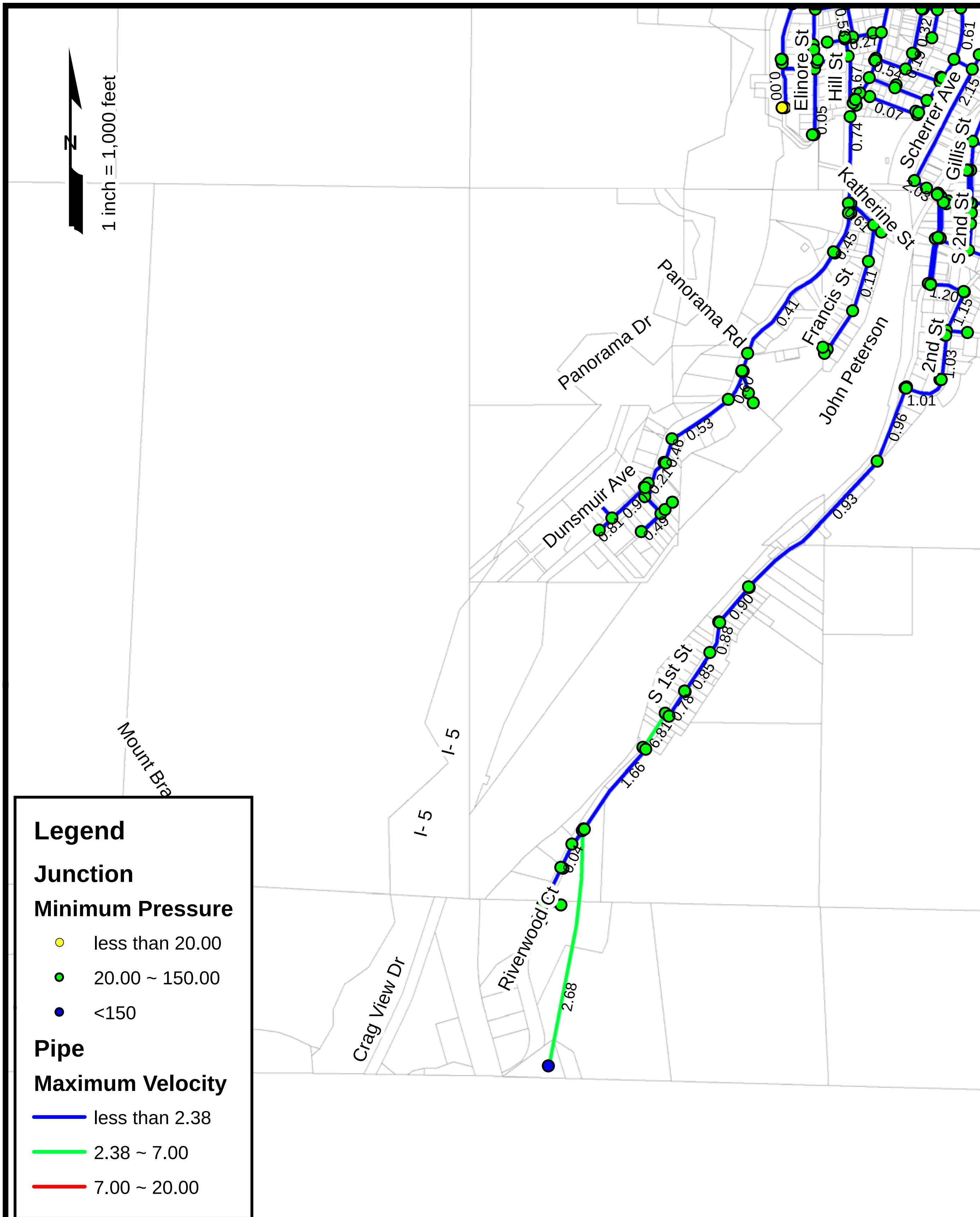
JOB# 204.52



PACE ENGINEERING
REDDING, CALIFORNIA

CITY OF DUNSMUIR
2015 MASTER WATER PLAN
2015 MODEL RESULTS

FIGURE 2
DATE 7/15
JOB# 204.52



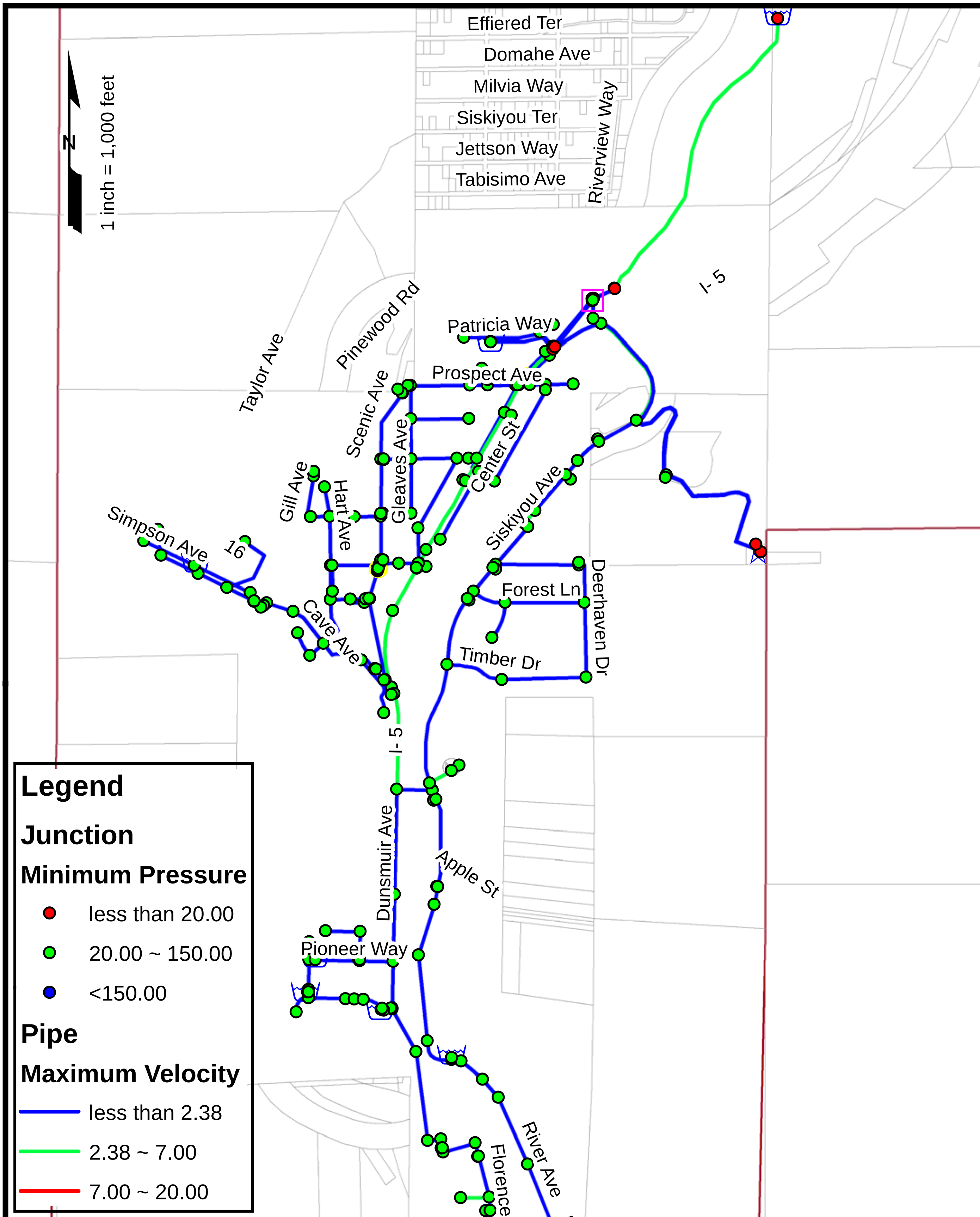
PACE ENGINEERING
REDDING, CALIFORNIA

CITY OF DUNSMUIR
2015 MASTER WATER PLAN
2015 MODEL RESULTS

FIGURE 3

DATE 7/15

JOB# 204.52



PACE ENGINEERING
REDDING, CALIFORNIA

CITY OF DUNSMUIR

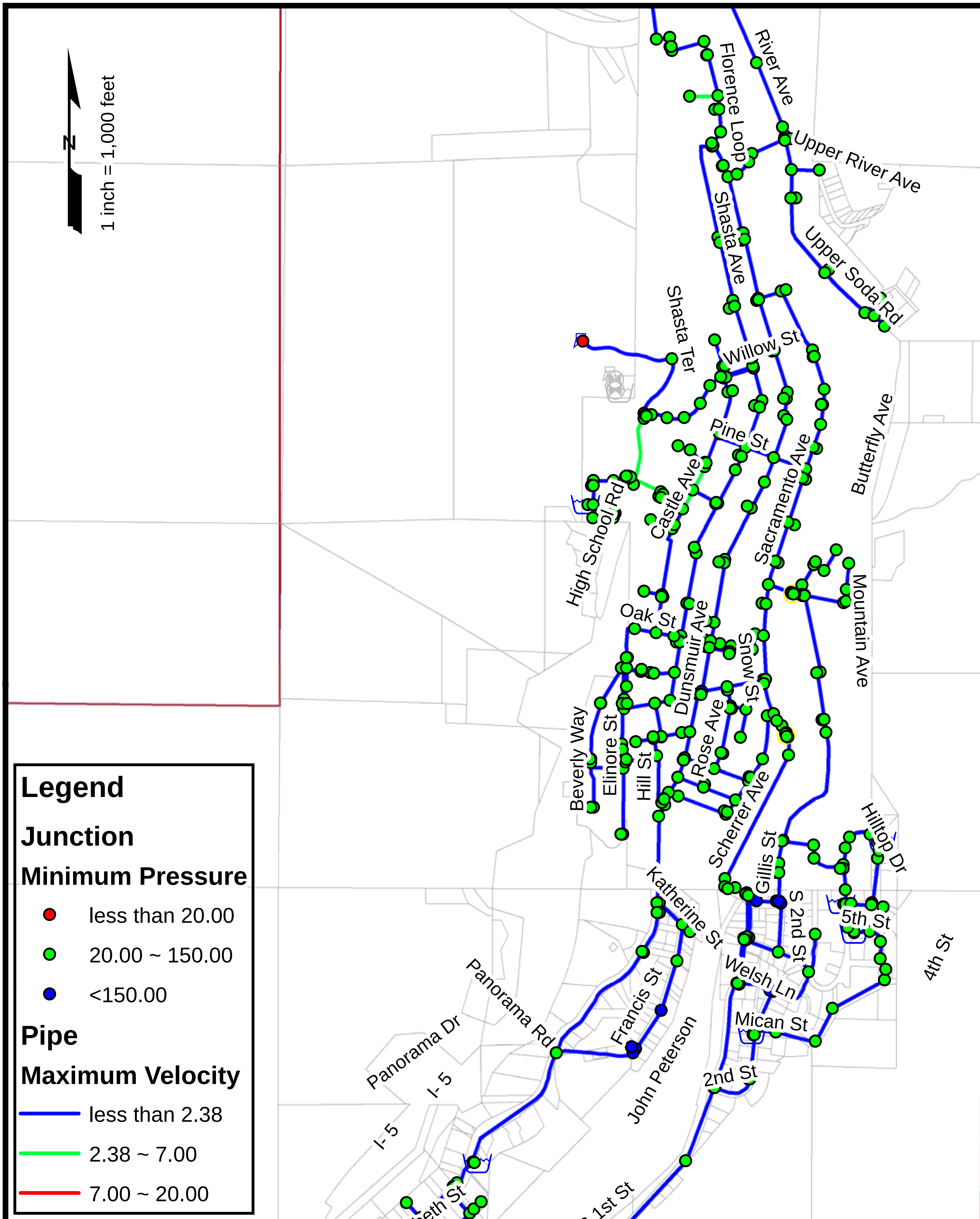
2015 MASTER WATER PLAN

ULTIMATE MODEL RESULTS

FIGURE 4

DATE 7/15

JOB# 204.52



PACE ENGINEERING
REDDING, CALIFORNIA

CITY OF DUNSMUIR

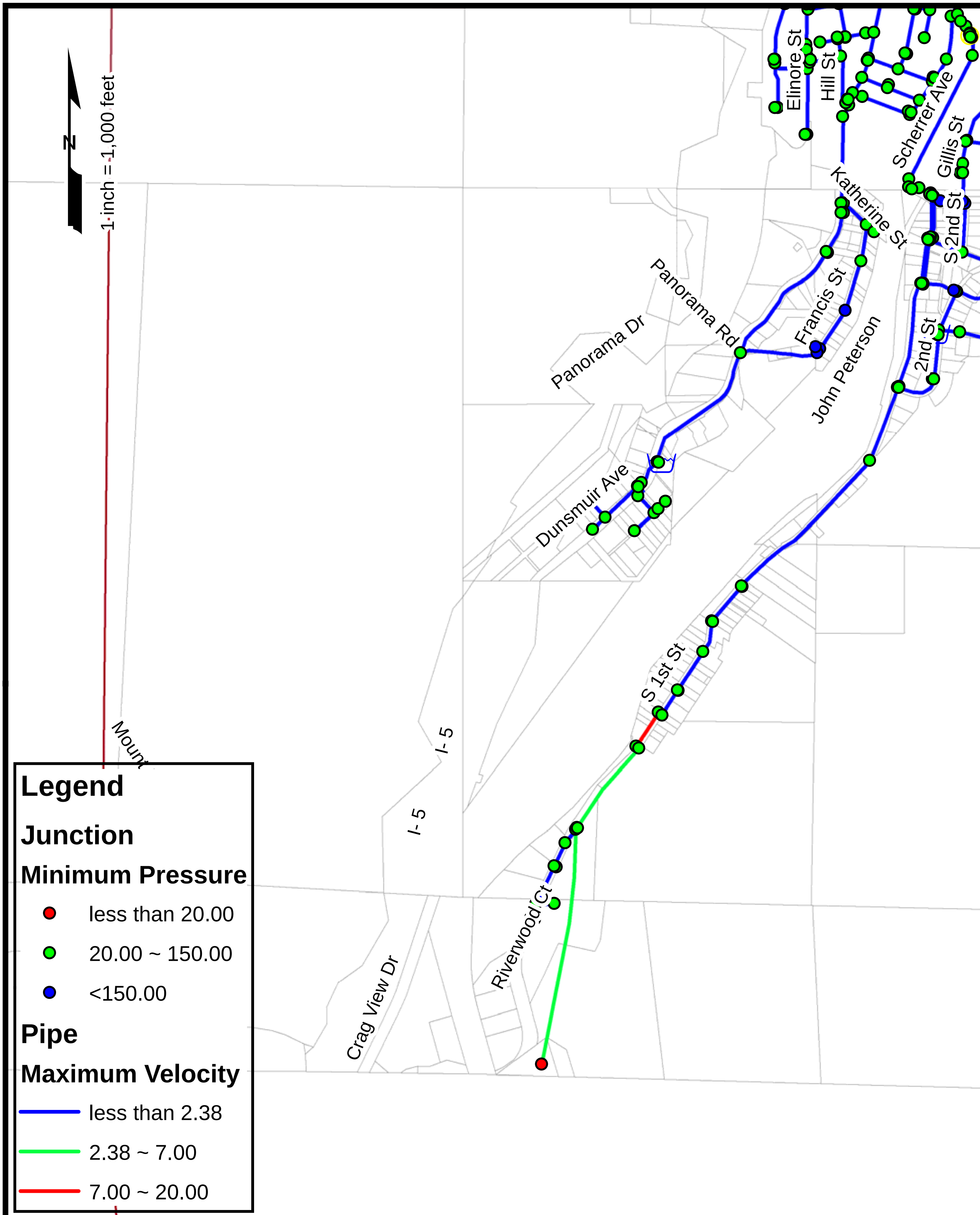
2015 MASTER WATER PLAN

ULTIMATE MODEL RESULTS

FIGURE 5

DATE 7/15

JOB# 204.52



PACE ENGINEERING
REDDING, CALIFORNIA

CITY OF DUNSMUIR

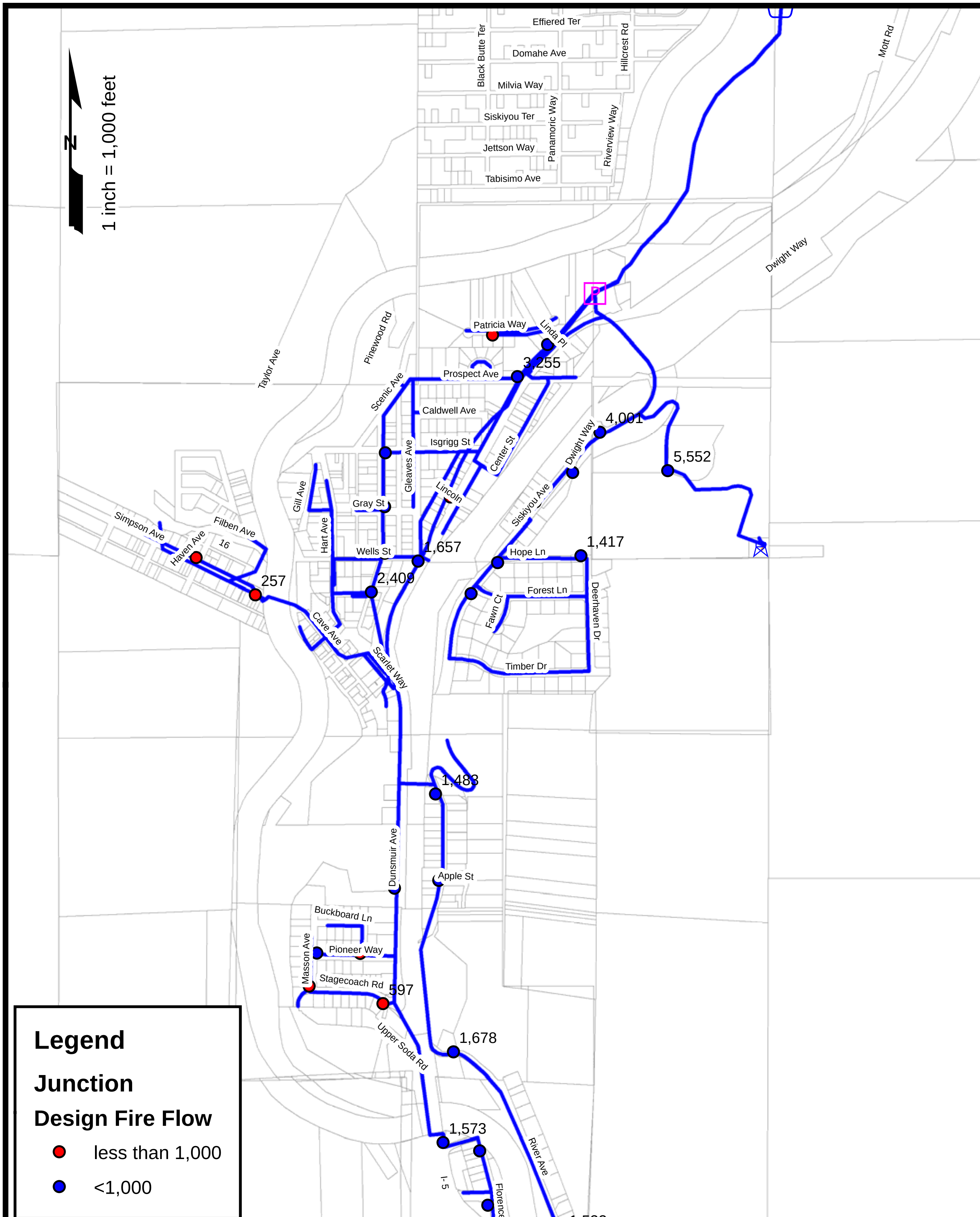
2015 MASTER WATER PLAN

ULTIMATE MODEL RESULTS

FIGURE 6

DATE 7/15

JOB# 204.52



PACE ENGINEERING
REDDING, CALIFORNIA

CITY OF DUNSMUIR

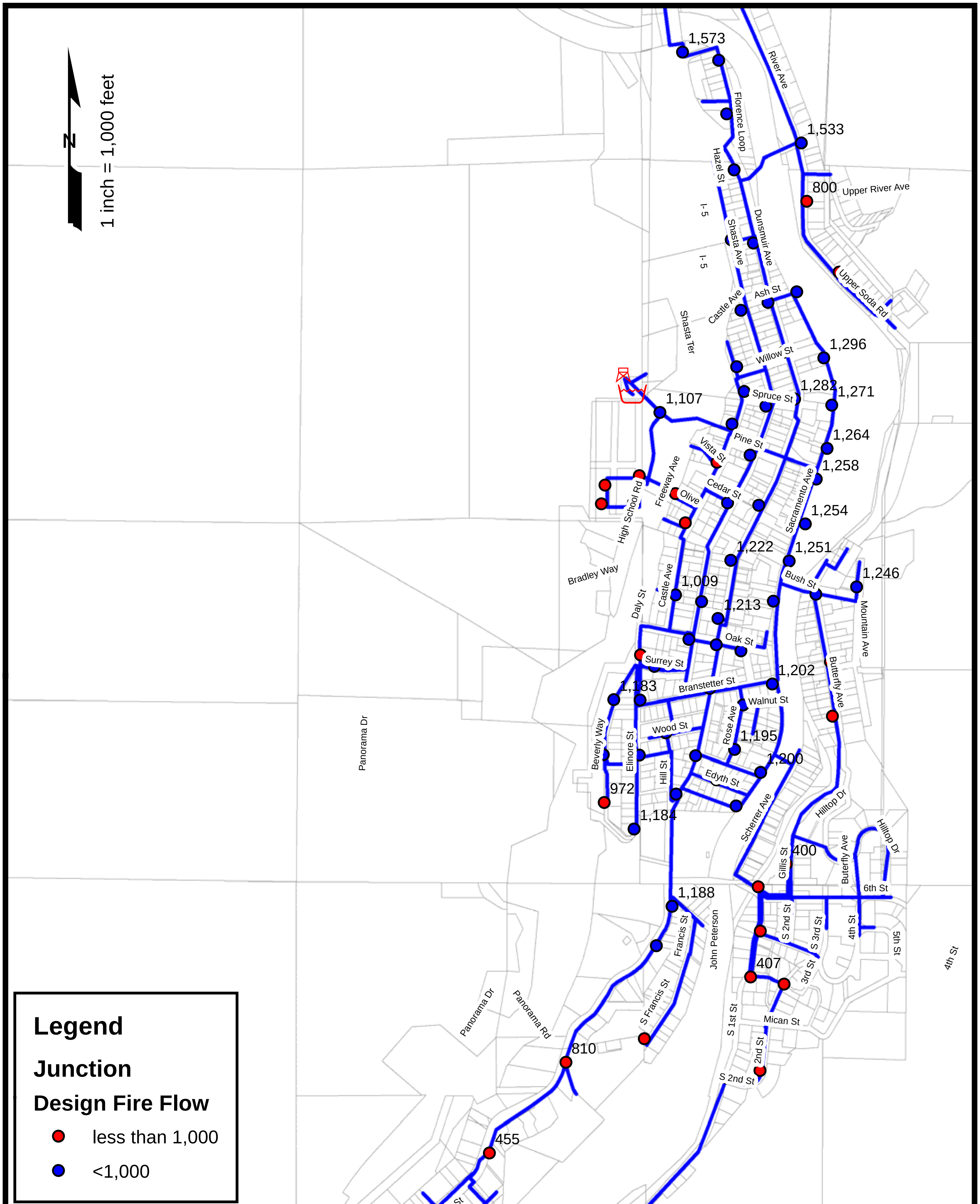
2015 MASTER WATER PLAN

2015 MODEL FIRE FLOW RESULTS

FIGURE 7

DATE 7/15

JOB# 204.52



CITY OF DUNSMUIR

2015 MASTER WATER PLAN

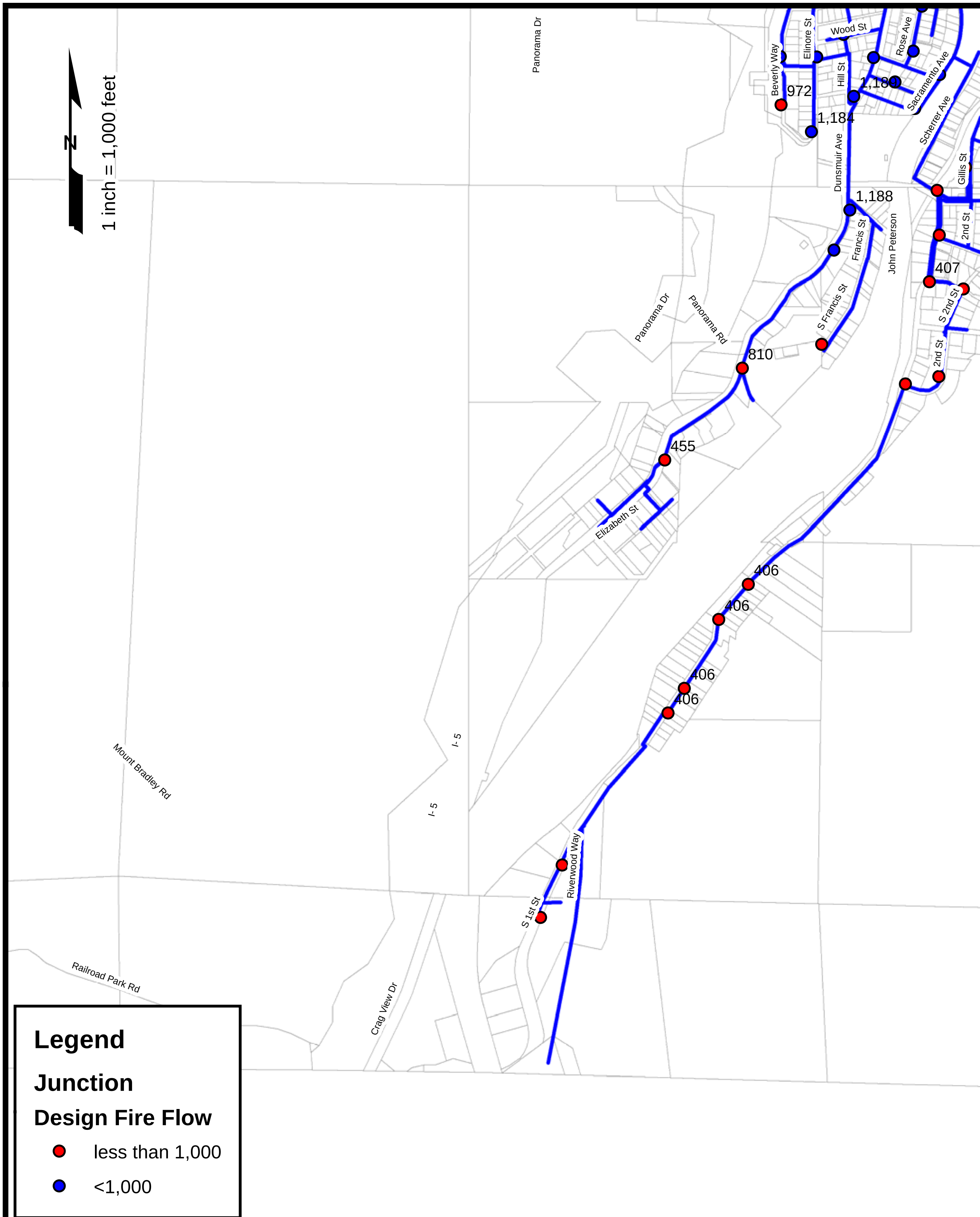
2015 MODEL FIRE FLOW RESULTS

FIGURE 8

DATE 7/15

JOB# 204.52

PACE ENGINEERING
REDDING, CALIFORNIA



PACE ENGINEERING
REDDING, CALIFORNIA

CITY OF DUNSMUIR

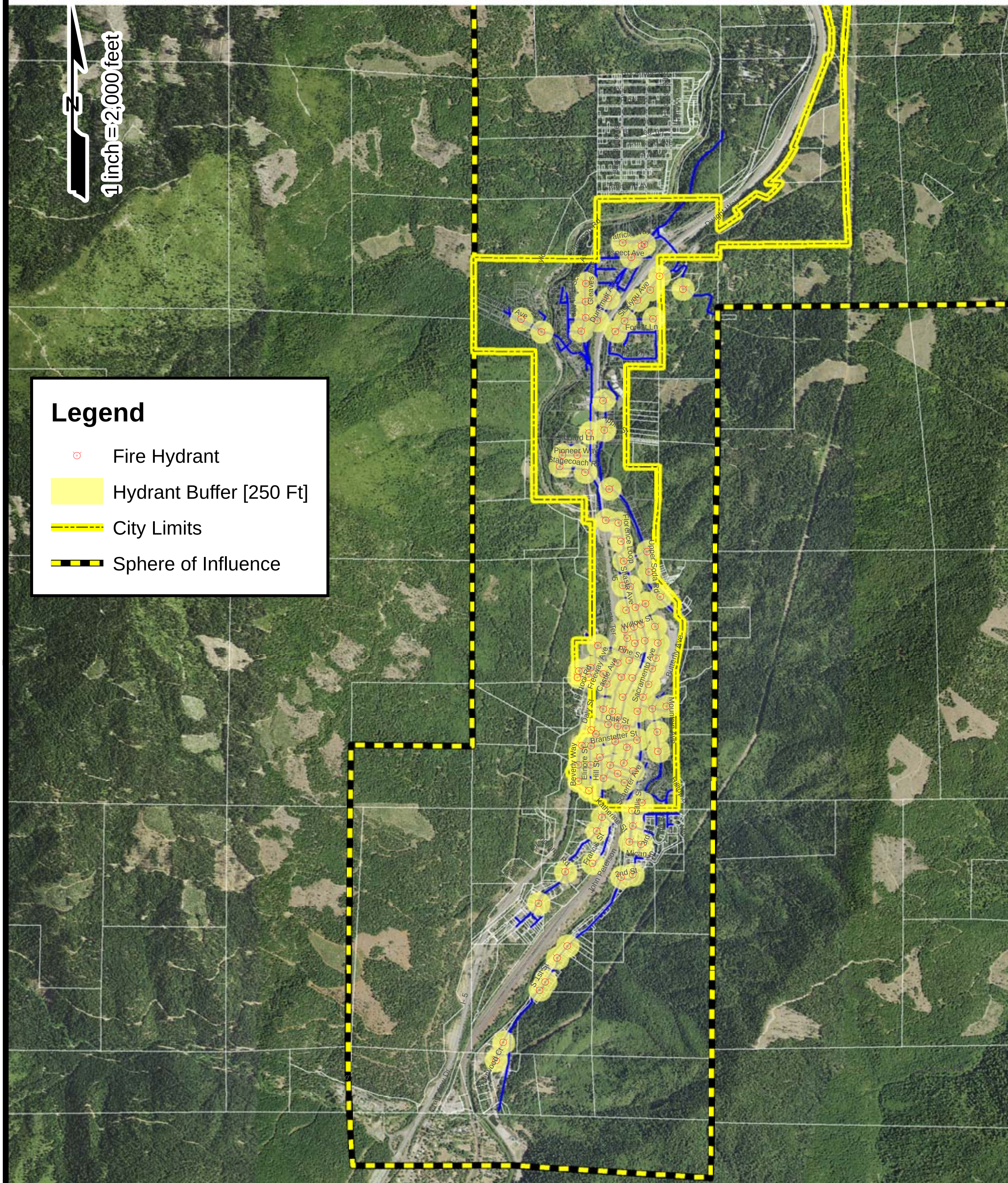
2015 MASTER WATER PLAN

2015 MODEL FIRE FLOW RESULTS

FIGURE 9

DATE 7/15

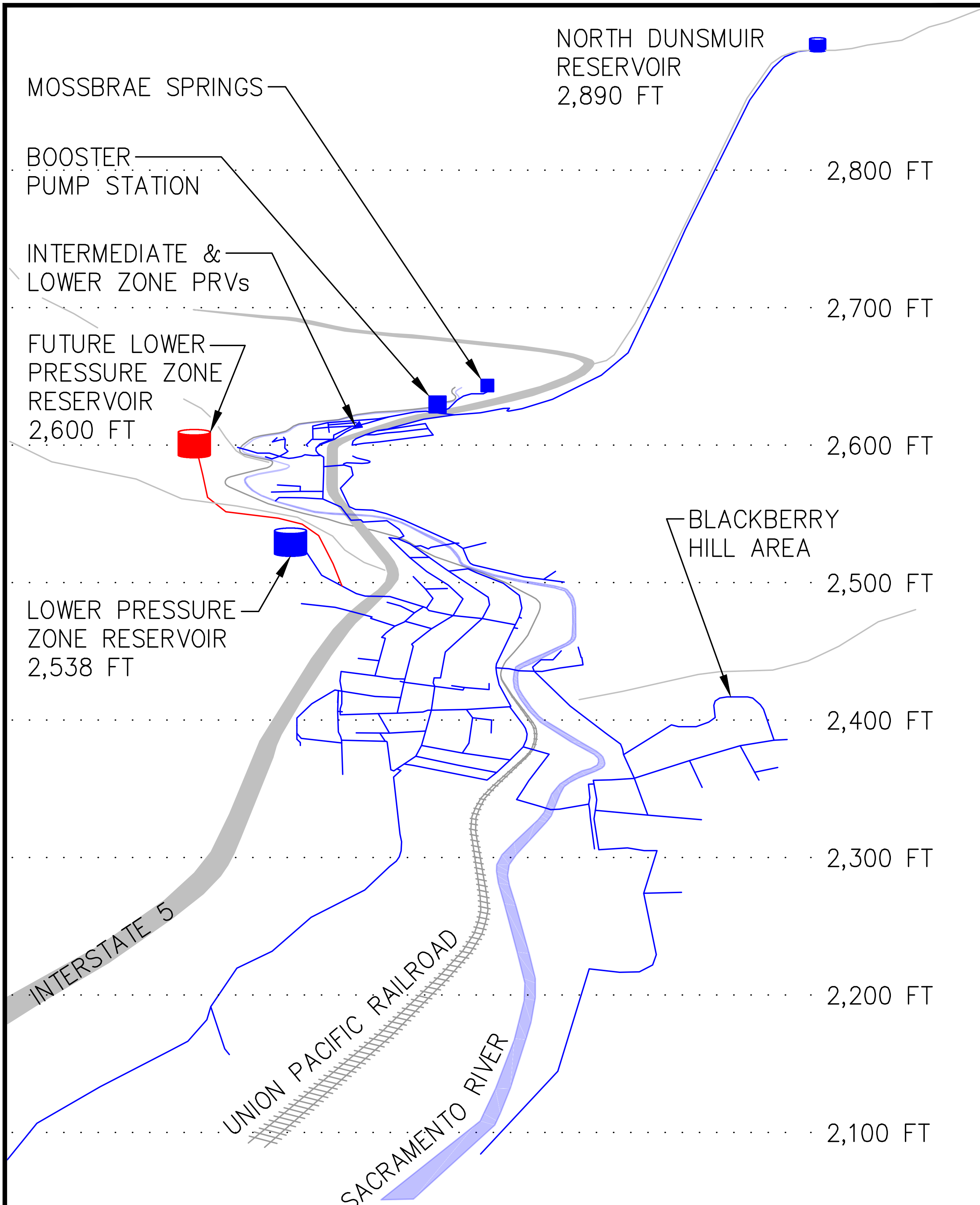
JOB# 204.52



PACE ENGINEERING
REDDING, CALIFORNIA

CITY OF DUNSMUIR
2015 MASTER WATER PLAN
FIRE HYDRANT SPACING

FIGURE 10
DATE 7/15
JOB# 204.52



DATE	PACE ENGINEERING REDDING, CALIFORNIA	CITY OF DUNSMUIR 2015 MASTER WATER PLAN WATER SYSTEM SCHEMATIC	FIGURE 11
7/15			JOB #204.52

Plot Date: July 21, 2015 – 6:35 am Login Name: gmaxwell
File Name: M:\Land Projects\0204.52 CDBG PTA Water Master Plan and Rate Study\DWG\Water System Schematic.dwg, Layout: FIG

APPENDIX A

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C94.02.02

HYDROGEOLOGIC CONDITIONS VICINITY TOWN OF DUNSMUIR AND POTENTIAL FOR WELL DEVELOPMENT

February 17, 1994

Prepared for
PACE Engineering
1730 South Street
Redding, CA 96001

Table of Contents

Text **Page**

Introduction

PACE Engineering is performing a master water plan for the City of Dunsmuir. This report has been prepared at their request to evaluate the potential for developing a 100-gpm, or greater, well in the vicinity northeast of town.

Findings

It appears there is potential for developing a 100-gpm, or greater, well on the basis of information determined for saturated interval and formation permeability, within the reach between the area to the northeast of the Saint Germain Foundation and Mott Field, and to the northeast of the Sacramento River drainage.

To achieve the above, wells would have to be drilled to a depth of approximately 500 feet, or to the top of the nonwater-bearing rocks, whichever comes first. The depth is predicated on a maximum depth to water of about 200 feet, and an estimated saturated interval within the water-bearing volcanics of abut 300 feet. If this depth of saturated volcanics can be realized, a minimum formation permeability of 40 gpd/ft2 must also occur to provide a yield of 100 gpm with not more than 30 feet of drawdown.

If the formation permeability is greater than 40 gpd/ft2, the saturated interval can be less than 300 feet and/or the yield of the well can be increased.

That the above is possible, is indicated by two drillers logs reporting yields of 100 and 236 gpm in Section 35 T40N/R4W, and Section 12 T39N/4W, respectively.

Geology

Geologic conditions of importance related to the occurrence of ground water consist of the depth and areal extent of water-bearing deposits. Figure 1 shows the outcrop pattern of these rocks in the vicinity of Dunsmuir.

The water-bearing deposits consist of Recent alluvium, Pleistocene ("younger") volcanics, and Tertiary ("older") volcanics. The two volcanic series are the principal aquifer units in the area.

The nonwater-bearing rocks outcropping adjacent to the alluvium and volcanics consist of Mesozoic metavolcanics, intrusives, and granitic rocks. Although classified as "nonwater-bearing," these rocks provide water to domestic wells in limited quantities.

The estimated depth of the water-bearing volcanic rocks is shown on Figures 2 and 3, which are sections drawn in the vicinity of Mott Field and Mossbrae Falls, respectively. Control for determining depth is based on the outcrop elevation of the Mesozoic rocks in the Sacramento River drainage. These rocks outcrop in the drainage above and below Shasta Springs, as shown on Figure 1.

The slope of the nonwater-bearing rocks to the east and north of the Sacramento River drainage is inferred from the slope of the ground surface. Also, none of the wells surveyed indicated metamorphic-type rock within the section drilled. This includes one well drilled to 347 feet located within Section 34, T40N, R4W.

Hydrology

Water table

The thickness of the saturated interval and the permeability of the rocks within this interval determines the potential for well yield. The saturated interval is the section below the water table within the water-bearing rocks, as shown on Figures 2 and 3 for the areas within the Dunsmuir City limit.

The water table, as shown on Figure 1, represents water levels measured in wells over the last several years, but mostly in 1991. Because the ground-water basin is more-or-less full, these levels should represent "steady-state" conditions, and be fairly representative of water levels occurring today.

The water levels are based on measurements in wells reported on drillers logs and measured by Lawrence & Associates. The latter wells include two wells operated by Saint Germain Foundation, two wells located near Mott Field, and an observation well located in Section 26, T40N/R4W, which is not shown on Figure 1. Additional control comes from the occurrence of springs and the Mossbrae Falls located along the Sacramento River drainage.

The bulk of the seepage in the vicinity of the Mossbrae Falls occurs at the interface between the younger and older alluvium, as shown on Figure 1. This seepage face reflects the difference in vertical permeability between the two units and also the lessor permeability of the older volcanics.

Well yield and formation permeability

Table 1 lists data from drillers logs located in the vicinity of Dunsmuir. Well yields vary from 5 to 236 gpm and average 35 gpm. The next highest yield was 100 gpm.

Most of the logs inspected were for domestic wells. These wells commonly are drilled until enough water is found and then the drilling is stopped, and the full potential of the aquifer is not realized.

To "normalize" aquifer conditions, the drillers logs were used to estimate formation permeability. This evaluation requires data on (1) storage coefficient, (2) duration of pumping, (3) discharge, (4) drawdown, and (5) saturated interval. Not all of this information was available, and so was estimated. The storage coefficient was estimated to be 0.07 (dimensionless), which represents water-table conditions. The saturated interval was taken as the difference between the water level and the depth of the well.

Drawdown information was the most sketchy on the well logs. Where drawdown was not given, it was assumed equal to 2/3 the available drawdown, i.e., 2/3 of the saturated interval. Because most of the wells were tested by blowing with air, 2/3 of the saturated interval seemed reasonable because air-lift discharge requires some submergence to work.

On some of the logs the driller indicated the water level was the same at the beginning and end of the test, or the drawdown was stated as "none." In these cases, the drawdown was assumed to be one foot. One final assumption was well efficiency, which was taken to be 80 percent.

The calculated permeability using the above assumptions is shown on Table 1. Values range between 1 and 747 gpd/ft2; average is 154 gpd/ft2 and the median value is 84 gpd/ft2. It is noted that the highest permeability is based on test data where no assumptions (other than storage coefficient) had to be made as to drawdown.

Ground-water discharge at Mossbrae Falls

An average annual discharge of about 70 cfs at Mossbrae Falls was calculated to determine the amount of ground-water movement occurring beneath the City's property northeast of the Sacramento River drainage. Calculations for determining this discharge is shown on Table 2, and was made using stream measurements occurring above and below the Falls. Figure 4 shows a yearly graph of the calculated discharge.

Using the 70 cfs annual discharge of the Falls gives a formation permeability of about 510 gpd/ft2, which is considerably higher than the 84 gpd/ft2 median value determined from the well logs, but definitely within the order of magnitude of some of the higher values determined from the logs.

The above permeability was calculated using the Darcy equation, $Q = KiA$, where Q equals discharge, i equals ground-water gradient, and A equals cross-sectional area of flow. Gradient was taken from the ground-water contours above the Falls between the 2800 and 3000-ft contours (200 ft/2700 ft). Cross-sectional area was based on a depth of flow of 300 feet (equal to the saturated interval shown on Figures 2 and 3) across a width of 4000 feet.

Potential well yield

Because well yield is a function of saturated interval, theoretically, the deeper the well the greater the yield, if the permeability stays the same throughout the depth of the well. For the Dunsmuir area, the saturated interval appears to be limited to about 300 feet, and possibly less, depending on how accurate the profiles are, as shown on Figures 2 and 3.

The next variable in the estimate of well yield is the formation permeability. Median permeability based on the analysis of 19 well logs (Table 1) is about 84 gpd/ft. Permeability, based on the discharge of ground-water to the reach of Mossbrae Falls, is about 500 gpd/ft.

To show how the saturated interval and permeability work together to reflect drawdown based on yield, three curves were constructed as shown on Figure 5. The curves relate drawdown, permeability and saturated interval. Fixed assumptions the curves are based on include the following:

Discharge = 100 gpm
Duration of continuous pumping = 180 days (period of no recharge to the aquifer)
Aquifer storage coefficient = 0.07 (dimensionless)
Radius of well = 10 inches
Well efficiency = 80 percent

The well efficiency reflects entrance velocities into the well. If the theoretical drawdown was 20 feet, at 80 percent efficiency the drawdown would be 25 feet (20 ft/0.80).

Another assumption used in derivation of the curves was 50 feet set aside for drawdown. For example, for a saturated 300-ft section the drawdown was calculated based on a thickness of 250 feet, and the remaining 50 feet was available for drawdown. When a well, under water-table conditions is drawn down, the transmissivity (equal to permeability times saturated thickness) becomes less because the saturated interval decreases. Without going through a vary time-consuming iterative process, the available depth for drawdown was kept at 50 feet regardless of the actual drawdown. Therefore, for the curves shown on Figure 4, the actual saturated thickness used in the drawdown calculations is 50 feet less than the thickness shown on the curves.

For the sake of an example, assume the maximum desirable drawdown was 30 feet. As shown on Figure 5, a permeability of about 40 gpd/ft2 would be required for a well having a saturated interval (before pumping) of 300 feet; a permeability of about 55 gpd/ft2 for an interval of 200 feet; and a permeability of about 170 gpd/ft for an interval of 100 feet.

In view of the above, it appears there is potential for developing a 100-gpm, or greater, well on the basis of information determined for saturated interval and formation permeability, within the reach between the area to the northeast of Saint Germain Foundation and Mott Field, and to the northeast of the Sacramento River drainage.

TABLE 1

DRILLERS LOGS INFORMATION LOCATED VICINITY OF DUNSMUIR - SORTED BY LOCATION AND DEPTH

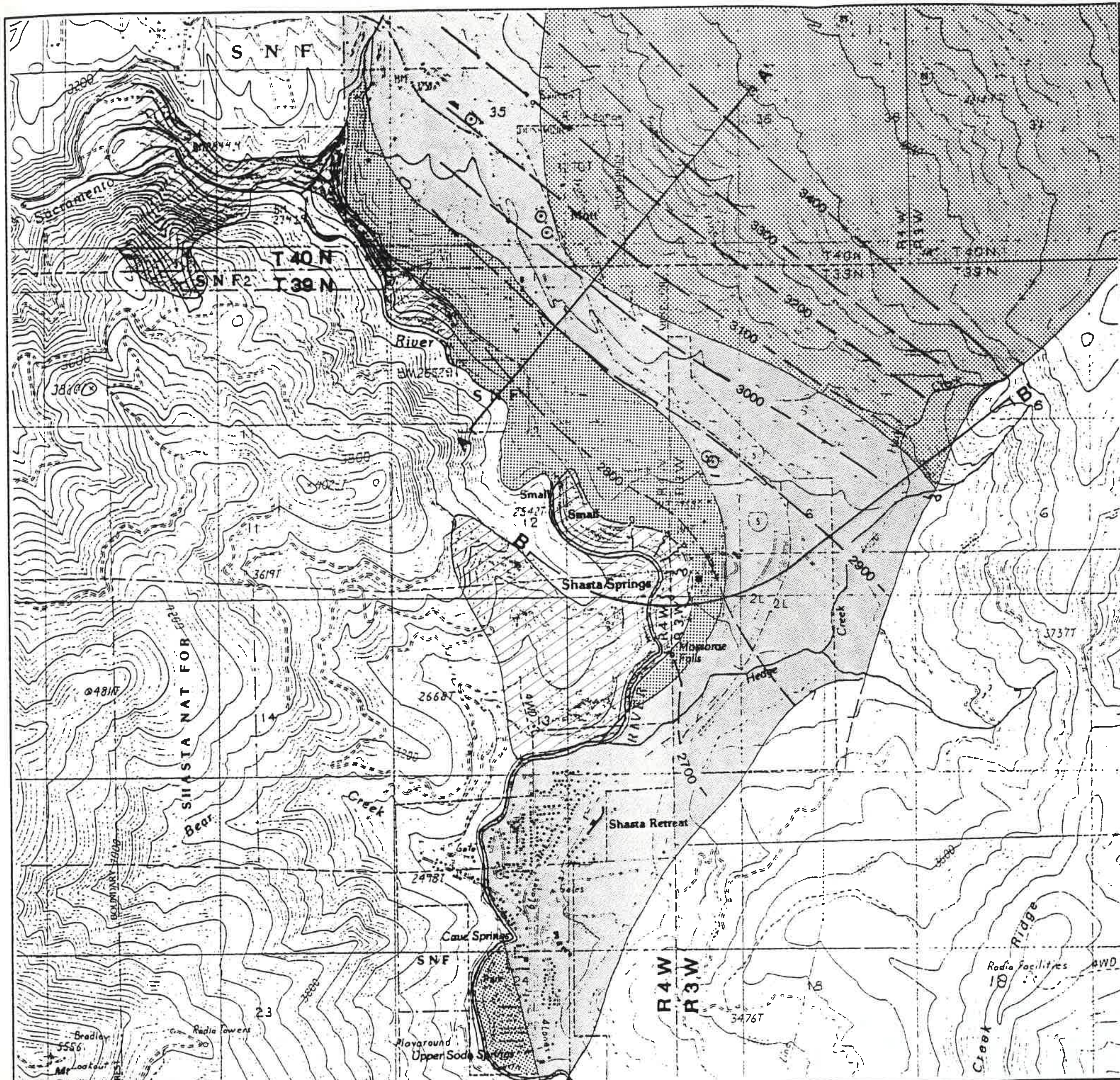
T/R-SEC	DEPTH	WATER LEVEL	DIS- CHARGE	LENGTH OF TEST	DRAW- DOWN	PERME- ABILITY	NOTES
	(FT)	(FT)	(GPM)	(HR)	(FT)	(GPD/FT2)	
39N/4W-1	165	140	10	24	17-NOTE	38	DRAWDOWN NOT GIVEN; ASSUMED EQUAL TO 2/3 AVAILABLE DRAWDOWN.
39N/4W-12	92	58	40	2-1/2	23-NOTE	73	DRAWDOWN NOT GIVEN; ASSUMED EQUAL TO 2/3 AVAILABLE DRAWDOWN.
39N/4W-12	104	76	30	4	19-NOTE	84	DRAWDOWN NOT GIVEN; ASSUMED EQUAL TO 2/3 AVAILABLE DRAWDOWN.
39N/4W-12	132	85	5	8	1-NOTE	185	NO DRAWDOWN INDICATED; ASSUMED 1 FOOT.
39N/4W-12	173	97	236	3/4	51-NOTE	84	DRAWDOWN NOT GIVEN; ASSUMED EQUAL TO 2/3 AVAILABLE DRAWDOWN.
39N/4W-12	198	110	27.3	16	53	9	
39N/4W-12	225	188	20	2	25-NOTE	27	DRAWDOWN NOT GIVEN; ASSUMED EQUAL TO 2/3 AVAILABLE DRAWDOWN.
39N/4W-7	230	212	50	2	6	747	
40N/4W-34	124	104	20	1	5	312	
40N/4W-34	190	100	12	1	10	15	
40N/4W-34	225	140	5	4	1-NOTE	91	NO DRAWDOWN INDICATED; ASSUMED 1 FOOT.
40N/4W-34	235	--	25	2	--	--	
40N/4W-34	245	--	10	--	--	--	
40N/4W-34	347	215	10	3	1-NOTE	129	NO DRAWDOWN INDICATED; ASSUMED 1 FOOT.
40N/4W-35	118	79	25	2	10	85	
40N/4W-35	180	148	30	2	5	292	
40N/4W-35	190	160	30	4	3	550	
40N/4W-35	240	175	30	2	43-NOTE	13	DRAWDOWN NOT GIVEN; ASSUMED EQUAL TO 2/3 AVAILABLE DRAWDOWN.
40N/4W-35	290	195	10	2	1-NOTE	174	NO DRAWDOWN INDICATED; ASSUMED 1 FOOT.
40N/4W-35	291	198	100	2	62-NOTE	23	DRAWDOWN NOT GIVEN; ASSUMED EQUAL TO 2/3 AVAILABLE DRAWDOWN.
40N/4W-35	320	210	7	2	60	1	
	----	----	----			----	
AVERAGE	205	142	35		AVERAGE	154	
MAXIMUM	347	215	236		MEDIAN	84	
MINIMUM	92	58	5				

NOTE: PERMEABILITY IS CALCULATED USING THE THEIS NONEQUILIBRIUM EQUATION ON A COMPUTER USING AN ITERATIVE PROCESS WHERE VARIOUS VALUES FOR TRANSMISSIVITY ARE ENTERED UNTIL THE CALCULATED DRAWDOWN EQUALS THE OBSERVED DRAWDOWN; THE PERMEABILITY IS EQUAL TO THE TRANSMISSIVITY DIVIDED BY THE SATURATED INTERVAL (DEPTH OF WELL MINUS WATER LEVEL).

TABLE 2

ESTIMATED MOSSBRAE SPRING DISCHARGE - SUMMER DISCHARGE PERIOD AUGUST 1960 TO OCTOBER 1971

YR	MO	OBSERVED STA 22	ESTIMATED STA 21	STA 22 MINUS STA 21	STA 22 TO STA 21 UNIT RUNOFF	INFLOW BELOW SPRINGS AND ABOVE STA 21	ESTIMATED SAC RIV AT SPRINGS	OBSERVED STA 19	STA 19 INDEX	STA 19 UNIT RUNOFF	INFLOW BELOW STA 19 AND ABOVE SPRGS	ESTIMATED SPRING FLOW	AVG SPRING FLOW	AVG STA 19 FLOW	AVG STA 19 INDEX
		(CFS)	(CFS)	(CFS)	(CFS/MI2)	(CFS)	(CFS)	(CFS)		(CFS/MI2)	(CFS)	(CFS)	(CFS)	(CFS)	
60	AUG	197	129.84	67.16	.280	8.67	121.16	46.8	65.90	.349	6.76	67.61			
	SEP	176	118.31	57.69	.240	7.45	110.86	49.1	69.14	.366	7.09	54.67			
	OCT	233	149.61	83.39	.347	10.77	138.84	62.7	88.29	.468	9.05	67.08	63.12	52.87	94.77
61	AUG	226	145.76	80.24	.334	10.36	135.40	49.7	69.98	.371	7.18	78.52	N/A	.00	N/A
	SEP	211	137.53	73.47	.306	9.49	128.04	50.8	71.53	.379	7.34	69.90	N/A	.00	N/A
	OCT	222	143.57	78.43	.327	10.13	133.44	63	88.71	.470	9.10	61.34	69.92	54.50	97.69
62	AUG	232	149.06	82.94	.346	10.71	138.35	52.3	73.64	.390	7.55	76.49	N/A	.00	N/A
	SEP	194	128.19	65.81	.274	8.50	119.69	49.4	69.56	.369	7.13	63.16	N/A	.00	N/A
	OCT	1335	754.72	580.28	2.418	74.95	679.76	321	451.99	2.396	46.35	--	70.83	50.85	91.15
63	AUG	265	167.18	97.82	.408	12.64	154.54	50.7	71.39	.378	7.32	96.52	N/A	.00	N/A
	SEP	242	154.55	87.45	.364	11.30	143.25	48.8	68.71	.364	7.05	87.41	N/A	.00	N/A
	OCT	342	209.46	132.54	.552	17.12	192.34	96	135.17	.716	13.86	82.48	88.80	65.17	116.82
64	AUG	169	114.46	54.54	.227	7.04	107.42	40.2	56.60	.300	5.81	61.42	N/A	.00	N/A
	SEP	172	116.11	55.89	.233	7.22	108.89	46.8	65.90	.349	6.76	55.34	N/A	.00	N/A
	OCT	195	128.74	66.26	.276	8.56	120.18	55.4	78.01	.413	8.00	56.78	57.84	47.47	85.09
65	AUG	243	155.10	87.90	.366	11.35	143.74	60.4	85.05	.451	8.72	74.62	N/A	.00	N/A
	SEP	204	133.68	70.32	.293	9.08	124.60	51.5	72.52	.384	7.44	65.66	N/A	.00	N/A
	OCT	200	131.49	68.51	.285	8.85	122.64	54.4	76.60	.406	7.86	60.38	66.89	55.43	99.37
66	AUG	188	124.90	63.10	.263	8.15	116.75	46.9	66.04	.350	6.77	63.07	N/A	.00	N/A
	SEP	189	125.45	63.55	.265	8.21	117.24	48.3	68.01	.360	6.97	61.96	N/A	.00	N/A
	OCT	196	129.29	66.71	.278	8.62	120.67	50.8	71.53	.379	7.34	62.54	62.53	48.67	87.24
67	AUG	290	180.91	109.09	.455	14.09	166.81	59.1	83.22	.441	8.53	99.18	N/A	.00	N/A
	SEP	240	153.45	86.55	.361	11.18	142.27	50.6	71.25	.378	7.31	84.37	N/A	.00	N/A
	OCT	262	165.53	96.47	.402	12.46	153.07	70.4	99.13	.525	10.17	72.50	85.35	60.03	107.61
68	AUG	212	138.08	73.92	.308	9.55	128.53	54.4	76.60	.406	7.86	66.27	N/A	.00	N/A
	SEP	188	124.90	63.10	.263	8.15	116.75	48.8	68.71	.364	7.05	60.90	N/A	.00	N/A
	OCT	252	160.04	91.96	.383	11.88	148.16	63.1	88.85	.471	9.11	75.95	67.71	55.43	99.37
69	AUG	229	147.41	81.59	.340	10.54	136.87	42.4	59.70	.316	6.12	88.35	N/A	.00	N/A
	SEP	506	299.51	206.49	.860	26.67	272.84	338	475.93	2.522	48.81	--	N/A	.00	N/A
	OCT	246	156.75	89.25	.372	11.53	145.22	77.1	108.56	.575	11.13	56.98	72.67	59.75	107.11
70	AUG	188	124.90	63.10	.263	8.15	116.75	41	57.73	.306	5.92	69.83	N/A	.00	N/A
	SEP	200	131.49	68.51	.285	8.85	122.64	51	71.81	.381	7.36	64.27	N/A	.00	N/A
	OCT	280	175.42	104.58	.436	13.51	161.91	91.4	128.70	.682	13.20	57.31	63.80	61.13	109.59
71	AUG	229	147.41	81.59	.340	10.54	136.87	50.9	71.67	.380	7.35	78.62	N/A	.00	N/A
	SEP	215	139.72	75.28	.314	9.72	130.00	52.1	73.36	.389	7.52	70.38	N/A	.00	N/A
	OCT	250	158.94	91.06	.379	11.76	147.18	71.4	100.54	.533	10.31	65.47	71.49	58.13	104.21
								71.0			AVERAGE	69.98		55.79	



LEGEND

WATER–BEARING DEPOSITS

- RECENT ALLUVIUM
- YOUNGER (PLEISTOCENE) VOLCANICS
- OLDER (TERTIARY) VOLCANICS

NONWATER–BEARING ROCKS AND INTRUSIVES

- METAVOLCANICS AND INTRUSIVES (MESOZOIC)
- — —3100— — LINE OF EQUAL GROUND–WATER ELEVATION, FEET, MSL
- SPRING
- A — A' HYDROGEOLOGIC SECTION LINE
- WELL WITH WATER–LEVEL CONTROL

N

SCALE : 1" = 2000'
TOPOGRAPHIC CONTOUR INTERVAL 40'

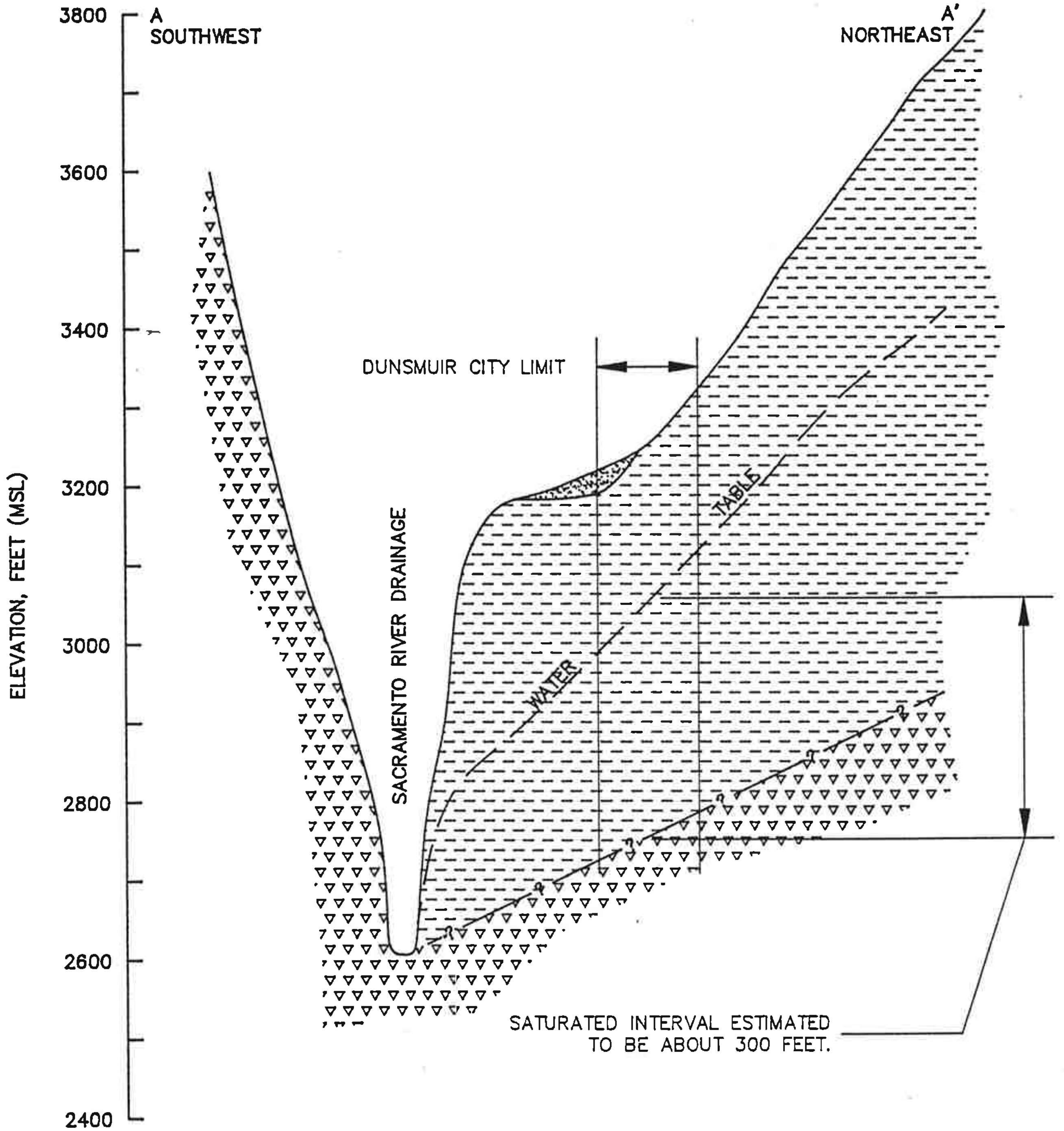
NOTE: OUTCROP GEOLOGY FROM "WEED SHEET", CALIF. DIV. M. & G., 1964

BASE MAP FROM FOLLOWING USGS 7.5–MINUTE SERIES QUADS: "DUNSMUIR", "McCLOUD", "GIRARD RIDGE", AND "CITY OF MOUNT SHASTA".

LAWRENCE & ASSOCIATES 2001 MARKET STREET REDDING, CALIFORNIA (916) 244–9703

HYDROGEOLOGIC MAP

CLIENT: PACE ENGINEERING	PROJECT: DUNSMUIR
DATE: 2/15/94	JOB NO.:
DRAWN BY: D.A.L.	CHECKED BY:
C:\ADCADD\P\PACE–DNS\HYD–GEO.DWG D.B.Z. 2/16/1994	
SCALE: 1"=2000'	FIGURE 1



C:\ADCADD\P\PACE-DNS\SECTN-A.DWG D.B.Z. 2/16/1994

WATER-BEARING DEPOSITS

RECENT ALLUVIUM

YOUNGER (PLEISTOCENE) VOLCANICS

NONWATER-BEARING ROCKS

METAVOLCANICS AND INTRUSIVES (MESOZOIC)

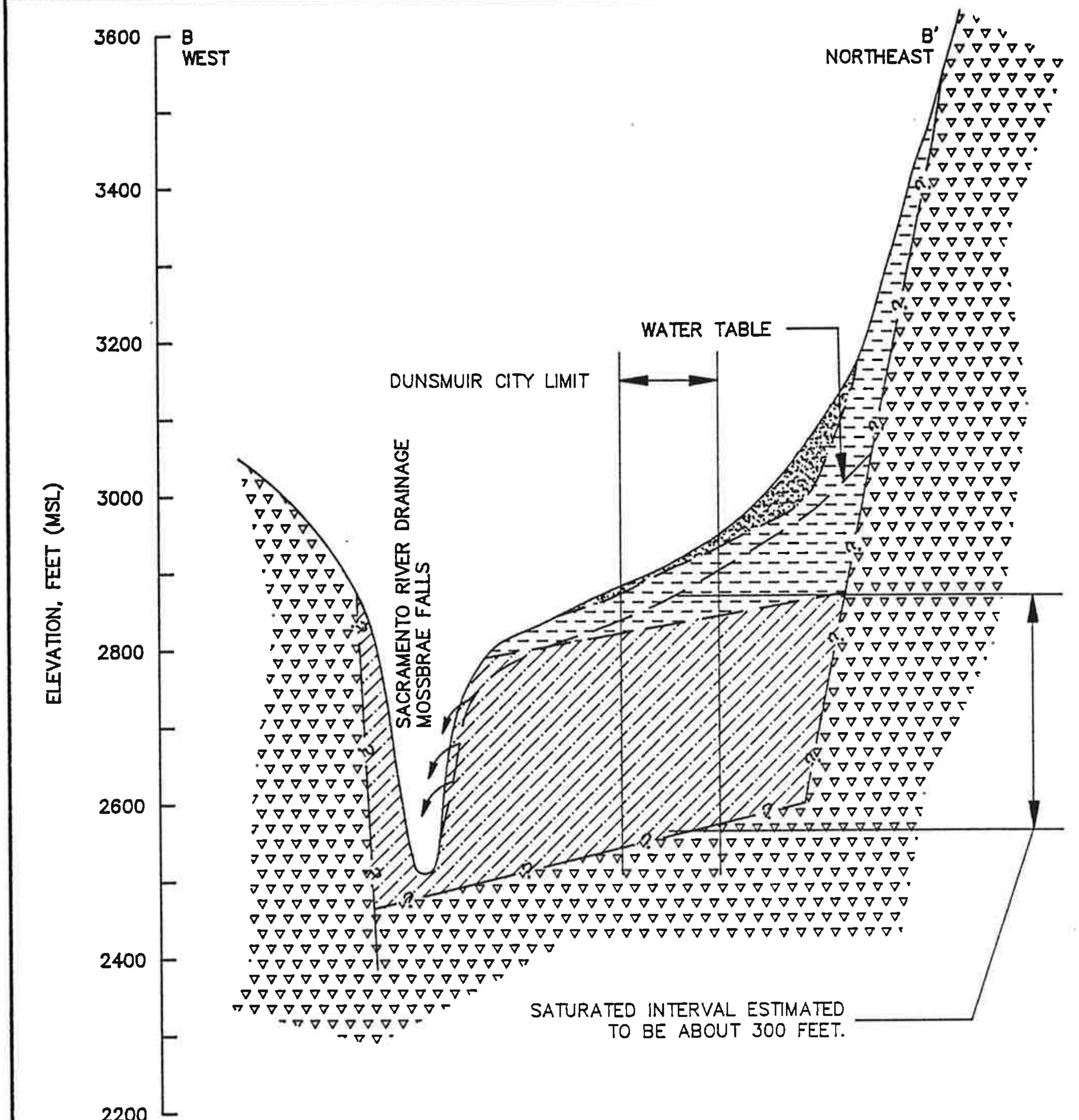
SCALE

VERTICAL : 1"=200'
HORIZONTAL : 1"=2000'

NOTE:

OUTCROP GEOLOGY FROM "WEED SHEET" CALIF. DIV. M & G, 1964

HYDROGEOLOGIC SECTION A-A' NEAR MOTT FIELD	LAWRENCE & ASSOCIATES 2001 MARKET STREET, RM. 523 REDDING, CA 96001 PHONE (916) 244-9703 FAX (916) 244-5021	SCALE: AS SHOWN DATE: 2/15/94 JOB NO: C94.02.02
CLIENT: PACE ENGINEERING	PROJECT: DUNSMUIR	DRAWN BY: D.A.L.
		FIGURE 2



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WATER-BEARING DEPOSITS

- RECENT ALLUVIUM
- YOUNGER (PLEISTOCENE) VOLCANICS
- OLDER (TERTIARY) VOLCANICS

WATER-BEARING DEPOSITS

- METAVOLCANICS AND INTRUSIVES (MESOZOIC)

SCALE

VERTICAL : 1"=200'
HORIZONTAL : 1"=2000'

NOTE:

OUTCROP GEOLOGY FROM "WEED SHEET"
CALIF. DIV. M & G, 1964

HYDROGEOLOGIC SECTION B-B' NEAR MOSSBRAE FALLS	LAWRENCE & ASSOCIATES 2001 MARKET STREET, RM. 523 REDDING, CA 96001 PHONE (916) 244-9703 FAX (916) 244-5021	SCALE: AS SHOWN DATE: 2/15/94 JOB NO: C94.02.02
CLIENT: PACE ENGINEERING / PROJECT: DUNSMUIR	DRAWN BY: D.A.L.	FIGURE 3

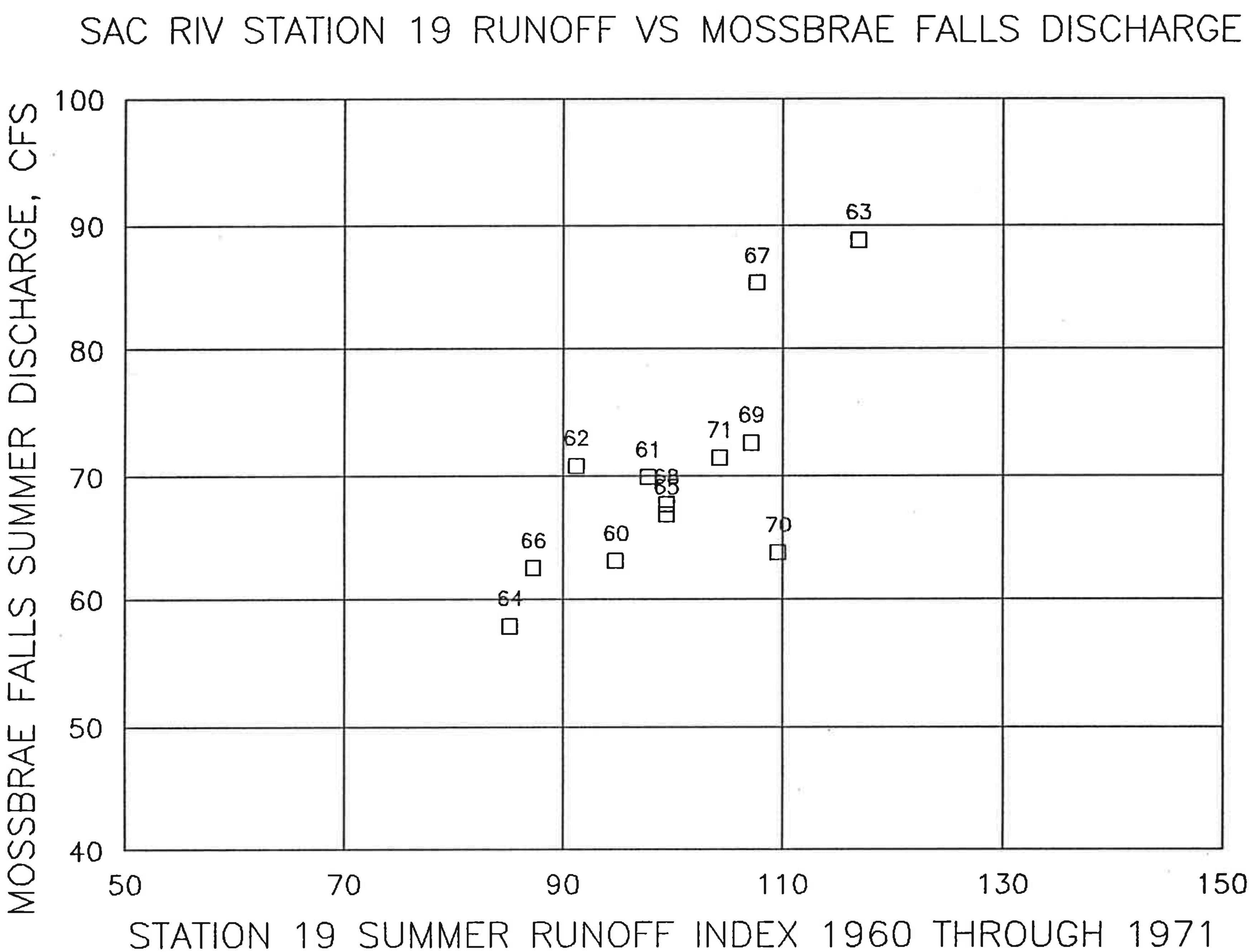
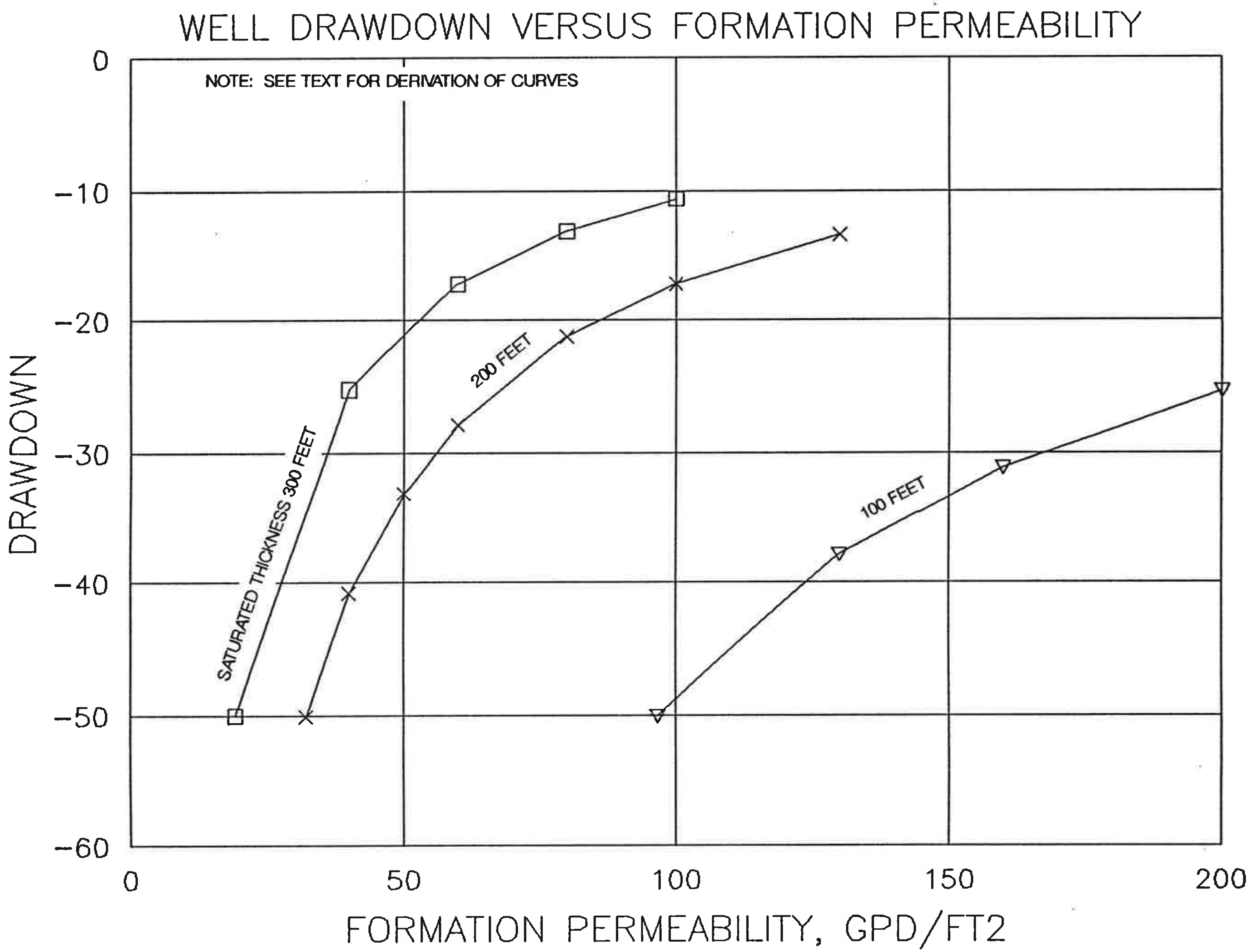

SAC RIV STATION 19 RUNOFF VS MOSSBRAE FALLS DISCHARGE
MOSSBRAE FALLS SUMMER DISCHARGE, CFS
100
90
80
70
60
50
40
50
70
90
110
130
150
STATION 19 SUMMER RUNOFF INDEX 1960 THROUGH 1971
63
67
69
71
62
61
68
65
70
60
66
64

FIGURE 4



WELL DRAWDOWN VERSUS FORMATION PERMEABILITY
NOTE: SEE TEXT FOR DERIVATION OF CURVES
DRAWDOWN
0
-10
-20
-30
-40
-50
-60
0
50
100
150
200
FORMATION PERMEABILITY, GPD/FT2
SATURATED THICKNESS 300 FEET
200 FEET
100 FEET

FIGURE 5

DATE
8/15

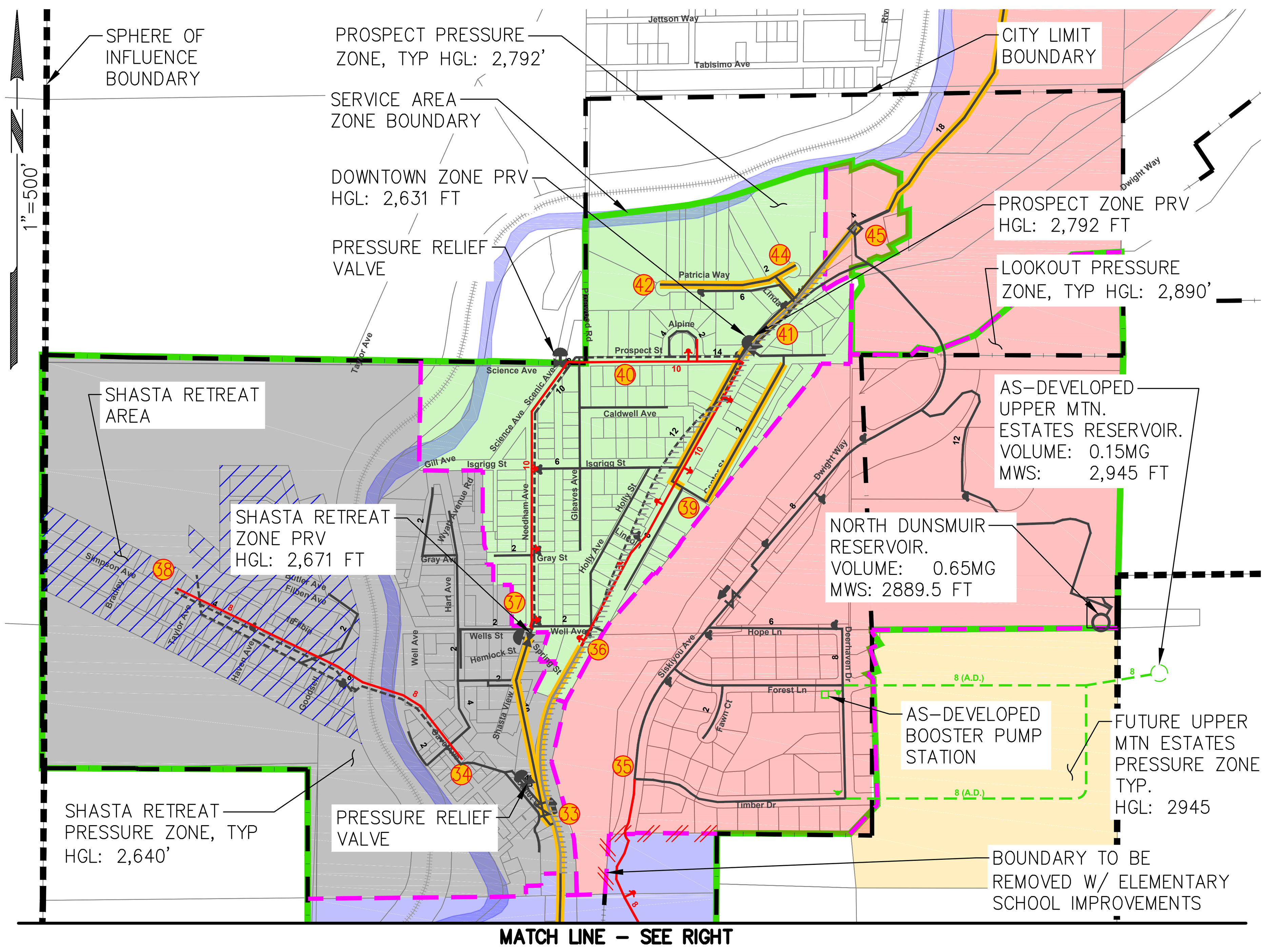
PACE ENGINEERING
REDDING, CALIFORNIA

CITY OF DUNSMUIR
2015 MASTER WATER PLAN

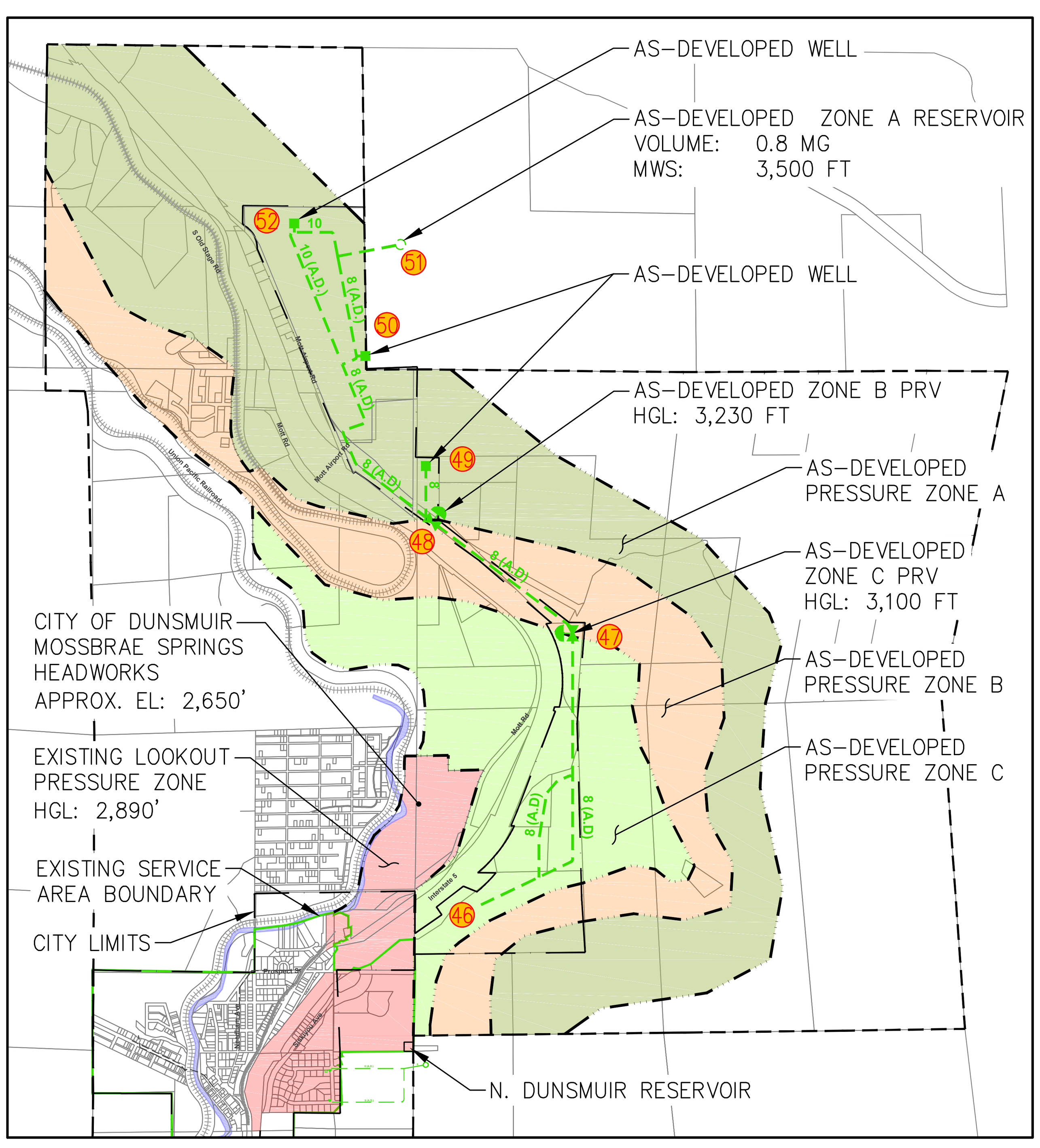
ZONING & GENERAL PLAN DESIGNATIONS

PLATE
1

Plot Date: July 20, 2015 – 9:54 am Login Name: gmaxwell
File Name: M:\Land Projects\0204.52 CDBG PTA Water Master Plan and Rate Study\DWG\PLATES.dwg, Layout: PLATE 1



SHASTA RETREAT, PROSPECT & LOOKOUT PRESSURE ZONES



AS-DEVELOPED PRESSURE ZONE A, B & C

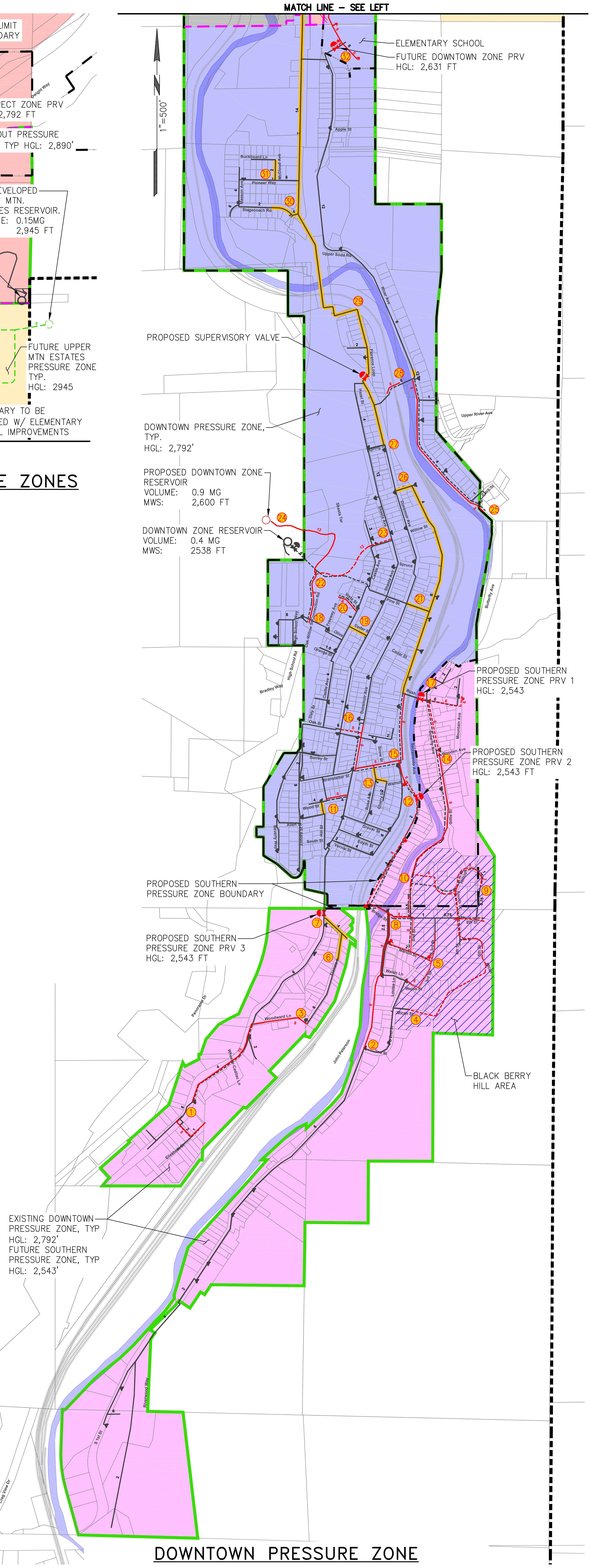
LEGEND

- PROPOSED BOOSTER PUMP STATION
- EXISTING BOOSTER PUMP STATION
- PROPOSED WELL
- EXISTING WELL
- EXISTING RESERVOIR
- PROPOSED RESERVOIR
- EXISTING FIRE HYDRANT
- EXISTING PRESSURE REDUCING STATION
- PROPOSED PRESSURE REDUCING STATION
- PROPOSED GROWTH AREAS
- WATER LINE
- WATER LINE TO BE ABANDONED
- OUT OF ZONE MAIN
- PLANNED 2015 IMPROVEMENTS
- PROPOSED IMMEDIATE WATER LINE
- PROPOSED NEAR-TERM WATER LINE
- PROPOSED AS-DEVELOPED WATER LINE
- EXISTING PRESSURE ZONE BOUNDARY
- PROPOSED PRESSURE ZONE BOUNDARY
- PRESSURE ZONE BOUNDARY TO BE REMOVED
- SERVICE AREA BOUNDARY
- CITY LIMITS BOUNDARY
- SPHERE OF INFLUENCE
- EXISTING LOW PRESSURE AREA
- IDENTIFICATION POINT
- LOOKOUT PRESSURE ZONE, HGL: 2,890'
- PROSPECT PRESSURE ZONE, HGL: 2,792
- SHASTA RETREAT PRESSURE ZONE, HGL: 2,640'
- DOWNTOWN PRESSURE ZONE, HGL: 2,792'
- FUTURE SOUTHERN PRESSURE ZONE, HGL: 2,543'
- FUTURE PRESSURE ZONE A, HGL: 3,500'
- FUTURE PRESSURE ZONE B, HGL: 3,230'
- FUTURE PRESSURE ZONE C, HGL: 3,100'

GRAPHIC SCALE

500 0 250 500 1,000 2,000

(IN FEET)
1 inch = 500 ft.



DOWNTOWN PRESSURE ZONE

DATE	PACE ENGINEERING REDDING, CALIFORNIA	CITY OF DUNSMUIR 2015 MASTER WATER PLAN DRAFT	PLATE
8/15		2015 EXISTING WATER DISTRIBUTION SYSTEM	2

Plot Date: August 17, 2015 – 7:35 am Login Name: gmaxwell
File Name: M:\Land Projects\0204.52 CDBG PTA Water Master Plan and Rate Study\DWG\PLATES.dwg, Layout: PLATE 2