Section 8: Hydraulic Analysis and Capital Improvement Program

This section presents the development of planning level unit costs, the hydraulic analysis of the system, the recommended Capital Improvement Program (CIP) for the Department and the methods used to determine the estimated cost of that program. The recommended projects allow the Department to address the deficiencies that have been identified throughout this document that are necessary to adequately serve the current water demands and future growth.

8.1 Planning Level Unit Costs

To budget for the integration of the system evaluation findings, applicable system unit costs and project cost must be derived. To this end, the opinions of probable construction costs are derived herein and are based on conceptual costs obtained from industry manufacturers, previous master planning project experience, master planning costs presented by similar agencies, and bid histories from comparable projects. All cost assumptions are based on 2014 U.S. Dollars using the ENR index from December 2014 for the Los Angeles area. Cost estimates reflect conceptual-level estimates which range between 50 percent above and 30 percent below actual capital costs. Engineering and administration costs are estimated to be 30 percent of the construction costs, Contractor overhead and profit are estimated to be 15 percent of performed work and 12 percent of subcontracted work, and a 25 percent contingency is added to the subtotal of all costs. Costs for land acquisition, right-of-way easements and environmental documentation preparation are not included as part of the estimated costs. A summary of the unit cost values for the Department's Water Master Plan are provided in the following sub-sections.

8.1.1 Pipelines

It is common for pipeline unit costs to vary considerably from one community to another. This variation is primarily attributed to the availability of nearby vacant land for construction staging, the age of the community and the magnitude of underground utilities and corridor limitations. For the Department, pipeline unit costs are driven by these factors, with additional changes in cost from various pipe diameters. A cost of $14.70/foot/inch diameter is to be used in this planning effort. A 30 percent factor for design and management related costs are included, along with a 25 percent contingency factor, for a total unit cost of $23/foot/inch.

8.1.2 Reservoirs

As preferred by the Department, new reservoirs are based on above ground steel tanks for storage volumes less than 4.0 million gallons and prestressed concrete for storage volumes 4.0 MG and greater. The unit cost for new reservoirs is based on $1.05 per gallon. Similar to the development of the pipeline unit cost, a 30 percent factor for design and management related costs is included, plus a 25 percent contingency factor, resulting in total unit costs of $1.64 per gallon of storage. This unit cost applies to both types of reservoirs at the different size ranges. This cost does not include an allowance for land acquisition.

8.1.3 Booster Stations

The unit costs for pump station improvements are based on the system analysis estimate of additional pumping capacity and the associated increase in horsepower required. For the Department, the unit cost is based on the estimated horsepower for the new pump station. Table 8-1 shows the unit cost data used to estimate the cost for each pump station. To these costs, a 30 percent allowance for design and management related costs should be included, along with a 25 percent contingency factor. In locations where additional pumping capacity can be added with the addition of a pump within an existing pump station, it is expected that costs per horsepower would be lower than the factors indicated below. However, for this document, the costs provided assume that a new pump station will be constructed.

Table 8-1: Booster Station Unit Costs for New Pump Stations

Size (hp)	Construction Cost ($/hp)	Total Cost ($/hp)
10	$22,500	$36,400
25	$18,500	$29,100
50	$15,000	$24,300
75	$12,000	$19,500
100	$9,000	$14,600
150	$7,500	$12,200
200	$7,200	$11,700
250	$6,750	$10,900
300	$6,300	$10,200
400	$6,000	$9,700
500	$5,550	$9,000
600	$5,250	$8,500
750 or larger	$4,800	$7,800

8.2 Existing Conditions Hydraulic Analysis

This section provides a description of the hydraulic issues that were identified within the Department's water infrastructure. Hydraulic evaluation of the Department's existing distribution system was performed and is explained in this section. The existing system evaluation applies current (CY 2012) demands and is based on the current infrastructure and operations strategies in place.

This Department has a 5-year CIP that it is currently implementing. The 5-year CIP is included in Appendix F. The Department has developed the 5-year CIP to remediate system issues that were derived from either the results of the 2007 water master plan or from system knowledge by Department staff. The 5-year CIP was evaluated and contrasted with the system analysis performed for this master plan, and was discussed with the Department. It was determined that 5-year CIP projects would be included in the model prior to beginning the analysis of the future system, but would not be included in the analysis of the existing system.

8.2.1 Existing System Evaluation Approach

Evaluations for pumping and storage capacity as well as evaluations of the distribution system under maximum demands and fire flows identify possible recommendations to address existing and future deficiencies. Pumping and storage capacity deficiencies are identified using capacity data provided by the Department as reflected in the Inventory Database, whereas capacity deficiencies in the distribution system are identified through analysis with the hydraulic model.

8.2.2 Existing Pump Capacity Evaluation

The pumping facilities for each zone, or group of zones, were evaluated to determine if there is sufficient pumping capacity to meet the criteria. Pressure zones with significant well capacity were not held to the same criteria. Additionally, zones that could receive supply from higher pressure zones through regulating valves were not held to the same criteria.

Typically in water system planning, it is assumed that the largest pump at a station may be out of service. The capacity of the pump station without the largest pump is referred to as the firm capacity of the pump station. In some situations, there are multiple pump stations serving the same zone. In these situations, it is assumed the largest single pump across all of the pump stations may be out of service. The firm capacity is examined for the entire pressure zone, assuming that only one pump among the multiple pump stations would be out of service.

While a more detailed table compiling the pumping capacity analysis results can be found in Appendix E, a summary of the pump station evaluation results is shown in Table 8-2.

The identified pumping deficiencies are summarized as follows:

1) The Intermediate zone has a pumping capacity deficit. However, this zone has wells and regulating valves that supplement supply. Therefore, this pumping capacity deficit does not need to be addressed.

2) The Lower zone has a pumping capacity deficit. However, this zone has wells and regulating valves that supplement supply. Therefore, this pumping capacity deficit does not need to be addressed.

3) The Mountain zone does have a relatively small pumping capacity deficit. The Department has a remediation plan in its 5-year CIP.

Table 8-2: Existing Pumping Capacity Evaluation

Zone	Firm Pumping Available (MGD)	Firm Pumping Required (MGD)	Additional Needed Capacity (MGD)	Notes
Cajon	15.12	2.25	0.00	
College/Palm	26.50	7.32	0.00	
Devil Canyon	0.22	0.00	0.00	
Daley	0.72	0.28	0.00	
Del Rosa	3.60	2.00	0.00	
Devore/Meyers	10.80	1.34	0.00	

Zone	Firm Pumping Available (MGD)	Firm Pumping Required (MGD)	Additional Needed Capacity (MGD)	Notes
Devore/Meyers Subzone (2300)	0.39	0.09	0.00	
Intermediate	1.87	4.53	2.66	This zone has wells and regulated supply
IVDA	3.17	0.12	0.00	
Lower	1.01	19.98	18.98	This zone has wells and regulated supply
Mountain	1.94	2.25	0.31	Deficit, addressed in Department 5-Year CIP
Mountain Subzone (1668)	1.01	0.08	0.00	
Mountain Subzone (1693)	0.50	0.04	0.00	
RidgeView	0.61	0.11	0.00	
Ridgeline	0.86	0.12	0.00	
Shandin Hills	0.43	0.06	0.00	
Sycamore	8.88	2.56	0.00	
Terrace	6.80	3.93	0.00	
Upper	42.50	13.43	0.00	

8.2.3 Existing Storage Evaluation

The storage evaluation determines whether the capacity available in the storage reservoirs to meet operational, emergency and fire storage requirements is sufficient. Storage is evaluated on a pressure zone and system wide basis. If a zone is found to be deficient, the first solution is to determine whether access to storage in a higher and adjacent zone is available that can be supplied through a PRV. If this is not feasible, another solution is to pump from excess storage to a deficient zone.

The existing distribution system contains an array of storage reservoirs and forebay tanks and has a total storage volume of approximately 120 MG. A system-wide comparison of available storage and required storage shows a surplus of approximately 88 MG under existing demand conditions, including operational, emergency and fire storage adequate to serve each zone. While a more detailed table compiling the storage analysis results can be found in Appendix E, a summary of the storage evaluation results is shown in Table 8-3.

Individual zones do show deficits in some instances. The Department has included storage tanks for some pressure zones in its 5-year CIP based on the prior water master plan and its knowledge of system issues. The 5-year CIP is included in Appendix F. In some instances, these planned tanks address the storage deficits identified in the analysis of the storage facilities. The storage deficits for existing demand conditions are summarized as follows:

1) The IVDA zone shows a storage deficit, but this zone is planned to be combined with the Intermediate zone, which has a large storage surplus. The existing IVDA tank is to be decommissioned.

2) The Ridgeline zone shows a small deficit, but the deficit is large in comparison to the demands for this zone, as it is a small zone.

3) The Terrace zone shows a small storage deficit for existing demand conditions. The final recommendation will depend on the results of a zone realignment study that is identified in section 8.2.6.

Table 8-3: Existing Storage Evaluation

Zone	Storage Required (gal)	Storage Available (gal)	Surplus/Deficit (gal)	Notes
Cajon	1,719,066	5,000,000	3,280,934	
College/Palm	4,504,519	11,905,000	7,400,481	Additional Tank Planned in Department's 5-Year CIP
Devil Canyon	180,000	230,000	50,000	
Daley	455,899	1,500,000	1,044,101	
Del Rosa	1,365,319	3,650,000	2,284,681	
Devore/Meyers	1,317,413	4,000,000	2,682,587	
Intermediate	2,970,525	10,355,500	7,384,975	
IVDA	366,196	250,000	-116,196	Tank to be Decommissioned
Lower	11,471,014	33,904,500	22,433,486	
Mountain	1,539,003	2,233,000	693,997	Additional Tank Planned in Department's 5-Year CIP
Ridgeview	238,960	330,000	91,040	
Ridgeline	247,459	102,000	-145,459	Small Deficit, but large in comparison to size of the pressure zone
Shandin Hills	214,062	219,000	4,938	
Sycamore	1,821,608	8,948,000	7,126,392	
Terrace	2,464,190	2,445,000	-19,190	Small Deficit
Upper	7,867,498	34,779,000	26,911,502	

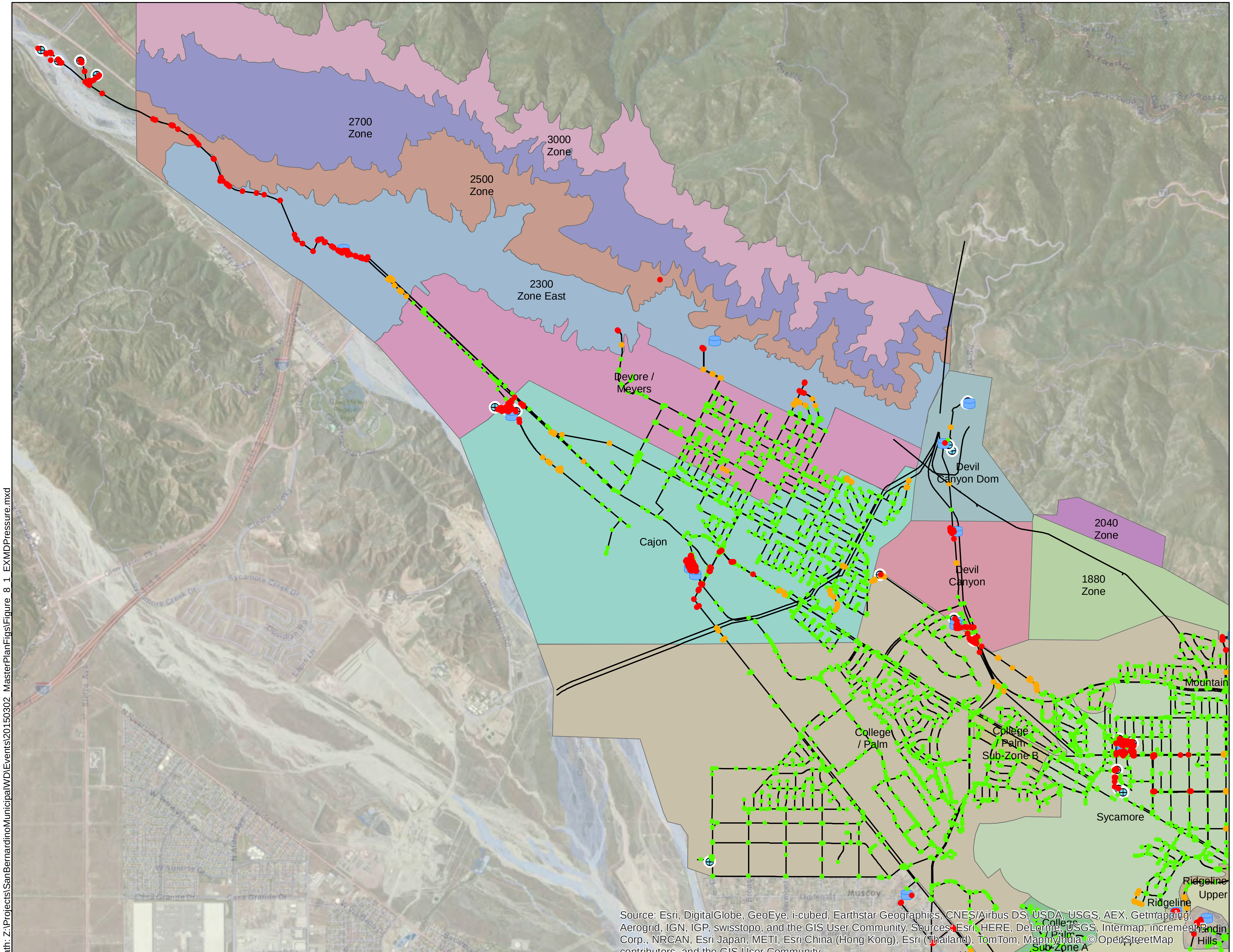
8.2.4 Existing Distribution System Evaluation

The hydraulic model constructed for this report was used to evaluate performance of the distribution system using the criteria for pressure, velocity and head loss that are presented in Section 6.

There were a few cases of maximum velocity criteria failure under MDD conditions. Several pipeline segments in the system were close to or in excess of the maximum head loss evaluation criteria. Most of those pipelines were pinch points, or pipes which were smaller in diameter than their upstream and downstream counterparts. Replacing these pipes would alleviate the issues observed at these locations. However, replacing these pipes is not a recommended improvement project. Unless areas of the system that fail the velocity or head loss criteria also fail the pressure criteria, or the velocity and head loss issues cause problems with system operation, resolving velocity and head loss issues is considered a low priority, and is not recommended.

The pressures at the demand junctions throughout the water distribution system are above the evaluation criterion of 40 psi in most cases. The majority of non-demand junctions also fell within the criterion of maintaining a minimum pressure of 10 psi, however, near existing storage facilities there was a tendency for some junctions to fall below 10 psi. The pressures in the system as calculated by the hydraulic model are shown on Figure 8-1.

The few cases where the pressure does fall below the criterion of 40 psi include a large portion of the Terrace zone and an area in the northwest corner of the Lower pressure zone. Other areas were generally small and isolated, and the pressure dropped below the criterion by a small amount and for only a small period of time during maximum day demands. The only one of these areas where the pressures drop fairly significantly below the 40 psi criterion is in a small portion of the Del Rosa zone just west of the 3 MG Del Rosa tank centered along Mesa Verde Avenue.



Path: Z:\Projects\SanBernardinoMunicipalWD\Events\20150302_MasterPlanFigs\Figure_8_1_EXMDPressure.mxd

Legend

- Minimum Pressure > 40 psi
- Minimum Pressure Between 20 and 40 psi
- Minimum Pressure < 20 psi
- Tanks
- Production Well

Main Line

- Main Line

PZNAME

- 1880 Zone
- 2040 Zone
- 2300 Zone East
- 2500 Zone
- 2700 Zone
- 3000 Zone
- Cajon
- College / Palm
- College / Palm Sub-Zone A
- College / Palm Sub-Zone B
- Daley
- Del Rosa
- Devil Canyon
- Devil Canyon Dom
- Devore / Meyers
- IVDA Upper
- Intermediate
- Lower Sub-Zone
- Lower Zone
- Mountain
- Mountain Sub-Zone A
- Mountain Sub-Zone B
- Ridgeline
- Ridgeline Hydro
- Ridgeview
- Shandin Hills
- Sycamore
- Terrace
- Upper

N

0 5,000 10,000
Feet

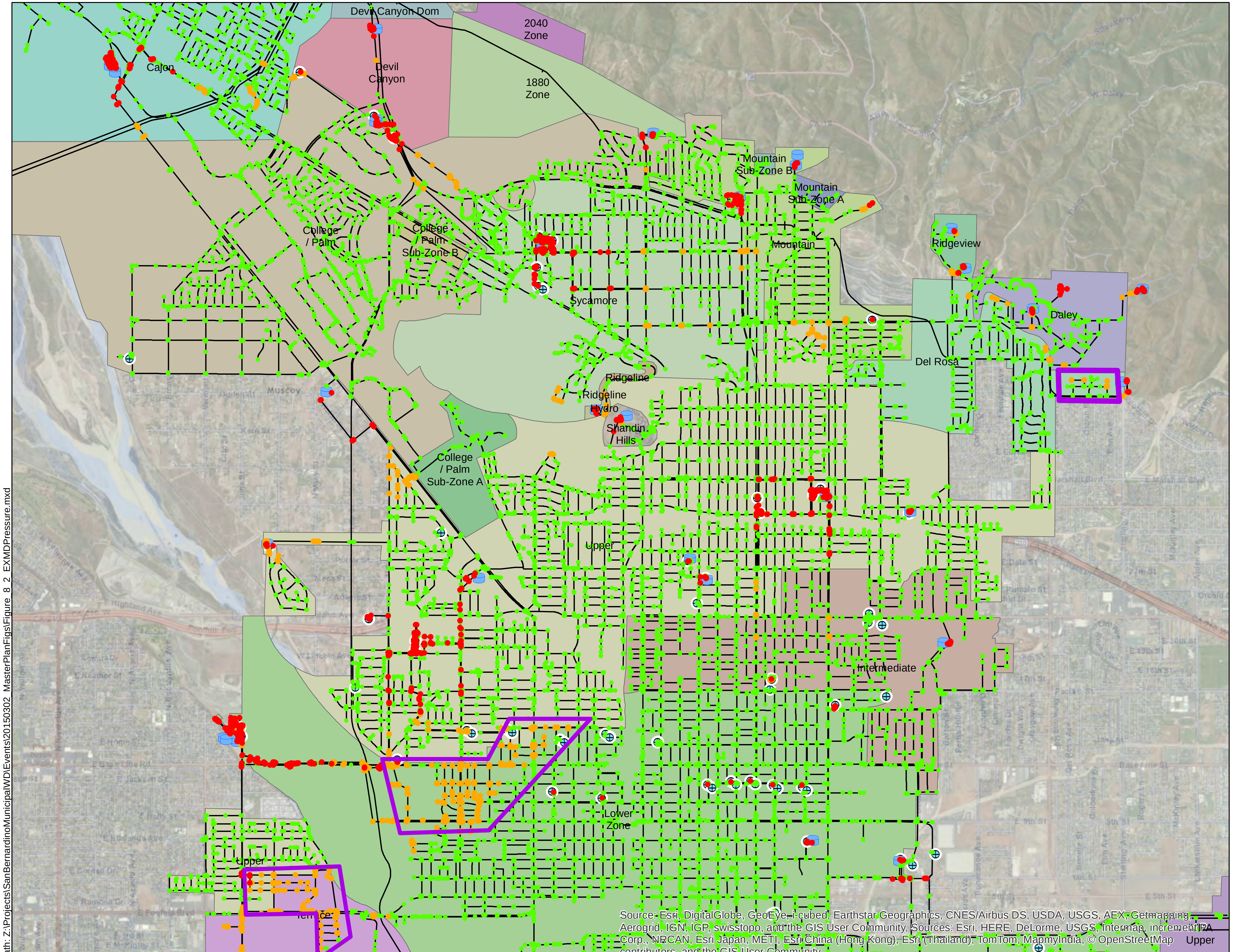
Kennedy/Jenks Consultants

San Bernardino Water Facilities MP
San Bernardino, California

Existing Maximum Day Demands
Minimum System Pressure
North Area

1383002*00
May 2015

Figure 8-1



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Legend

- Minimum Pressure > 40 psi
- Minimum Pressure Between 20 and 40 psi
- Minimum Pressure < 20 psi
- Tanks
- Production Well

Main Line

- Main Line

PZNAME

- 1880 Zone
- 2040 Zone
- 2300 Zone East
- 2500 Zone
- 2700 Zone
- 3000 Zone
- Cajon
- College / Palm
- College / Palm Sub-Zone A
- College / Palm Sub-Zone B
- Daley
- Del Rosa
- Devil Canyon
- Devil Canyon Dom
- Devore / Meyers
- IVDA Upper
- Intermediate
- Lower Sub-Zone
- Lower Zone
- Mountain
- Mountain Sub-Zone A
- Mountain Sub-Zone B
- Ridgeline
- Ridgeline Hydro
- Ridgeview
- Shandin Hills
- Sycamore
- Terrace
- Upper

Proposed Zone Realignment

N

0 5,000 10,000
Feet

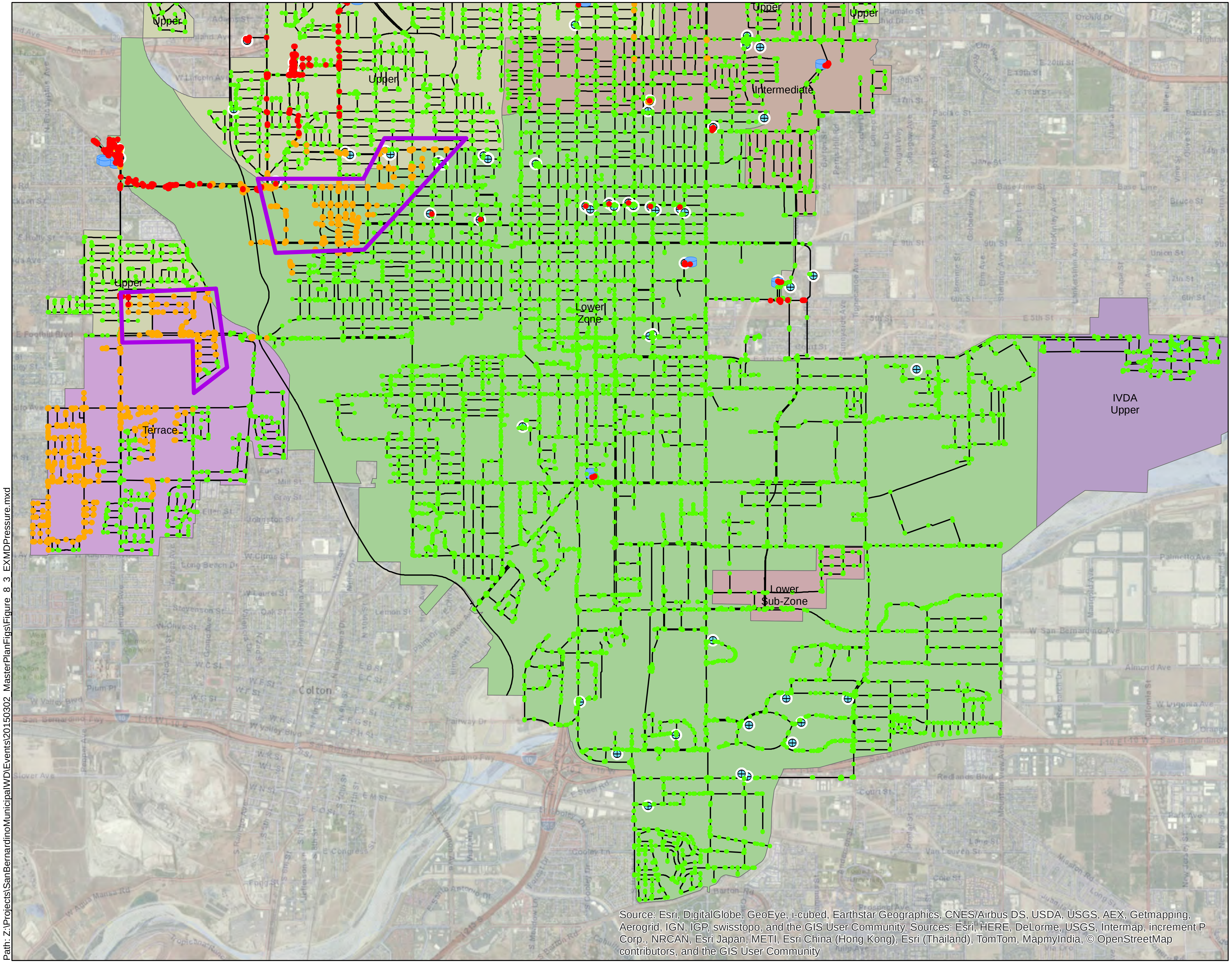
Kennedy/Jenks Consultants

San Bernardino Water Facilities MP
San Bernardino, California

Existing Maximum Day Demands
Minimum System Pressure
Central Area

1383002*00
May 2015

Figure 8-2



Legend

- Minimum Pressure > 40 psi
- Minimum Pressure Between 20 and 40 psi
- Minimum Pressure < 20 psi
- Tanks
- Production Well

Main Line

- Main Line

PZNAME

- 1880 Zone
- 2040 Zone
- 2300 Zone East
- 2500 Zone
- 2700 Zone
- 3000 Zone
- Cajon
- College / Palm
- College / Palm Sub-Zone A
- College / Palm Sub-Zone B
- Daley
- Del Rosa
- Devil Canyon
- Devil Canyon Dom
- Devore / Meyers
- IVDA Upper
- Intermediate
- Lower Sub-Zone
- Lower Zone
- Mountain
- Mountain Sub-Zone A
- Mountain Sub-Zone B
- Ridgeline
- Ridgeline Hydro
- Ridgeview
- Shandin Hills
- Sycamore
- Terrace
- Upper

Proposed Zone Realignment

N

0 5,000 10,000

Feet

Kennedy/Jenks Consultants

San Bernardino Water Facilities MP
San Bernardino, California

Existing Maximum Day Demands
Minimum System Pressure
South Area

1383002*00
Mayl 2015

Figure 8-3

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8.2.5 Existing Fire Flow Evaluation

The hydraulic model was also used to evaluate the distribution system under fire flow conditions. The specific criterion evaluated included a minimum system pressure of 20 psi when fire flow demands are applied to the system in addition to maximum day demands.

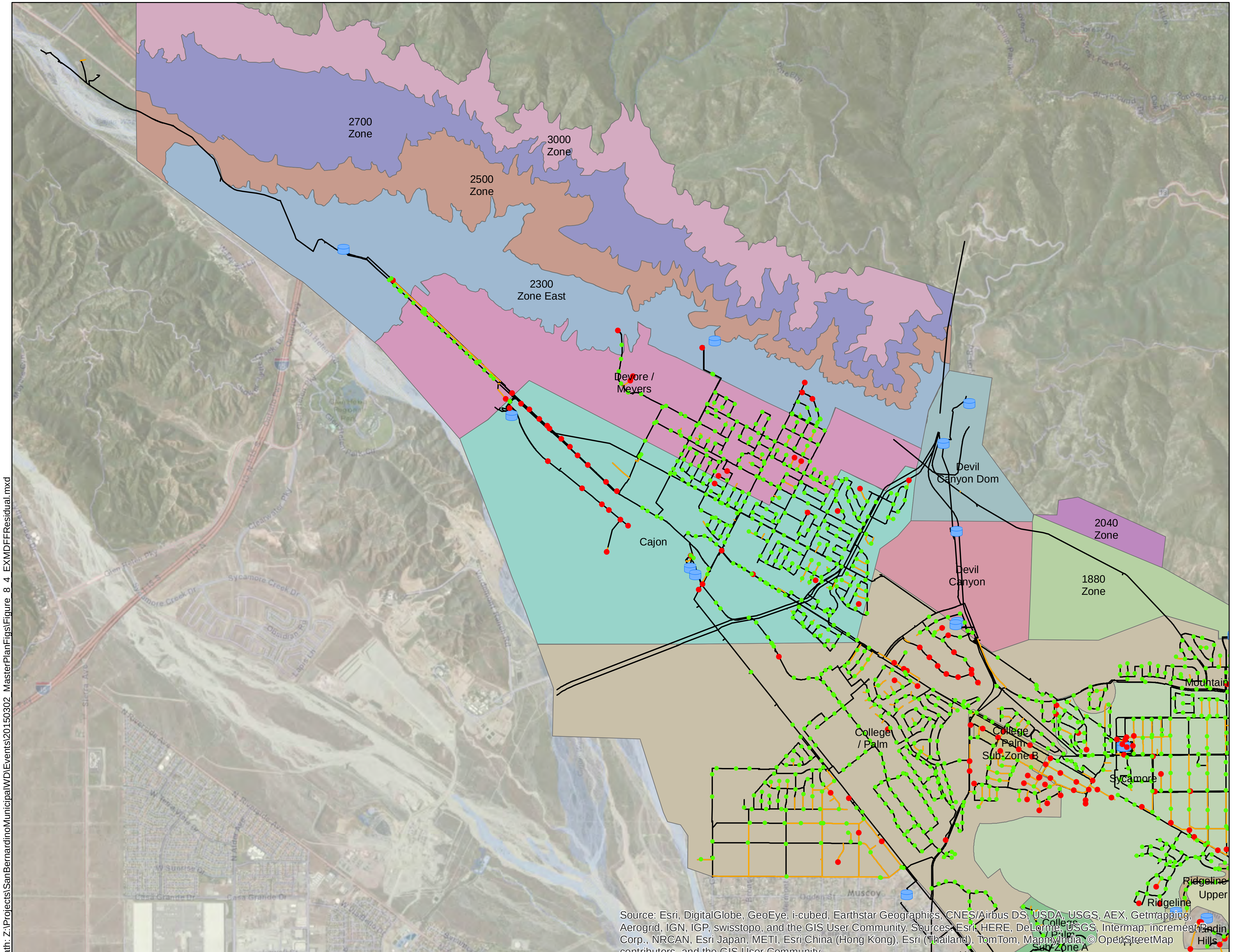
In many locations, the distribution system was not able to satisfy the allowable criterion. These locations are predominantly located along pipelines with a diameter of 6 inches or smaller. Since most of these pipelines are supplied by a larger pipeline, a simple upsizing of the pipe in question generally solves all velocity and pressure problems. The pressures in the system under fire flow conditions, as calculated in the model, are shown on Figure 8-4, Figure 8-5 and Figure 8-6.

In several industrial locations, specific hydrants had large fire flow demands of as high as 4,000 gpm. It is not generally possible for a single hydrant to supply 4,000 gpm, even if the distribution system can supply that rate of flow to the hydrant. In some locations, there were multiple nearby hydrants that could assist in meeting the fire flow requirement. If there were more than one hydrant in the vicinity of a hydrant that did not meet the criterion, the total capacity of the failing hydrant and the nearby hydrants was considered. If the total capacity was sufficient to meet the fire flow requirements in the area, then no improvement project was recommended.

8.2.6 Recommended System Improvements for Existing Conditions

As a complete system, the Department's distribution system operates well. However, there are significant deficiencies for fire flow capacity, and a deficiency in the Terrace zone under maximum day demand conditions. A major issue revealed through various existing condition evaluations and the hydraulic modeling analyses included undersized pipes which serve developments that may be larger than originally intended. A second issue is with adequate supply into the Terrace zone under the highest demand periods in maximum day demand conditions. A third issue is the lack of storage and adequate pumping in a few pressure zones, as has been detailed in sections 8.2.2 and 8.2.3.

Pumping capacity deficits were identified for the Mountain, Intermediate, and Lower pressure zones. However, since the Lower and Intermediate zones both have additional supply from wells and regulating valves from higher zones, the criteria for pumping capacity should not be applied in the same way for these zones. Increasing the pumping capacity for these two zones is not recommended. The only pumping capacity project that needs to be addressed is for the Mountain zone. The capacity deficit for this zone is relatively minor for existing conditions, and will increase for future demands. Therefore, when this pumping capacity deficit is addressed, it is recommended that projected increases in the pumping capacity deficit for future demands be considered. It is recommended that this project be deferred and addressed with the other recommended projects for future conditions.



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Legend

- Residual Pressure > 20 psi
- Residual Pressure < 20 psi
- Tanks

Main Line

- Main Line
- Pipe Diameters =< 6"
- CIP Projects

PZNAME

- 1880 Zone
- 2040 Zone
- 2300 Zone East
- 2500 Zone
- 2700 Zone
- 3000 Zone
- Cajon
- College / Palm
- College / Palm Sub-Zone A
- College / Palm Sub-Zone B
- Daley
- Del Rosa
- Devil Canyon
- Devil Canyon Dom
- Devore / Meyers
- IVDA Upper
- Intermediate
- Lower Sub-Zone
- Lower Zone
- Mountain
- Mountain Sub-Zone A
- Mountain Sub-Zone B
- Ridgeline
- Ridgeline Hydro
- Ridgeview
- Shandin Hills
- Sycamore
- Terrace
- Upper

Proposed Zone Realignment

N

0 5,000 10,000
Feet

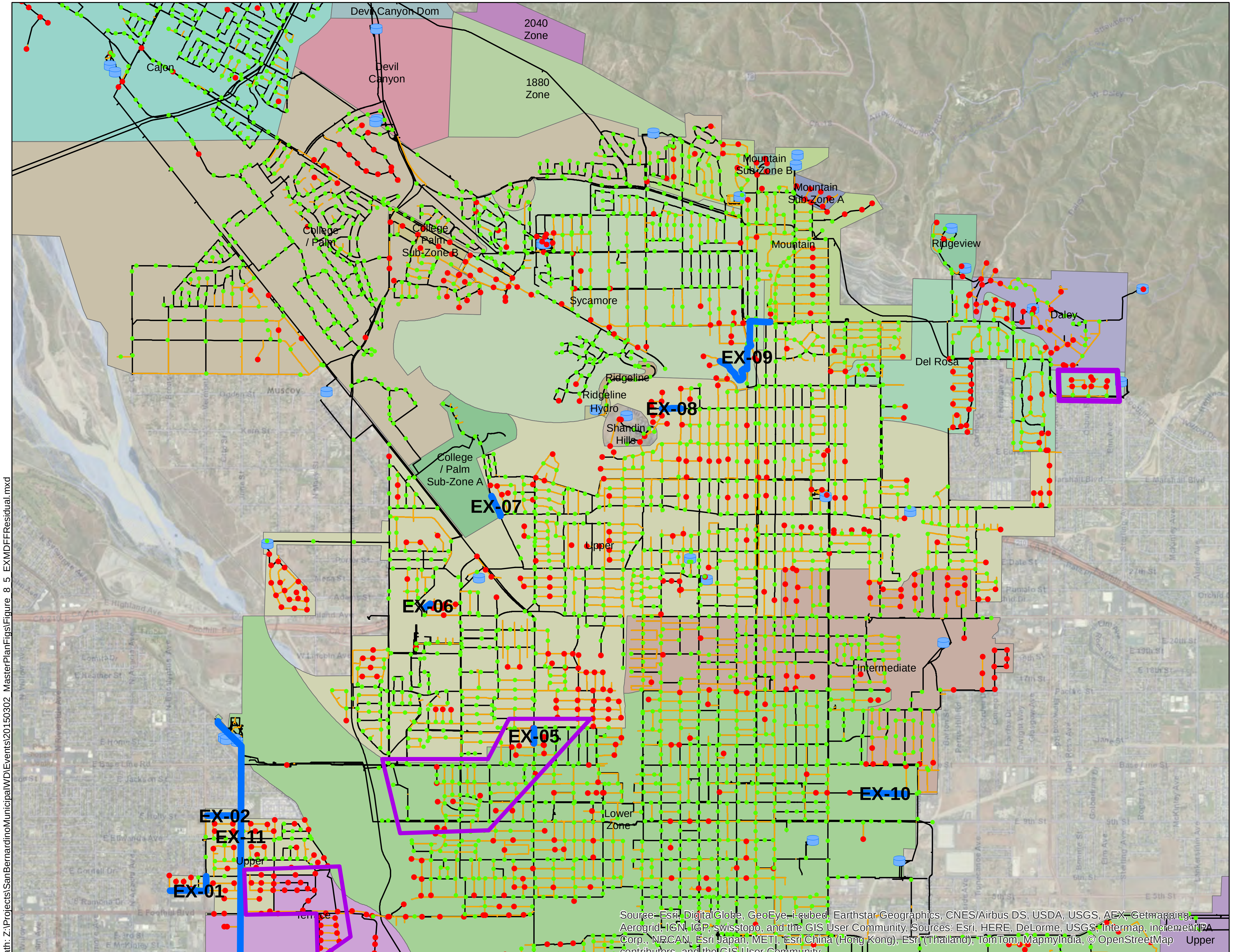
Kennedy/Jenks Consultants

San Bernardino Water Facilities MP
San Bernardino, California

Existing Maximum Day Demands
Plus Fire Flow Demands
Residual System Pressure in North Area

1383002*00
May 2015

Figure 8-4



Legend

- Residual Pressure > 20 psi
- Residual Pressure < 20 psi
- Tanks

Main Line

- Main Line
- Pipe Diameters =< 6"
- CIP Projects

PZNAME

- 1880 Zone
- 2040 Zone
- 2300 Zone East
- 2500 Zone
- 2700 Zone
- 3000 Zone
- Cajon
- College / Palm
- College / Palm Sub-Zone A
- College / Palm Sub-Zone B
- Daley
- Del Rosa
- Devil Canyon
- Devil Canyon Dom
- Devore / Meyers
- IVDA Upper
- Intermediate
- Lower Sub-Zone
- Lower Zone
- Mountain
- Mountain Sub-Zone A
- Mountain Sub-Zone B
- Ridgeline
- Ridgeline Hydro
- Ridgeview
- Shandin Hills
- Sycamore
- Terrace
- Upper

Proposed Zone Realignment

N

0 5,000 10,000
Feet

Kennedy/Jenks Consultants

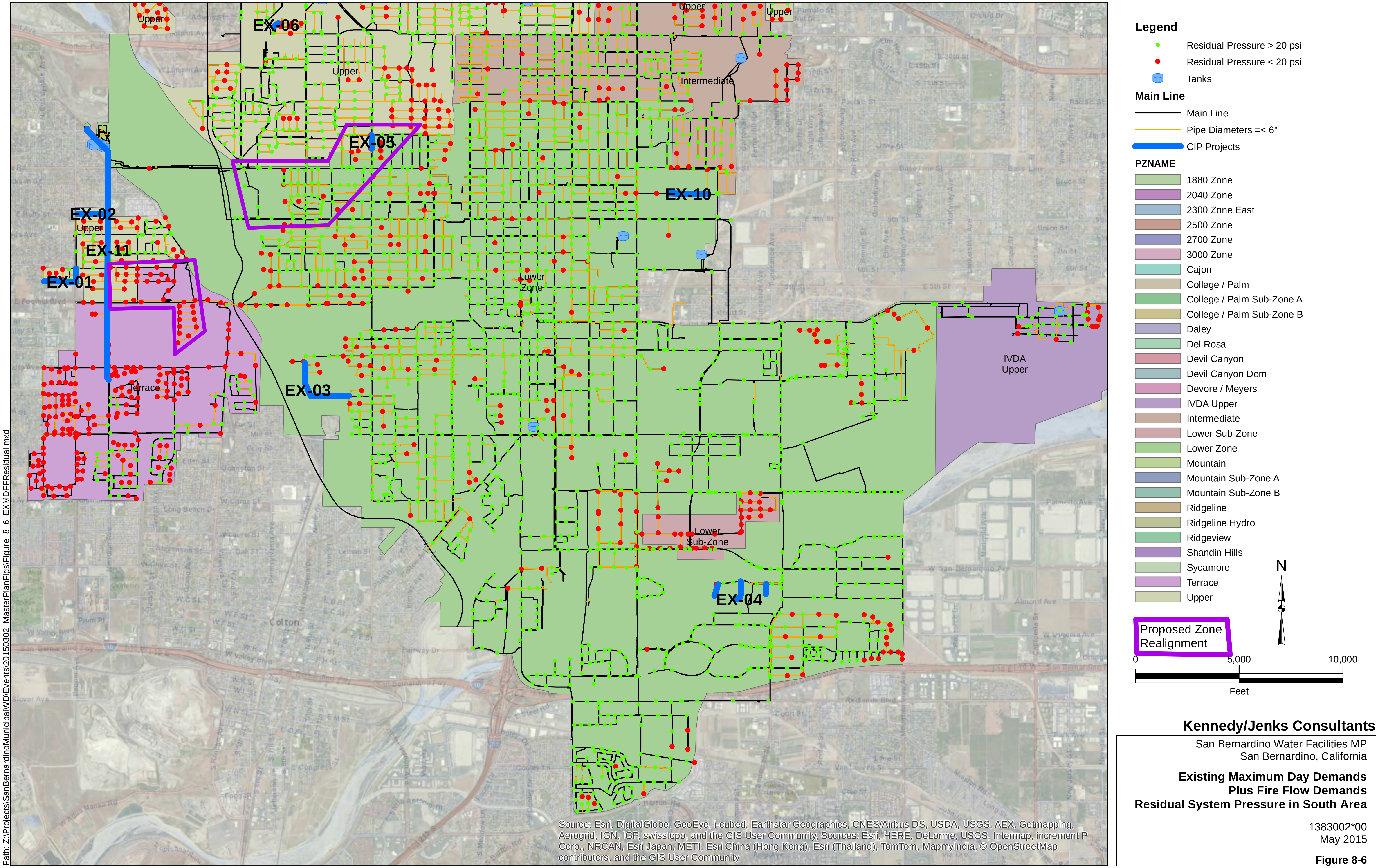
San Bernardino Water Facilities MP
San Bernardino, California

Existing Maximum Day Demands Plus Fire Flow Demands Residual System Pressure in Central Area

1383002*00
May 2015

Figure 8-5

Path: Z:\Projects\SanBernardinoMunicipalWD\Events\20150302_MasterPlanFigs\Figure_8_5_EXMDFFResidual.mxd



Kennedy/Jenks Consultants

San Bernardino Water Facilities MP
San Bernardino, California

Existing Maximum Day Demands Plus Fire Flow Demands Residual System Pressure in South Area

1383002*00
May 2015

Figure 8-6

Storage capacity deficits were identified for the Ridgeline, IVDA and Terrace zones. The Department is planning to combine the IVDA zone with the Intermediate zone and decommission the IVDA elevated storage tank. Therefore, no storage project is recommended for the IVDA zone, as the Intermediate zone has adequate storage to add the demands from the IVDA zone. The storage deficit for the Terrace zone is relatively small. The Ridgeline zone does have a storage deficit that should be addressed. While the storage deficit is not particularly large in terms of volume, it is significant when compared to the existing storage in the Ridgeline zone. The recommended project will more than double the storage for the Ridgeline zone. Additionally, this zone currently does not have enough storage to meet the fire flow portion of the required storage, which makes this project even more important. The recommended project is listed in Table 8-4.

Table 8-4: Recommended Storage Project

Zone	Storage Deficit (gallon)	Unit Cost ($/gallon)	Cost ($)
Ridgeline	145,500	1.64	239,000
Total			**239,000**

Pipeline capacity deficiencies were identified in several zones throughout the system. As is shown in Table 8-5 and detailed further in Section 8, approximately 4.0 miles of pipe is being recommended for replacement. Upsizing of these pipes will correct deficiencies which have been identified as existing problems. The deficiencies identified were generally focused in areas where the existing pipelines were larger than 6", but were still deficient, in areas where the fire flow demands were generally higher than the 1,500 gpm required for residential areas, and in areas where a pipeline project can help to provide sufficient capacity to multiple hydrants. In this way, the recommended projects were focused on the more severe system deficiencies.

Table 8-5: Recommended Pipeline Projects

Project Number	Streets	Original Pipe Diameter (in)	New Pipe Diameter (in)	Pipe Length (ft)	Zone	Cost ($)
1	Spruce Street from Eucalyptus to Pepper and Pepper Avenue from Spruce to 6th	8	12	1,820	Upper	502,000
2	9th Street from Pepper to Meridian Avenue	8 CI	12	1,260	Upper	348,000
3	Muscott and Walnut Streets from Belleview Street to west side of railroad right-of-way by Artesian Street	4,6,8	12	2,920	Lower	806,000
4	Cooley Court, Gage Street and Sunnyside Avenue, south of Cooley Street	8	12	1,750	Lower	483,000
5	Mount Vernon Avenue from 13th Street to 14th Street	8 CI	12	540	Lower	150,000
6	Not used					

7	Little Mountain Drive from 30th to south of Bussey Street	8 CI	12	800	Upper	221,000
8	36th Street from F Street to G Street	8	12	670	Upper	185,000
9	40th Street from Genevieve to Palm, Palm from 40th to 39th, continuing south to Edgerton, continuing west to end of Egderton, Skylark Drive from Edgerton to end	6,8	12	5,320	Mountain	1,468,000
10	Olive Street, from Myrtle west to approximately 600 feet west of La Junta	None	8	1,500	Lower	276,000
11	Meridian Avenue from Terrace tank to railroad right-of-way just south of Rialto	16	30	5,600	Terrace	3,864,000
				21,250	**Total**	**8,302,000**

While pipeline projects one through ten are focused on increasing hydraulic capacity to a particular area to meet larger fire flow demands, Project 11 along Meridian Avenue merits further explanation. The recommended project is a 30" pipeline that will replace the 16" pipeline between the existing Terrace storage tanks and the Terrace zone. Currently the Terrace zone is supplied only through the existing 16" pipeline from the tanks, and from the Terrace Foothill Booster Station on Foothill Boulevard. In the highest demand hours under maximum day demands, these two supply sources do not have the capacity to provide adequate flow to the zone. Additionally, under maximum day demands plus fire flow, these two supply sources do not have adequate capacity. There are other options for addressing this deficiency, such as increasing the capacity of the Foothill Booster station or installing a regulating valve that would provide additional flow from the adjacent Upper zone. However, each of these options will also require pipeline upgrades either within the Terrace zone to provide flow to the appropriate parts of the Terrace zone, or within the zones from which the additional supply will be provided. The existing 16" pipeline between the Terrace tanks and the Terrace zone was built in the mid 1950's and is likely reaching the end of its useful life. Given that it will need to be replaced due to its age, it was decided that the best option for addressing the supply deficiency for the Terrace zone would be to combine the age-based replacement with a capacity upgrade to address the capacity deficiency. The size of the proposed pipeline was determined from the analysis of future demands so that this pipeline will have adequate capacity under future demand conditions.

There are three other areas in the system where parts of zones at higher elevations may benefit from a zone boundary alignment. In these areas, the system does not meet the evaluation criteria for maximum day demands and/or maximum day plus fire flow. These three areas are described as follows:

1) Terrace zone: The portion of the Terrace zone north of Foothill Boulevard, as well as the area south of Foothill Boulevard along and between Macy Street and Terrace Street does not meet the evaluation criteria. This area could be transferred to the adjacent Upper zone. A study is recommended to evaluate the effect of the transfer of the demands on the Upper zone, and to determine the facility changes that would be

required. Transfer of demand from the Terrace to the Upper zone will also help ensure that Pipeline Project 11 will adequately resolve the supply issues in the Terrace zone. Verification of this should be included in the zone boundary analysis.

2) Lower zone: The portion of the Lower zone north of 9th Street, east of Pennsylvania Avenue, and approximately west of Highway 215 does not meet the evaluation criteria. This area could be transferred to the adjacent Upper zone. A study is recommended to evaluate the effect of the transfer of the demands on the Upper zone, and to determine the facility changes that would be required. Both the Lytle reservoirs and the B. Warren Cocke (also known as Medical Center) reservoir are connected to the Lower zone through the area that is proposed to be transferred to the Upper zone. Adequate capacity must be maintained for these storage facilities to supply the Lower zone through the area to be transferred.

3) Del Rosa zone: The portion of the Del Rosa zone north of Foothill Drive between Chiquita Lane and Elm Avenue does not meet the evaluation criteria. This area could be transferred to the adjacent Daley zone. A study is recommended to evaluate the effect of the transfer of the demands on the Daley zone, and to determine the facility changes that would be required. This area is close in proximity and elevation to the Del Rosa 3 tank, which is why the pressures are low under some demand conditions. It appears that there is existing piping in place along Del Rosa Avenue and Foothill Drive that will assist with the transfer of this area. However, because this piping is only 6" diameter, additional supply will be required. It is likely that a connection between Osbun Road in the Daley zone and Mesa Verde Avenue will provide adequate capacity. When this change was preliminarily tested in the hydraulic model, pressures along Mesa Verde were as high as 160 psi, which is excessive. Therefore, this area may need to be its own regulated subzone supplied by the Daley zone.

It is recommended that these zone realignment studies be conducted before capital improvement projects in these three areas are begun. It is recommended that the Department include $50,000 for each of the three separate zone realignment studies. The three zone realignment studies are listed in Table 8-6.

Table 8-6: Zone Realignment Studies

Project	Zone	Estimated Cost
1	Terrace	$50,000
2	Lower	$50,000
3	Del Rosa	$50,000

8.3 Future Conditions Hydraulic Analysis

The analyses for future demand conditions were conducted similarly to the analyses for existing demand conditions.

8.3.1 Future Pump Capacity Evaluation

For future demand conditions, the pumping facilities for each zone, or group of zones, were evaluated to determine if there is sufficient pumping capacity to meet the criteria. Pressure zones with significant well capacity were not held to the same criteria. Additionally, zones that could receive supply from higher pressure zones through regulating valves were not held to the same criteria. Table 8-7 summarizes the additional pumping capacity needed for each pressure zone based on future demands.

The identified pump station deficits are summarized as follows:

1) The Daley zone shows a small deficit that should be evaluated in the future as demands increase to determine if the deficit needs to be addressed. With the current demand projections, the deficit is likely too small to be addressed. However, if the proposed zone realignment is undertaken to transfer demand from the Del Rosa zone to the Daley zone, this pumping capacity deficit may increase to the level that it should be dealt with.

2) The Devore/Meyers Subzone zone shows a small deficit that should be evaluated in the future as demands increase to determine if the deficit needs to be addressed.

3) The Intermediate zone has a pumping capacity deficit. However, this zone has wells and regulating valves that supplement supply. Therefore, this pumping capacity deficit does not need to be addressed.

4) The Lower zone has a pumping capacity deficit. However, this zone has wells and regulating valves that supplement supply. Therefore, this pumping capacity deficit does not need to be addressed.

5) The Mountain zone does have a pumping capacity deficit that is addressed in the Department's 5-Year CIP.

6) The Terrace zone shows a small deficit. This deficit may need to be addressed in the future, perhaps in conjunction with other improvements to the Terrace zone. Given that there is a recommendation for a zone boundary realignment for the Terrace zone that has been proposed for existing demand conditions, this deficit should be considered in conjunction with the zone boundary realignment, as the deficit may be lessened, or may no longer exist after the boundaries are realigned.

Table 8-7: Future Pumping Capacity Evaluation

Zone	Firm Pumping Available (MGD)	Firm Pumping Required (MGD)	Additional Needed Capacity (MGD)	Notes
Cajon	15.12	4.24	0.00	
College/Palm	26.50	13.29	0.00	
Devil Canyon	0.22	0.00	0.00	
Daley	0.72	0.79	0.07	Small Deficit
Del Rosa	3.60	3.03	0.00	
Devore/Meyers	10.80	4.00	0.00	

Zone	Firm Pumping Available (MGD)	Firm Pumping Required (MGD)	Additional Needed Capacity (MGD)	Notes
Devore/Meyers Subzone (2300)	0.39	0.52	0.13	Small Deficit
Intermediate	1.87	5.66	3.79	This zone has wells and regulated supply
IVDA	3.17	0.12	0.00	
Lower	1.01	37.76	36.75	This zone has wells and regulated supply
Mountain	1.94	3.94	2.00	Deficit addressed in Department 5-Year CIP
Mountain Subzone (1668)	1.01	0.21	0.00	
Mountain Subzone (1693)	0.50	0.06	0.00	
Ridgeview	0.61	0.23	0.00	
Ridgeline	0.86	0.26	0.00	
Shandin Hills	0.43	0.26	0.00	
Sycamore	8.88	5.84	0.00	
Terrace	6.80	6.98	0.18	Small Deficit
Upper	42.50	17.31	0.00	

8.3.2 Future Storage Evaluation

The storage analysis for future demand conditions consisted of evaluating the volume of the existing storage facilities within each pressure zone, or group of pressure zones, to determine if that volume was equal to or greater than the minimum required storage based on the future demands. Table 8-8 summarizes the amount of storage required for each pressure zone based on future demands, the amount of existing storage in each zone and the deficit or surplus in each zone. The storage deficits are summarized as follows:

1) The College/Palm zone does not show a storage deficit according to the analysis. However, the Department has included a tank in its 5-year CIP for the east end of this zone to help with supply reliability in that area of the system.

2) The IVDA zone shows a storage deficit, but this zone is planned to be combined with the Intermediate zone, which has a large storage surplus. The existing IVDA tank is to be decommissioned.

3) The Mountain zone shows a relatively small deficit, but the City has already included a new tank for this zone in its 5-year CIP which will address this deficit.

4) The Ridgeline zone shows a small deficit, but the deficit is large in comparison to the demands for this zone, as it is a small zone. It is recommended that this deficit be addressed.

5) The Shandin Hills zone shows a small deficit, but the deficit is large in comparison to the demands for this zone, as it is a small zone. It is recommended that this deficit be addressed.

6) The Terrace zone shows a significant storage deficit for future demand conditions. This deficit was identified in the prior water master plan. It is recommended that this deficit be addressed.

Table 8-8: Future Storage Evaluation

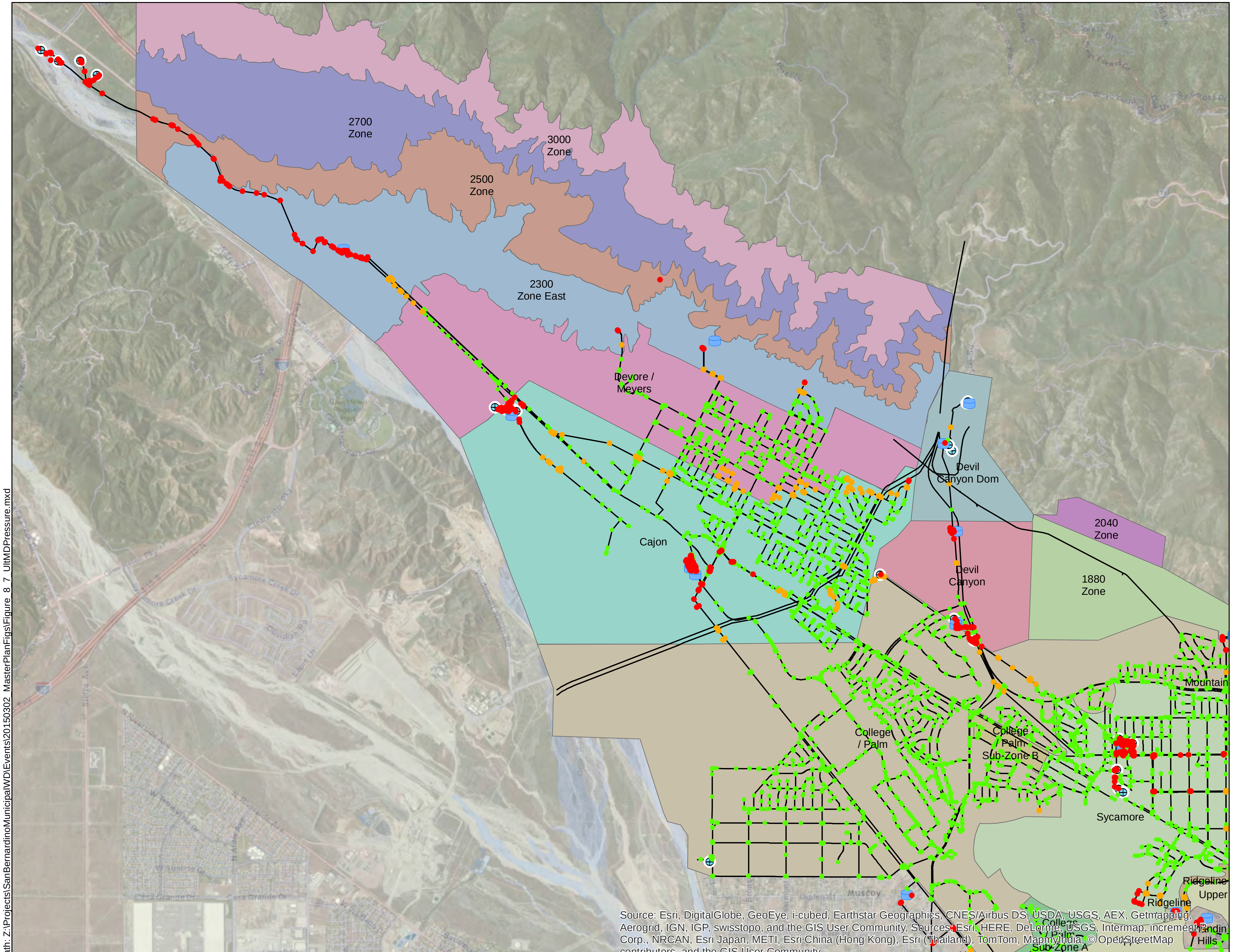
Zone	Storage Required (gal)	Storage Available (gal)	Surplus/Deficit (gal)	Note
Cajon	2,813,027	5,000,000	2,186,973	
College/Palm	7,790,461	11,905,000	4,114,539	Additional Tank Planned in Department's 5-Year CIP
Devil Canyon	180,000	230,000	50,000	
Daley	735,740	1,500,000	764,260	
Del Rosa	1,584,024	3,650,000	2,065,976	
Devore/Meyers	3,953,628	4,000,000	46,372	
Intermediate	3,591,577	10,355,500	6,763,923	
IVDA	366,332	250,000	-116,332	Tank to be Decommissioned
Lower	21,247,674	33,904,500	12,656,826	
Mountain	2,468,871	2,233,000	-235,871	Small Deficit – Tank Planned in Department's 5-Year CIP
Ridgeview	304,400	330,000	25,600	
Ridgeline	324,748	102,000	-222,748	Small Deficit, but large in comparison to size of the pressure zone
Shandin Hills	320,930	219,000	-101,930	Small Deficit, but large in comparison to size of the pressure zone
Sycamore	3,546,120	8,948,000	5,401,880	
Terrace	4,141,369	2,445,000	-1,696,369	Significant Deficit
Upper	10,001,834	34,779,000	24,777,166	

8.3.3 Future Distribution System Evaluation

The hydraulic model constructed for this report was used to evaluate performance of the distribution system for future demand conditions using the criteria for pressure, velocity and head loss that are presented in Section 6.

The Department has incorporated most of the improvement projects that had been recommended in the prior master plan. The improvement projects that have already been constructed are reflected in the scenarios for the existing system. The Department has a list of projects included in its 5-year CIP that have not yet been constructed. These projects have been included in the model for the future scenarios under the assumption that they will be constructed within the next 5 years. In this manner, the distribution system was evaluated for future demand conditions with the projects on the 5-year CIP list assumed to be already constructed. The projects recommended for existing conditions were also included in the future scenarios.

The distribution system did not show significant differences in performance between the analysis for existing and future conditions. The results from the maximum day and fire flow analyses are shown in Figure 8-7, Figure 8-8, Figure 8-9, Figure 8-10, Figure 8-11 and Figure 8-12. The pipelines from the existing system recommendations and the 5-year CIP assisted in maintaining the performance of the system as the demands increased to the buildout projections. The only differences that were identified were in the extent of the areas in the Terrace and Lower zones that are recommended to be transferred to the Upper zone through a zone boundary realignment. The areas that did not meet the criteria were larger under future demand conditions. Otherwise, the distribution system performed well under future maximum day demands and future maximum day plus fire flow, except for the areas where hydrants are supplied by distribution pipelines that are 6 inches or smaller. As in the existing system, there are many areas where the system cannot provide adequate fire flow through the smaller diameter pipelines. The major areas where fire flow capacity is inadequate were dealt with through the recommendations for existing conditions. There are no further pipeline recommendations for future demand conditions. However, the smaller diameter pipelines should be dealt with as part of the Department's pipeline replacement program.



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Legend

- Minimum Pressure Between 20 and 40 psi
- Minimum Pressure > 40 psi
- Minimum Pressure < 20 psi
- Tanks
- Production Well

Main Line

- Main Line

PZNAME

- 1880 Zone
- 2040 Zone
- 2300 Zone East
- 2500 Zone
- 2700 Zone
- 3000 Zone
- Cajon
- College / Palm
- College / Palm Sub-Zone A
- College / Palm Sub-Zone B
- Daley
- Del Rosa
- Devil Canyon
- Devil Canyon Dom
- Devore / Meyers
- IVDA Upper
- Intermediate
- Lower Sub-Zone
- Lower Zone
- Mountain
- Mountain Sub-Zone A
- Mountain Sub-Zone B
- Ridgeline
- Ridgeline Hydro
- Ridgeview
- Shandin Hills
- Sycamore
- Terrace
- Upper

N

Proposed Zone Realignment

0 5,000 10,000

Feet

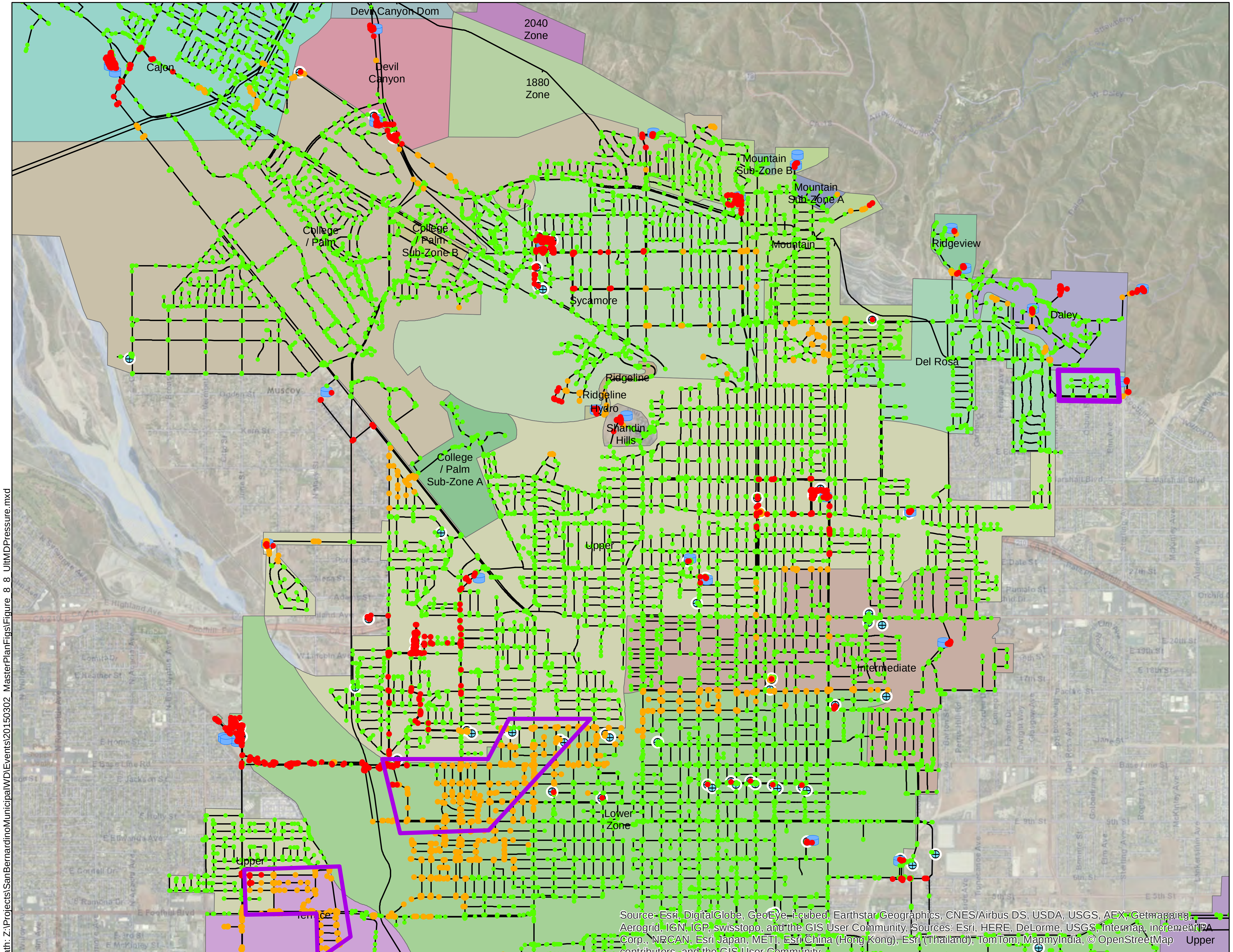
Kennedy/Jenks Consultants

San Bernardino Water Facilities MP
San Bernardino, California

Ultimate Maximum Day Demands
Minimum System Pressure
North Area

1383002*00
May 2015

Figure 8-7



Legend

- Minimum Pressure Between 20 and 40 psi
- Minimum Pressure > 40 psi
- Minimum Pressure < 20 psi
- Tanks
- Production Well

Main Line

- Main Line

PZNAME

- 1880 Zone
- 2040 Zone
- 2300 Zone East
- 2500 Zone
- 2700 Zone
- 3000 Zone
- Cajon
- College / Palm
- College / Palm Sub-Zone A
- College / Palm Sub-Zone B
- Daley
- Del Rosa
- Devil Canyon
- Devil Canyon Dom
- Devore / Meyers
- IVDA Upper
- Intermediate
- Lower Sub-Zone
- Lower Zone
- Mountain
- Mountain Sub-Zone A
- Mountain Sub-Zone B
- Ridgeline
- Ridgeline Hydro
- Ridgeview
- Shandin Hills
- Sycamore
- Terrace
- Upper

Proposed Zone Realignment

N

0 5,000 10,000
Feet

Kennedy/Jenks Consultants

San Bernardino Water Facilities MP
San Bernardino, California

Ultimate Maximum Day Demands
Minimum System Pressure
Central Area

1383002*00
May 2015

Figure 8-8

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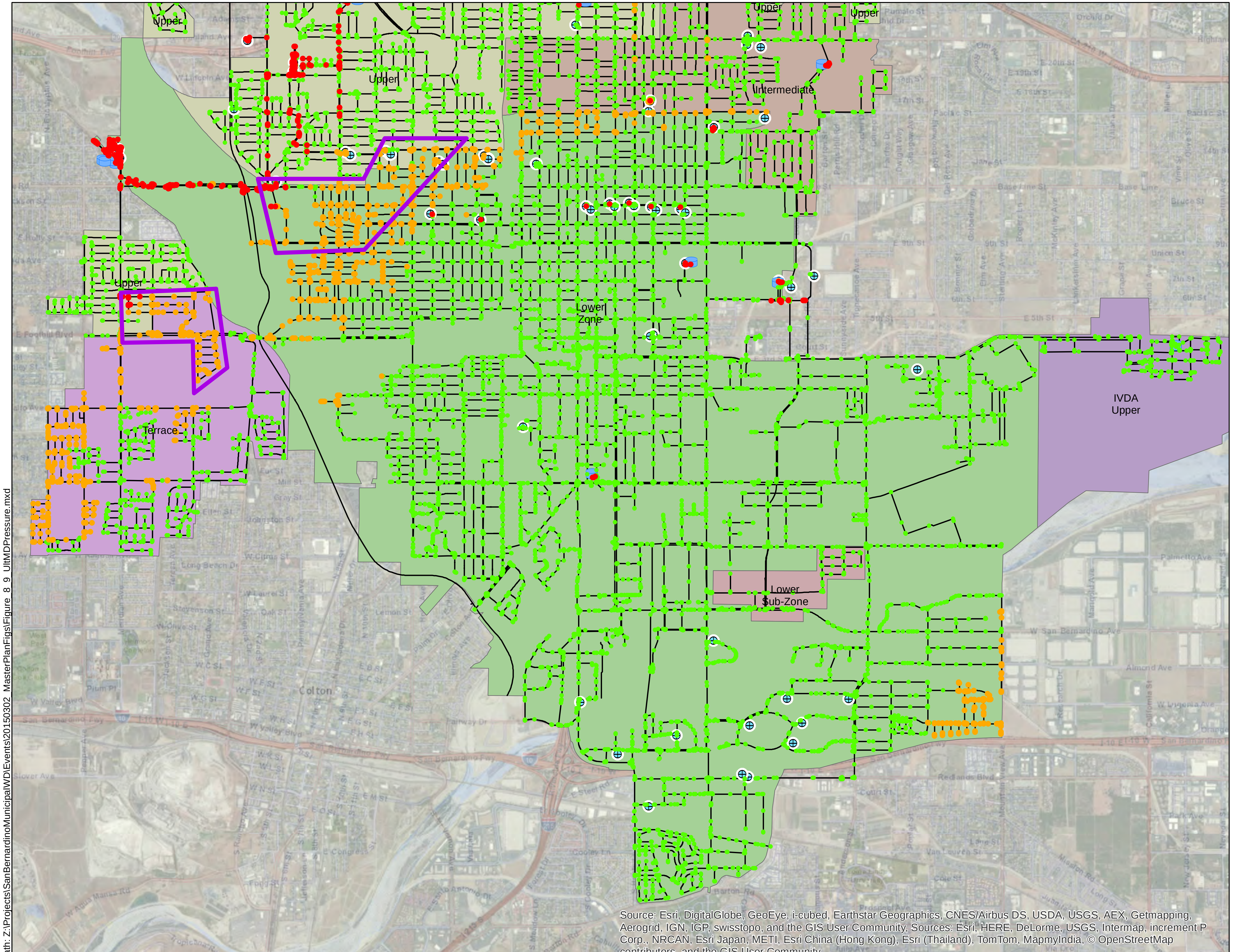

Legend

- Minimum Pressure Between 20 and 40 psi
- Minimum Pressure > 40 psi
- Minimum Pressure < 20 psi
- Tanks
- Production Well

Main Line

- Main Line

PZNAME

- 1880 Zone
- 2040 Zone
- 2300 Zone East
- 2500 Zone
- 2700 Zone
- 3000 Zone
- Cajon
- College / Palm
- College / Palm Sub-Zone A
- College / Palm Sub-Zone B
- Daley
- Del Rosa
- Devil Canyon
- Devil Canyon Dom
- Devore / Meyers
- IVDA Upper
- Intermediate
- Lower Sub-Zone
- Lower Zone
- Mountain
- Mountain Sub-Zone A
- Mountain Sub-Zone B
- Ridgeline
- Ridgeline Hydro
- Ridgeview
- Shandin Hills
- Sycamore
- Terrace
- Upper

Proposed Zone Realignment

N

0 5,000 10,000

Feet

Kennedy/Jenks Consultants

San Bernardino Water Facilities MP
San Bernardino, California

Ultimate Maximum Day Demands
Minimum System Pressure
South Area

1383002*00
May 2015

Figure 8-9

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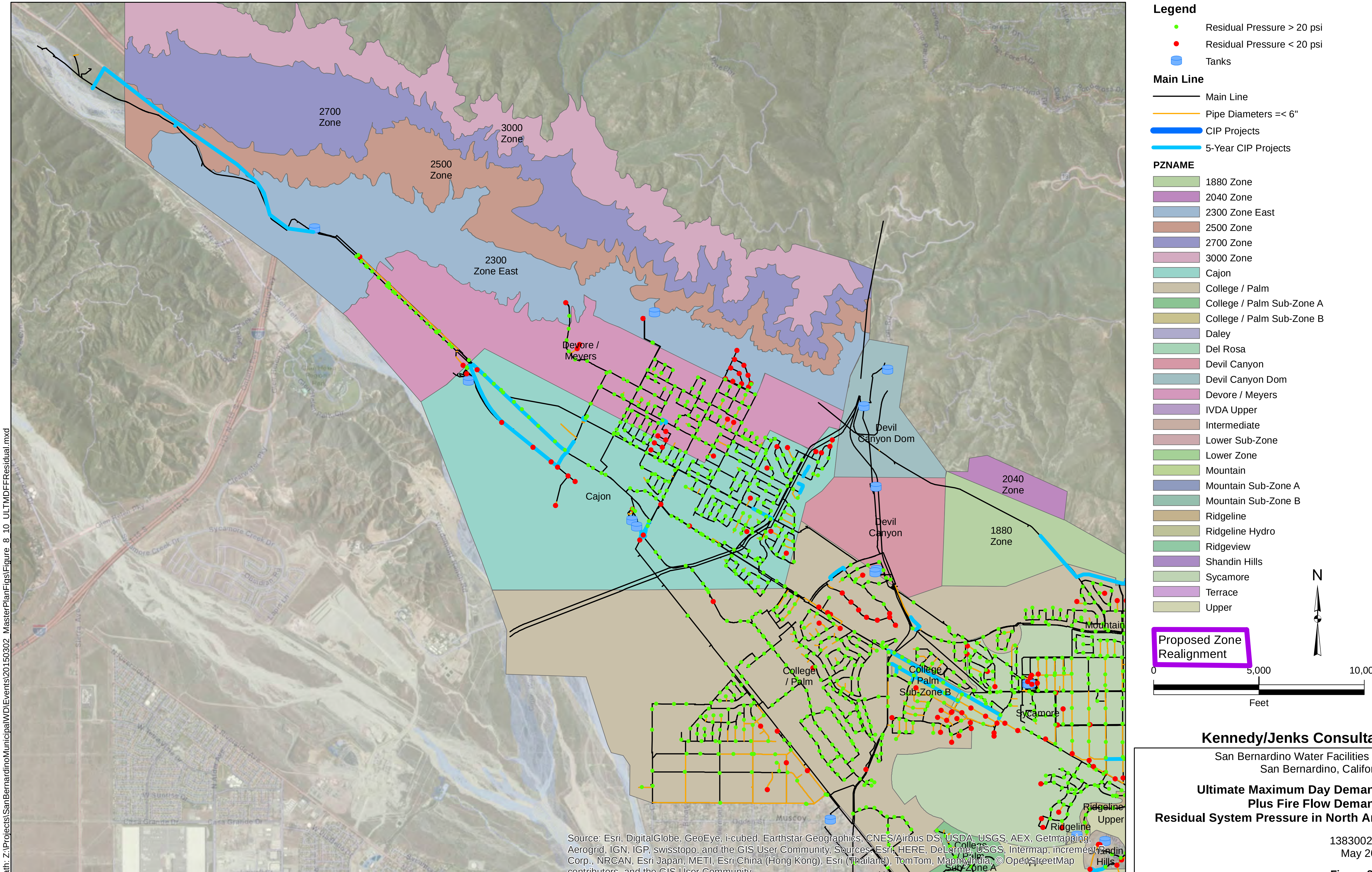

Kennedy/Jenks Consultants

San Bernardino Water Facilities MP
San Bernardino, California

Ultimate Maximum Day Demands Plus Fire Flow Demands Residual System Pressure in North Area

1383002*00
May 2015

Figure 8-10

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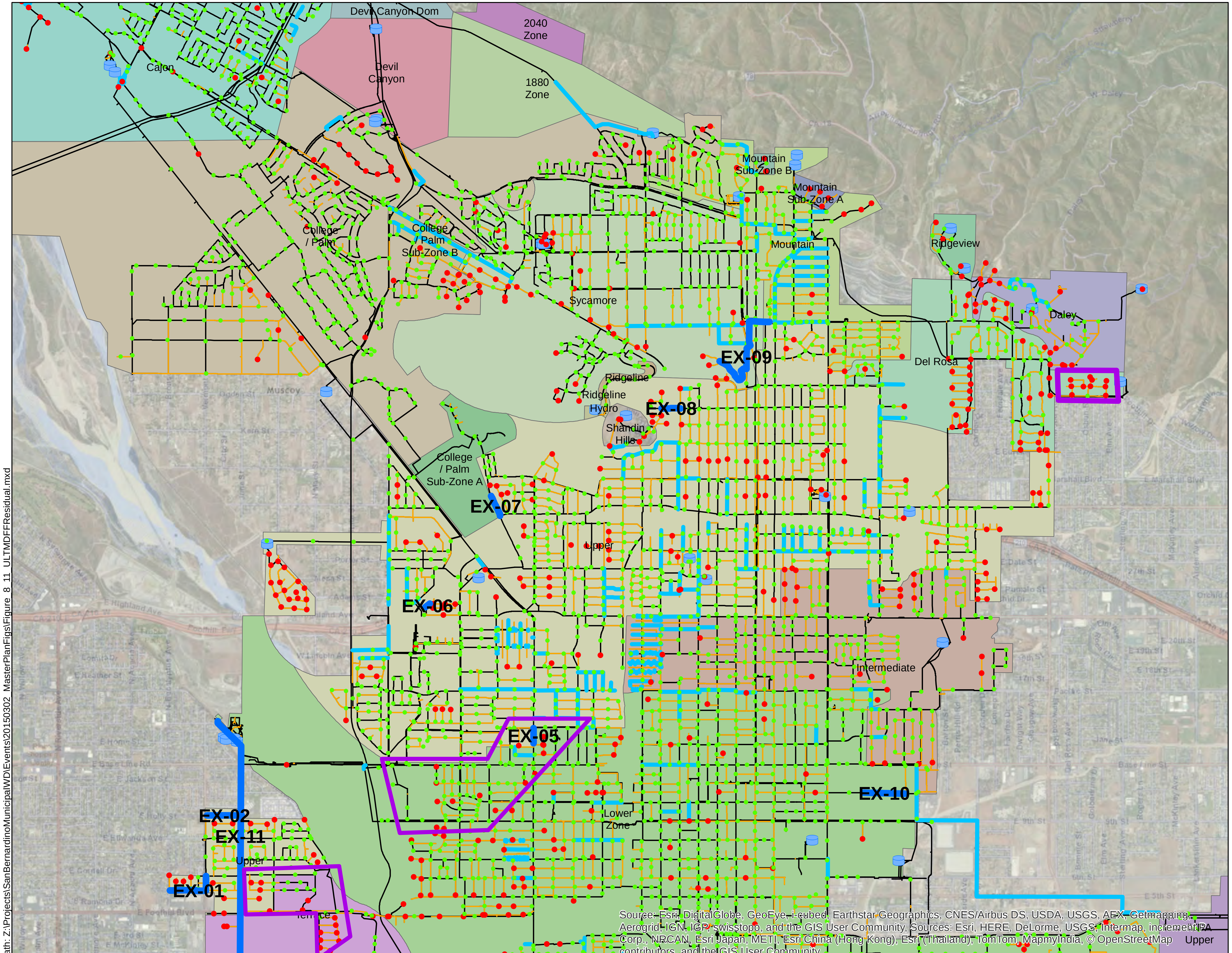

Legend

- Residual Pressure > 20 psi
- Residual Pressure < 20 psi
- Tanks

Main Line

- Main Line
- Pipe Diameters =< 6"
- CIP Projects
- 5-Year CIP Projects

PZNAME

- 1880 Zone
- 2040 Zone
- 2300 Zone East
- 2500 Zone
- 2700 Zone
- 3000 Zone
- Cajon
- College / Palm
- College / Palm Sub-Zone A
- College / Palm Sub-Zone B
- Daley
- Del Rosa
- Devil Canyon
- Devil Canyon Dom
- Devore / Meyers
- IVDA Upper
- Intermediate
- Lower Sub-Zone
- Lower Zone
- Mountain
- Mountain Sub-Zone A
- Mountain Sub-Zone B
- Ridgeline
- Ridgeline Hydro
- Ridgeview
- Shandin Hills
- Sycamore
- Terrace
- Upper

Proposed Zone Realignment

N

0 5,000 10,000
Feet

Kennedy/Jenks Consultants

San Bernardino Water Facilities MP
San Bernardino, California

Ultimate Maximum Day Demands Plus Fire Flow Demands Residual System Pressure in Central Area

1383002*00
May 2015

Figure 8-11

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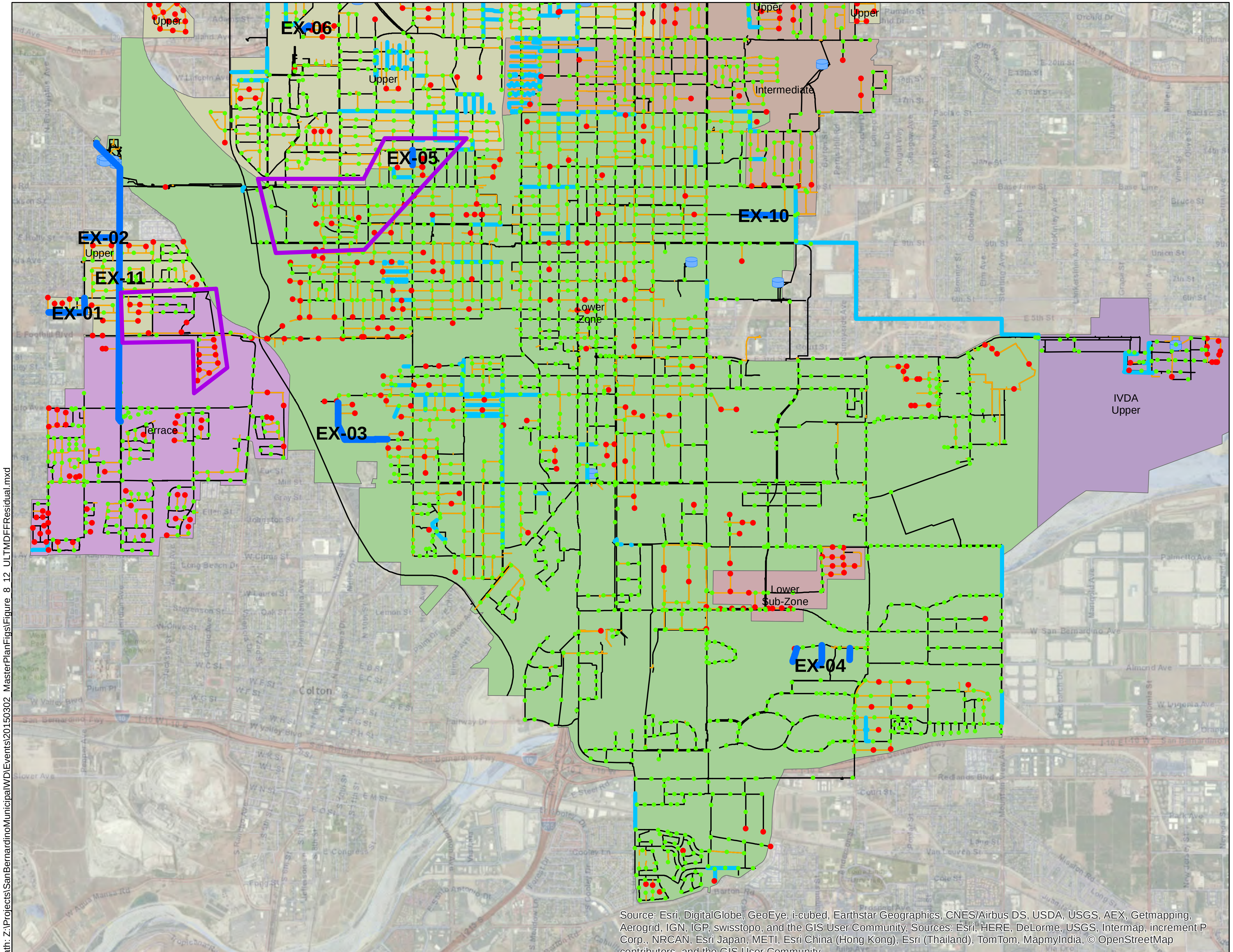

Legend

- Residual Pressure > 20 psi
- Residual Pressure < 20 psi
- Tanks

Main Line

- Main Line
- Pipe Diameters =< 6"
- CIP Projects
- 5-Year CIP Projects

PZNAME

- 1880 Zone
- 2040 Zone
- 2300 Zone East
- 2500 Zone
- 2700 Zone
- 3000 Zone
- Cajon
- College / Palm
- College / Palm Sub-Zone A
- College / Palm Sub-Zone B
- Daley
- Del Rosa
- Devil Canyon
- Devil Canyon Dom
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- Intermediate
- Lower Sub-Zone
- Lower Zone
- Mountain
- Mountain Sub-Zone A
- Mountain Sub-Zone B
- Ridgeline
- Ridgeline Hydro
- Ridgeview
- Shandin Hills
- Sycamore
- Terrace
- Upper

Proposed Zone Realignment

N

0 5,000 10,000

Feet

Kennedy/Jenks Consultants

San Bernardino Water Facilities MP
San Bernardino, California

Ultimate Maximum Day Demands Plus Fire Flow Demands Residual System Pressure in South Area

1383002*00
May 2015

Figure 8-12

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8.3.4 Recommendations for Future System Improvements

As a complete system the Department's distribution system operates well. However, there are significant deficiencies for fire flow capacity, and a deficiency in the Terrace zone under maximum day demand conditions. The major issues revealed through various existing condition evaluations and the hydraulic modeling analyses included undersized pipes which serve developments that may be larger than originally intended, an issue with adequate supply into the Terrace zone under the highest demand periods in maximum day demand conditions and the lack of storage and adequate pumping in a few pressure zones, as has been detailed in sections 8.3.1 and 8.3.2.

Pumping capacity deficiencies were identified for the Mountain, Intermediate, Lower, Terrace, and Daley zones and the Devore/Meyers subzone. Since the Lower and Intermediate zones have alternate supply from wells and regulating valves, the criteria for pumping capacity should not be applied in the same way for these zones. The capacity deficits for the Terrace, Daley and Devore/Meyers subzones are small for future conditions. Pumping projects are not recommended for these zones. The only pumping capacity project that is recommended is for the Mountain zone. The recommended project is listed in Table 8-9. The pump capacity deficit for the Mountain zone is already included the Department's 5-year CIP.

Table 8-9: Recommended Pumping Project for Future Conditions

Zone	Pump Capacity Required (hp)	Unit Cost ($/hp)	Cost ($)
Mountain	100	14,600	1,460,000
Total			**1,460,000**

Storage capacity deficits were identified for the IVDA, Mountain, Ridgeline, Shandin Hills and Terrace zones. Costs for a storage project for the Mountain zone are not included as these are already included in the Department's 5-year CIP. The Department has also included a storage project for the College/Palm zone in its 5-year CIP. The IVDA is planned to be combined with the Intermediate zone, as mentioned previously in section 8.2.6. Storage projects are recommended for the Ridgeline and Shandin Hills zones. These are both small zones, and the recommended projects represent a significant increase in storage. The recommended projects are listed in Table 8-10. Note that the recommended storage project for Ridgeline is in addition to the storage project recommended for existing conditions.

Table 8-10: Recommended Storage Projects for Future Conditions

Zone	Storage Deficit (gal)	Unit Cost ($/gal)	Cost ($)
Ridgeline	77,300	1.64	127,000
Shandin Hills	102,000	1.64	167,000
Terrace	1,700,000	1.64	2,788,000
Total			**3,082,000**

The Department has several pipeline projects included in its 5-year CIP. Since the analysis of the future distribution system did not reveal significant capacity related issues beyond the small pipes that supply hydrants, no further pipeline projects are recommended for future demand conditions.

8.4 Additional Analyses

The Department requested that the model developed for the master plan be used to analyze two other issues that the Department would like to resolve. One issue is the Department's idea to combine the IVDA pressure zone with the Intermediate pressure zone. The other issue is to investigate the water quality issues associated with a 78" pipeline within the Lower zone that the Department recently acquired and integrated with their distribution system.

8.4.1 IVDA Pipeline

The Department would like to combine the existing IVDA pressure zone on the east end of the system with the Intermediate pressure zone. The hydraulic grade line of the IVDA pressure zone is 1,294 feet, while the HGL of the Intermediate pressure zone is 1,311 feet. Because the HGLs of the two zones are within 17 feet of each other, it is expected that pressures in the IVDA would rise by no more than 8 psi when the IVDA pressure zone is combined into the Intermediate zone.

The storage and pumping analysis for existing and future conditions indicates that the surplus of storage in the Intermediate zone is far greater than the increase in demands from the IVDA zone. The pumping analysis indicates that the Intermediate zone does not meet the criteria used to evaluate the required firm pumping capacity for a pressure zone, indicating a pumping capacity deficit that would be worsened with the additional demands from the IVDA zone. However, given that there are wells within the Intermediate zone, and there are multiple regulating valves that provide additional supply to the Intermediate zone, the zone does not rely exclusively on pumping capacity for its supply. Therefore, it is not appropriate to apply the pumping capacity criteria to the Intermediate zone.

In order to integrate the IVDA zone into the Intermediate zone, a pipeline will be required that will hydraulically connect the two zones. The preliminary alignment for this pipeline has been selected by the Department, and will be approximately 14,000 feet long, connecting from the intersection of Baseline and Bobbett, south along Bobbett, east along 9th, south along Tippecanoe, east along 5th, south along Sterling and east along Perimeter, connecting to the existing IVDA system just east of the existing IVDA booster station. The IVDA zone will be fed by gravity through this proposed pipeline. The existing IVDA elevated storage tank will be decommissioned and the existing IVDA booster station will remain as a supply point from the Lower zone to the rest of the Department's system via the Intermediate zone. In order to adequately supply the IVDA zone for its maximum day plus fire flow demands, the proposed pipeline must be correctly sized so as not to induce excessive head loss. The model was analyzed under future max day demands, as well as for future max day demands plus fire flow demands. The results indicated that a 24" pipeline will be required to provide sufficient pressure to the IVDA area from the Intermediate zone. This pipeline is already included in the Department's 5-year Capital Improvement Program.

8.4.2 Lower Zone 78" Pipeline

The Department acquired a 78" pipeline from another water purveyor that is located within the Lower zone. This pipeline is hydraulically integrated for only a portion of its extent. This hydraulically integrated portion begins with a 48" pipeline on 9th Street from Pennsylvania Avenue to Perris Street. The pipeline continues as a 60" pipeline along 9th Street from Perris Street to Wall Avenue, and then continues on 9th Street as a 78" pipeline until approximately Bobbett Drive. From there the pipeline heads south along Pedley Road, Lena Road and Valley View Avenue, until Orange Show Road. The pipeline then heads west along Orange Show Road and then south along Washington Avenue, ending south of Dumas Street.

Because this pipeline is a large diameter pipeline, and is significantly larger than most other pipelines in the distribution system, the Department is concerned that water may move slowly through it, with the low velocities potentially causing water quality issues resulting from high water ages.

A water age scenario was created in the hydraulic model to evaluate the calculated water ages in and around the larger diameter pipelines, and specifically in the 78" portion. This scenario ran an extended period simulation for 168 hours, or 7 days. shows the results of water age analysis. The large diameter pipeline is shown in red. The junctions in the model are colored according to the maximum water age calculated during the analysis. Green junctions indicate a maximum water age less than 80 hours. Yellow junctions indicate a maximum water age of between 80 and 124 hours. Orange junctions indicate a maximum water age of greater than 124 hours. This figure indicates that the areas of the Lower zone with lower water ages tend to be those areas closer to this newly acquired large diameter pipeline. Areas farther away from the larger diameter pipeline tend to have longer water ages. An explanation for this is that this large diameter pipeline acts as a conveyance "highway", focusing flow through the zone from the storage facilities and wells in the north to the areas along the large diameter pipeline, and the southeast corner of the zone where this pipeline ends. This conveyance highway transmits large amounts of water from the northern part of the zone from storage and wells to the southeast corner, keeping the water age along the pipeline relatively low. The areas with less direct access to the large diameter pipeline are flushed less with the newer water and end up with longer water ages.

In summary, the extended period simulation illustrates that the 78-inch diameter pipeline does not result in long water age and therefore, should not contribute to water-age related water quality problems.

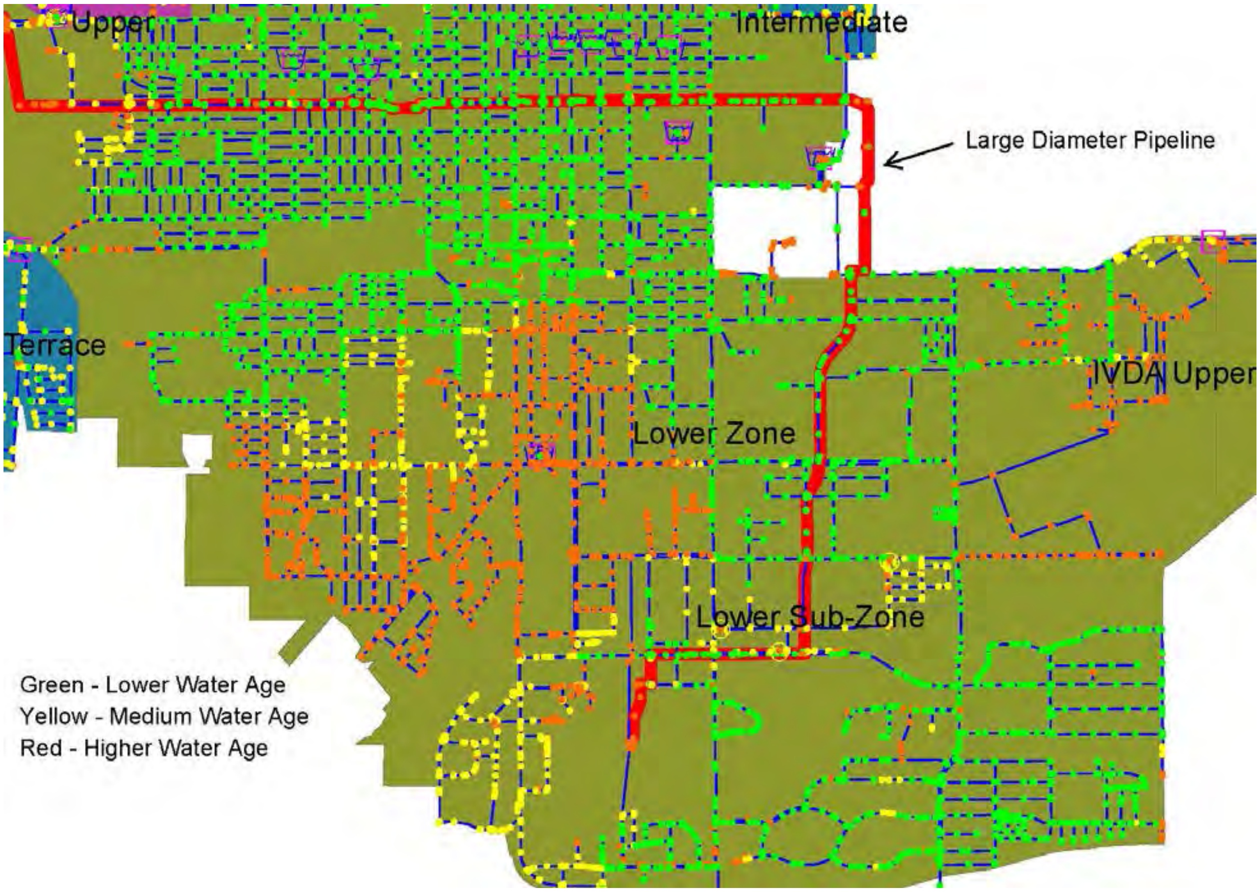

Figure 8-13 Water Age in Lower Zone

8.4.3 Lower Zone Reservoir Imbalance

The Department has noticed an imbalance in reservoir levels in the Lower Zone, and as part of this master plan, has requested an investigation as to why this is happening. These reservoirs consist of the two Lytle Creek Reservoirs, the Medical Center Reservoir and Waterman Reservoir. The Department indicated that the Lytle Creek Reservoirs were frequently at a much lower level than the other two reservoirs during periods of high demand.

The first step in the analysis of the imbalance was to analyze the available SCADA data for these four tanks. The data reveals that the level in the Lytle Creeks Reservoirs is indeed approximately 5 feet lower that the level in either the Waterman or the Medical Center Reservoirs. However, the Medical Center Reservoir is 5 feet deeper than the other reservoirs, with its base at an elevation that is 5 feet lower than the base elevation of the other reservoirs. When the reservoir levels were converted into hydraulic grade lines for the tanks, it became clear that the Medical Center Reservoir was typically at a hydraulic grade line similar to that in the Lytle Creek Reservoirs. All three of those tanks are frequently at a hydraulic grade line that is about 5 feet lower than that of the Waterman Reservoir.

The second step of the analysis was to use the hydraulic model to analyze this issue, as well, and run the model for a 30-day period under maximum day demands. The model showed results that are similar to the SCADA information, with the Waterman Reservoir typically at a higher HGL than the other reservoirs. The model results revealed that the Scott Labs Booster Pumps, also referred to as the Medical Center Booster Pumps, appear to be the cause of the lower HGL in the Medical Center Reservoir. These booster pumps are located adjacent to the Medical Center Reservoir. Figure 8-14 shows that when the Scott Booster pumps turn on, the HGL in the Medical Center Reservoir drops quickly. The controls in the model turn three booster pumps on at the same time, drawing approximately 10,000 gpm out of the Medical Center Reservoir.

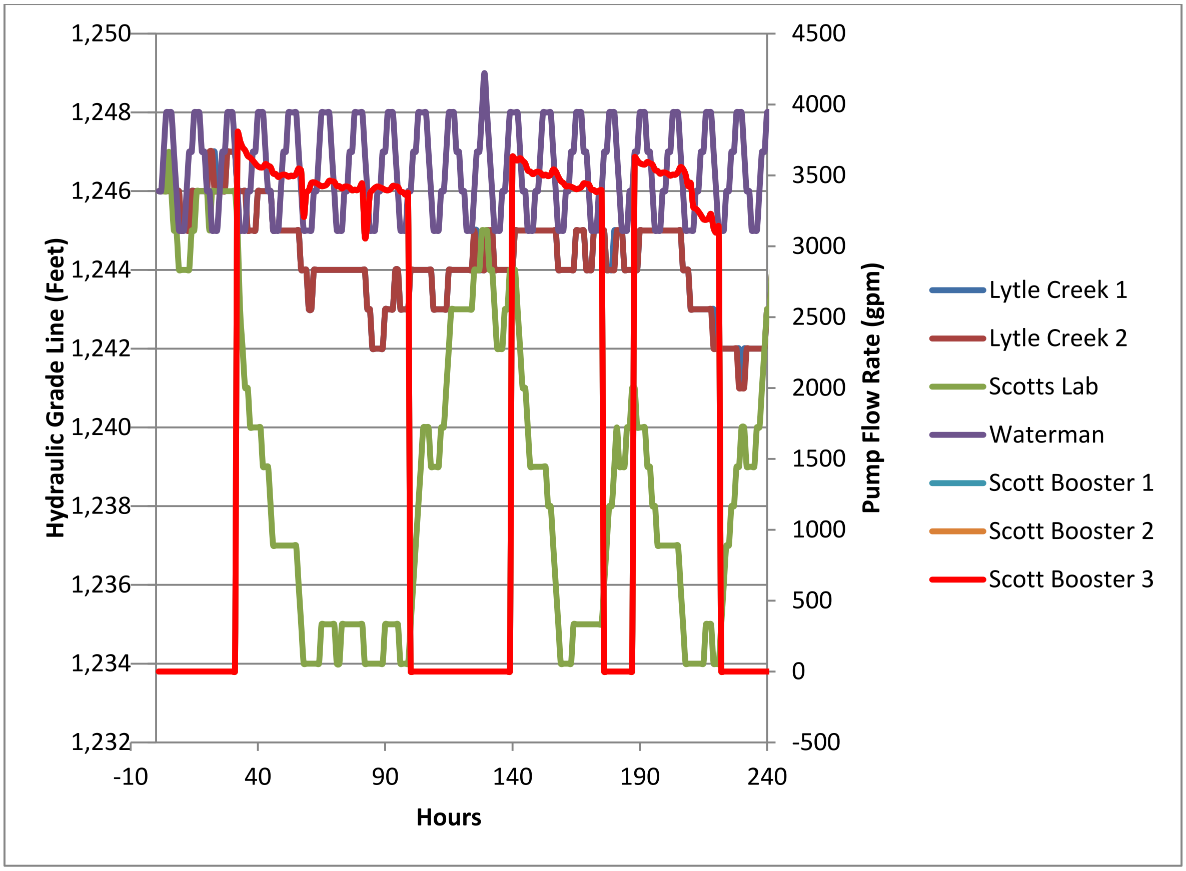

Figure 8-14 Lower Zone Facilities

The controls for these pumps were adjusted so that one pump ran continuously, while the other two were turned on when needed. This did not resolve the issue, and the results showed the same quick drop in HGL in the Medical Center Reservoir when the additional pumps turned on. The controls were adjusted again, with two pumps running continuously, with a third pump turned on when needed. This changed the results, with the level in the Medical Center Reservoir staying at approximately a constant 5 feet HGL below that of the other reservoirs in the Lower Zone. However, this did not resolve the imbalance issue.

The analysis of the hydraulic model reveals that the Scotts Lab Boosters draw down the HGL in the Medical Center Reservoir when they are operating, which is the cause of the imbalance in the hydraulic model. It is suspected that this may be the case in the actual distribution system, as these pumps each pump at a rate that is about twice that of the pumps that pump out of the other reservoirs in the Lower Zone. This larger draw out of the Medical Center Reservoir is the likely cause of the lower HGL in the western part of the Lower Zone.

8.5 Capital Improvement Program

The Department's overall capital improvement program is formed by merging the capacity related improvements derived herein with other asset management, operational, and reliability related improvements identified by the Department in its 5-Year CIP. These programs and projects are developed to address the full range of capacity, reliability, sustainability, and self-sufficiency improvements. This plan is intended to be a living document and will evolve over time to adapt to new conditions, regulations, operational efficiencies, and local policies.

8.5.1 Capacity Improvement Program

As previously discussed, a number of capacity related improvements have been identified for the San Bernardino Municipal Water Department. These improvements are located throughout the service area, consist of storage and pumping system improvements, and are associated with needed increases in pipeline capacity. The recommended system improvements are based upon deficiencies derived throughout the evaluation process of the existing system, anticipated development throughout the Department's service area, additional deficiencies recognized after accounting for anticipated development and improvement of the water system reliability. The costs and prioritization of these improvements are provided herein.

8.5.2 Capacity Related Prioritization Criteria

Similar to the pipeline replacement program, some general criteria are required to prioritize the identified improvements to promote an efficient capital improvement implementation plan. The criteria for the three primary asset categories (tanks, pumps, and pipes) are as follows:

Storage Tank Capacity Improvements - Storage deficiencies under current conditions are greater priority than future storage deficits. Current storage deficits are prioritized by the severity of the deficiency by pressure zone.

Pumping Capacity Improvements - Pumping deficiencies under current conditions are greater priority than future pumping deficits. Current pumping deficits are prioritized by the severity of the deficiency by pressure zone. Pumping capacity deficits for zones with no alternate supply are greater priority than those for zones with an alternate supply.

Pipeline Capacity Improvements - Similar to the storage and pumping prioritization, pipelines that were identified to have capacity deficiencies under current conditions have a higher priority than those pipelines that exhibited a capacity deficit only under future demand conditions. Additionally, fire flow related capacity deficiencies have a higher priority than peak hour pressure-related capacity deficiencies, which have a higher priority than deficiencies related to excessive velocity or head loss. The degree of deficiency also provides a tertiary criterion for phasing improvements among both fire flow and capacity improvements.

As discussed with the Department, there is a significant length of small 4- and 6-inch diameter pipelines in the water system. Since these small pipelines are typically challenged to meet larger fire flow demands, it is recommended that all small diameter pipelines that include a fire hydrant be hydraulically evaluated for their ability to provide an appropriate level of fire flow demands. The findings of this analysis should then be integrated in the pipeline replacement program for methodical replacement as appropriate.

8.5.3 Capacity Improvement Program Summary

A capacity-based improvement program is derived by applying the unit costs and prioritization criteria to the system hydraulic improvements identified in Sections 8.2.6 and 8.3.4. The results are summarized by facility type in Table 8-11.

Table 8-11 Summary of Capacity-Based Capital Improvements

CIP Description	Cost to Meet Deficiencies Under Existing Demand Conditions	Cost to Meet Deficiencies Under Ultimate Demand Conditions
Pipe CIP	$8,062,000	$0
Storage CIP	$239,000	$3,081,000
Pumping CIP	0	$1,460,000
Zone Realignment Studies	$150,000	
Total CIP	**$8,451,000**	**$4,541,000**

All of the pipeline projects that were identified are for fire-flow related deficiencies, except for project 11 in the Terrace zone, which is related to both fire flow and maximum day pressures. Given that the other ten projects all resulted from the same criteria, there is no effective method of prioritizing these projects based on their capacity deficiency. However, given that there is already an effort within the Department to replace pipes that have reached their useful life, the installation date and material of the pipes identified for capacity-based improvements were further examined. To prioritize these capacity-based pipeline improvement projects using material as an indication of age, it is recommended that cast iron pipes be the highest priority, asbestos cement the second priority and ductile iron or steel the third priority. Since these particular improvements are primarily facilities already scheduled for replacement, the annual capital replacement fund would be an appropriate funding mechanism, suggesting no additional capacity-based CIP line item is required in the Department's future budget.

Given these guidelines, Projects 2, 7 and 8 would be given the highest priority, as the existing pipes that will be replaced are cast iron. The pipelines to be replaced by the other projects are a mixture of steel and ductile iron, with a few short segments of cast iron.

From an installation date standpoint, Projects 2, 7 and 8 have the oldest installation dates, along with Projects 5 and 9, and would be given the highest priority.

8.5.4 Pipeline Replacement Program

To proactively plan for continued, long-term asset reliability, the Department has developed a capital rehabilitation/replacement program. The primary focus of this program is to address the substantial amount of pipelines in the water system.

The broad purpose of this program is to maintain and/or enhance system reliability by replacing deteriorated and/or critical assets. Age and material is often used in the absence of actual condition assessment data to establish an initial pool of assets that are most apt to need additional attention and may be required for replacement. Since age in and of itself is not an appropriate predictor of pipeline performance, some additional general criteria is required to prioritize the vast number of pipelines that are greater than 50 years old, and effectively implement the capital replacement program. When practical, pipeline replacements should be implemented in groups rather than isolated pipelines in various streets within the community. As previously discussed, it is recommended that small pipe fire flow considerations be incorporated in the Department's annual pipeline replacement program.