Appendix K

Sewer Master Plan

Stantec, December 2016

City of Merced
Sewer Master Plan

Draft

Prepared for:
City of Merced

Prepared by:
Stantec Consulting Services Inc.

October 28, 2016

Sign-off Sheet

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1.0 INTRODUCTION AND BACKGROUND

The City of Merced (the City) recently retained Stantec to update their Sewer Master Plan (Master Plan). This Master Plan addresses wastewater collection system capacity, identifies necessary improvements to eliminate system deficiencies and provides a plan for locating and sizing trunk sewers to service areas within the existing City Limits, as well as the balance of areas within the Specific Urban Development Plan (SUDP) boundary contained in the City of Merced Vision 2030 General Plan (Vision 2030 General Plan).

The previous planning document, the *City of Merced Sewer Master Plan* (ECO:LOGIC Engineering, January 2007, Draft) was developed in part to update the servicing plan for what has been termed South Merced (the portion of the City located south of Bear Creek), as well as consider options for servicing North Merced, including the new UC Merced Campus. The draft 2007 Master Plan was prepared in the context of servicing the Merced Vision 2015 General Plan, which included a SUDP boundary and land use assumptions which differ from those in the Vision 2030 General Plan.

Prior to the draft 2007 Master Plan, the City had developed separate sewer servicing plans for North and South Merced. The *City of Merced North Merced Sewer Master Plan* was prepared by ECO:LOGIC Engineering in 2002, while the previous master plan for South Merced was completed in 1982. These Plans were never formally adopted by the City Council and became working documents for City staff to revise as development assumptions changed over time.

1.1 PURPOSE

City objectives for the current Master Plan include:

1. Provide an update of the evaluation of options for servicing areas within the Vision 2030 General Plan SUDP;
2. Re-assess the capacity of the existing trunks within the city limits and the SUDP;
3. Provide recommendations for projects that would fulfill the City's desire to service lands within the SUDP;
4. Revisit the assessment from the 2002 North Merced Sewer Master Plan of options for servicing that area with satellite treatment plants and reusing effluent;
5. Provide recommendations for upsizing existing trunk sewers, or other means to address deficiencies identified as part of the assessment of the collection system capacity.

6. Prepare a list of capital improvement projects to address existing system deficiencies as well as projects that would be needed to serve the SUDP, including planning-level cost estimates.

This Master Plan document addresses the following subjects:

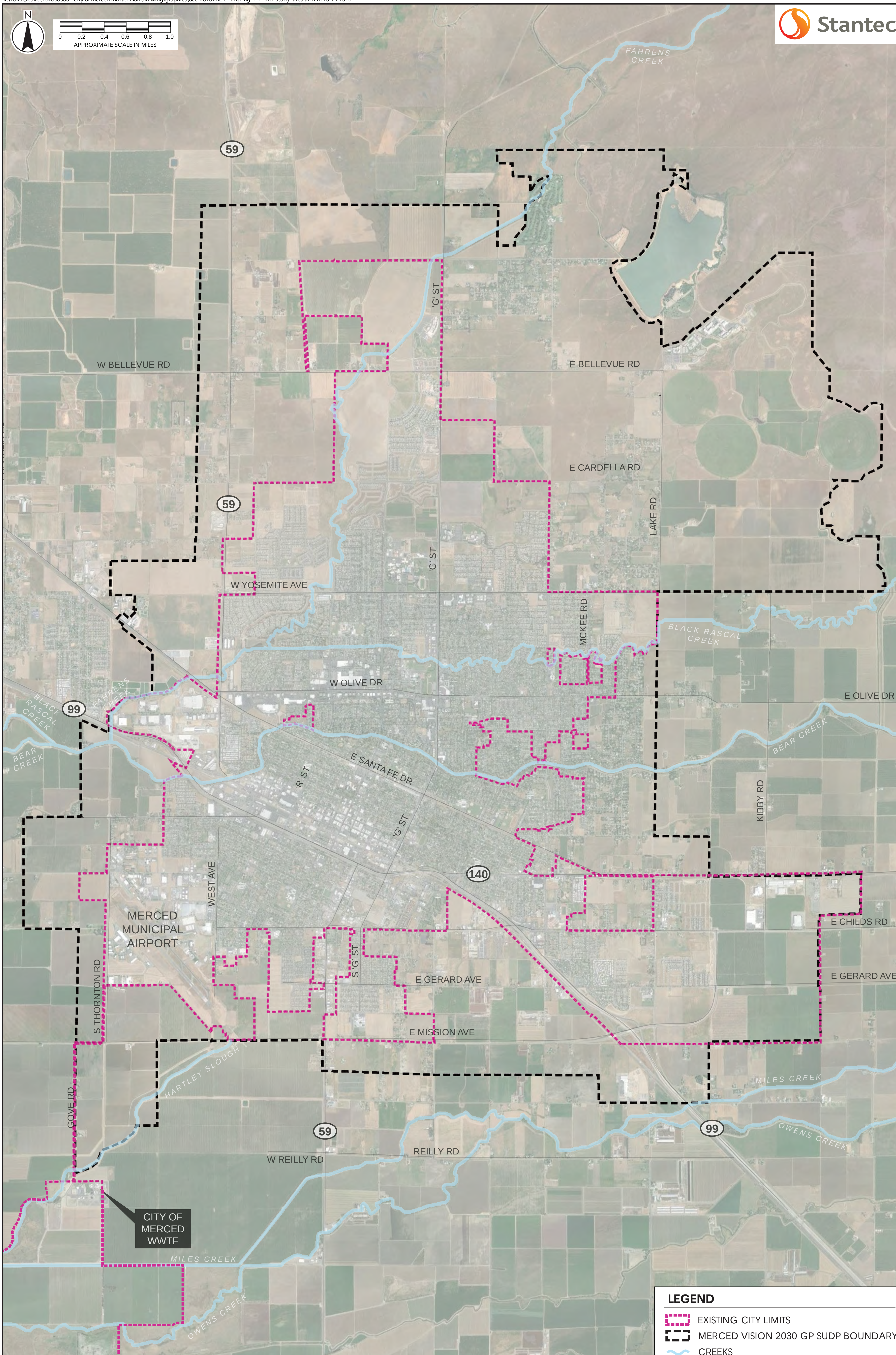
- Existing Collection System
- Flow Estimates
- System Evaluation Criteria and Methodology
- Satellite Treatment Options
- Results and Recommendations

1.2 STUDY AREA

The current master planning effort considered a number of alternatives for servicing the SUDP, including alternatives for maximizing the remaining capacity in existing trunk sewers and serving areas of growth using satellite treatment plants and reusing effluent.

The SUDP is a growth boundary which sets the physical extent of new development for the City. The Vision 2030 General Plan includes policies which dictate how new development may occur as well as defining approved land uses within the SUDP. The Vision 2030 General Plan SUDP boundary and land uses as well as information for land uses within the Campus Community were provided to Stantec by the City. This information forms the basis for the analyses described in this Master Plan.

The City Limits and SUDP boundary are shown in **Figure 1-1**.



City of Merced
Sewer Master Plan

Figure 1-1
Master Plan Study Area

2.0 EXISTING WASTEWATER COLLECTION SYSTEM

2.1 INTRODUCTION

This chapter describes the City's existing wastewater collection system. The results of the capacity analysis performed to support development of this Master Plan are presented in Chapter 6. Historically, the City has considered their collection system to consist of two primary sewer sub-basins: 1) the northern portion which includes all infrastructure north of Bear Creek, and 2) the southern portion consisting of all infrastructure south of Bear Creek.

This chapter is divided into the following sections:

- Description of Existing Trunk Sewer System
- Existing Wastewater Flows
- Land Use Data
- GIS Data
- Previous System Investigations

2.2 DESCRIPTION OF EXISTING TRUNK SEWER SYSTEM

Wastewater generated within the City is collected in a series of pipelines which the City owns, operates, and maintains. The system includes over 400 miles of gravity sewers ranging in size from 6 to 48 inches in diameter. **Figure 2-1** depicts the existing trunk sewer system. The City's system is described frequently in this document in terms of two major geographical boundaries (North Merced and South Merced) delineated by Bear Creek, which runs roughly east to west through the City.

The only major pumping facility within the system is the Highway 59 pump station. Several smaller pump stations serve smaller areas within the City (such as individual subdivisions). These are not considered part of the sewer trunk system; therefore, these smaller pump stations were not evaluated as part of this Master Plan update.

The existing City sewer trunk system consists of three primary branches which convey flows from three distinct sewer sub-sheds. These include:

1. The 48-inch trunk sewer "Interceptor". The Interceptor dates from the 1980s and replaced a pump station and portions of the West Avenue Trunk. The Interceptor conveys flow from the northern portion of the City's system.
2. The West Avenue Trunk serving the southwestern portion of the City.

3. The Gerard Trunk serving the southern portion of the City system, east of the West Avenue Trunk sewer shed. The Gerard Trunk intersects with the West Avenue Trunk and continues as a 42-inch gravity trunk to the City's WWTF.

The three major trunks as well as other significant features of the City's sewer system are illustrated in **Figure 2-1**. There are three different creeks flowing through the City which drive the configuration of the City's trunk sewer system. In particular, Black Rascal and Bear Creeks flow from east to west across the extent of the City and the SUDP. To the extent possible, the City has constructed sewers that allow gravity flow at creek crossing locations. This minimizes the number of pump stations that would otherwise be required in the system, thereby reducing operation and maintenance costs.

In addition to the main trunks of the City's domestic sewer system, a portion of the Western Industrial Area located west of Highway 59, north-east of Highway 99, between Bear and Black Rascal Creeks is also served by a dedicated 14-inch force main originally constructed for use by a single user (the City refers to this as the "old Ragu line"). This conveyance runs south, all the way to the City's WWTF. This line is not currently in use and was not modeled as part of this master planning effort. A separate assessment of the dedicated industrial line was included in a document entitled *Merced WWTF Industrial Waste Acceptance Evaluation* (Stantec, May 2014). This dedicated line is reserved by the City for potential future "wet" industries which may wish to locate within the Western Industrial Area.

The Western Industrial Area is served via a collector which drains east along Cooper Avenue to a trunk in Highway 59. This trunk in Highway 59 conveys flow from the Western Industrial Area, the Highway 59 pump station, and the trunk in West Olive Avenue, south to the City's 48-inch Interceptor. These features are all shown in **Figure 2-1**.

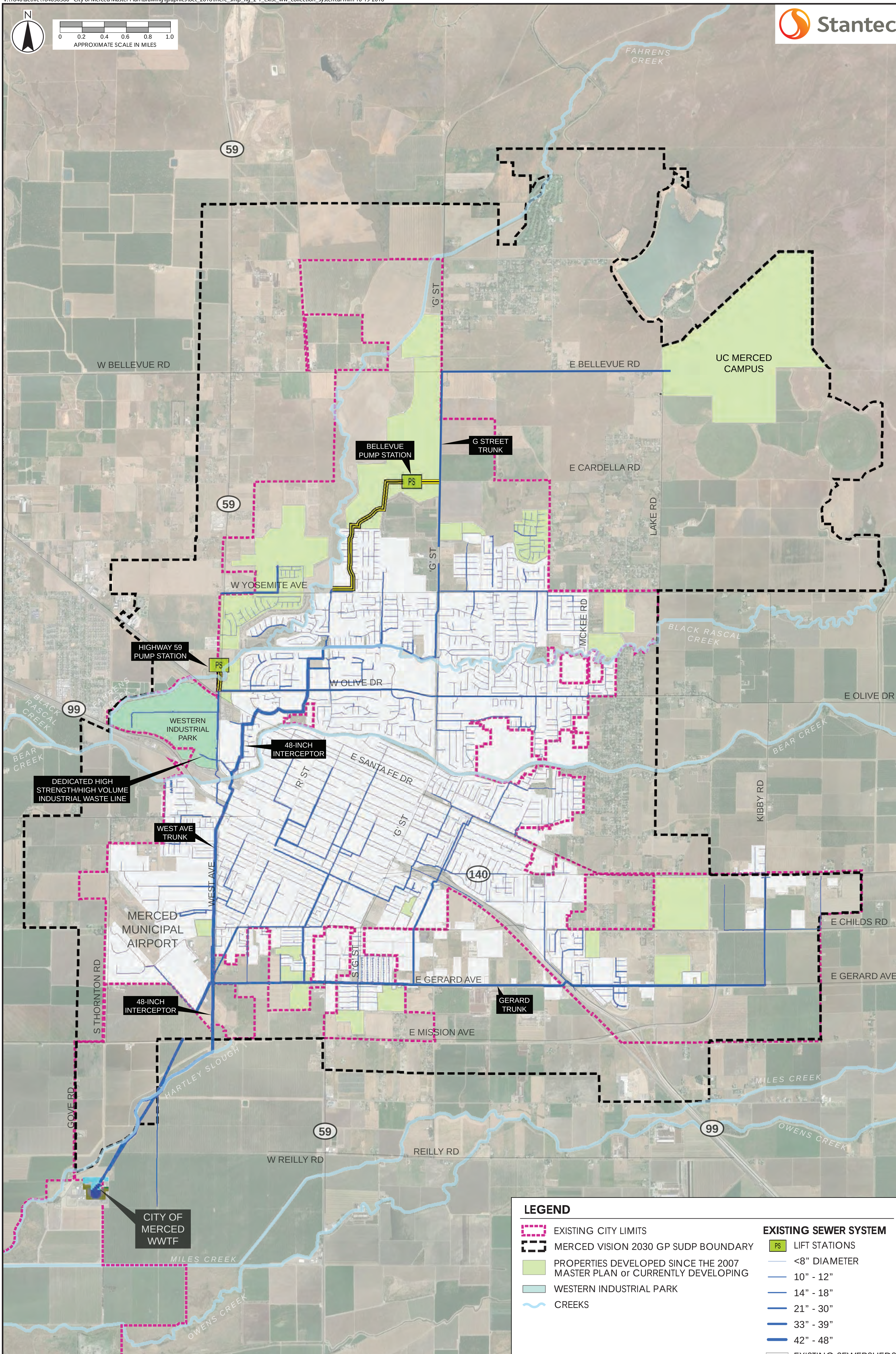
2.3 EXISTING WASTEWATER FLOWS

Wastewater sources in the City of Merced include residential customers, commercial users, industrial users and public uses (such as City administrative offices and public service facilities, libraries, parks, schools and airports). A majority of the wastewater generated within the service area originates from residential customers.

Infiltration and inflow also contribute to the volume of wastewater that makes its way into the collection system. Infiltration and inflow (I/I) enters the collection system through different mechanisms. Infiltration enters the collection system from subsurface sources such as defective pipes, pipe joints, connections or leaky manholes. Infiltration can occur during periods of wet weather when soil becomes saturated and shallow groundwater becomes elevated or during dry weather if local conditions are such that groundwater is sufficiently high. Inflow is a term used to describe non-wastewater sources which are more direct connections, such as leaky manhole lids which allow storm runoff to enter the collection system, roof gutters or yard drains which are inappropriately connected to sewer service clean outs or directly to sewer mains. Inflow is most often associated with wet weather conditions.

Like most communities in the Central Valley, sewer flows into the City's wastewater treatment facility (WWTF) have steadily reduced over the last decade, caused apparently by a combination of water conservation due to the regional drought and reduced occupancy resulting from the housing crisis which occurred in the latter portion of the preceding decade. California's unprecedented drought, mandated water reductions, as well as more water efficient fixtures installed in homes have been shown to decrease both potable water usage and wastewater generation. For example, the average day annual wastewater flows into the WWTP were reported in April of 2005 (Preliminary Design Report TM 1, April 15, 2005, ECO:LOGIC Engineering) to be approximately 8.1 Mgal/d. In 2010 average flows were reported to be approximately 7.1 Mgal/d.

The recent lack of significant storms under saturated conditions also tends to cause any recent peak wet weather flow data to trend lower than what may be observed in wetter years. As a result, this master plan uses wastewater generation rates for different land uses established in the mid-2000s (discussed below), updated based on input from the City Planning Department and applies them to current land use data for projected flows.



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0 0.2 0.4 0.6 0.8 1.0
APPROXIMATE SCALE IN MILES
Stantec
FAHRENS CREEK
59
W BELLEVUE RD
E BELLEVUE RD
UC MERCED CAMPUS
'G' ST
G STREET TRUNK
BELLEVUE PUMP STATION
PS
E CARDELLA RD
LAKE RD
W YOSEMITE AVE
MCKEE RD
BLACK RASCAL CREEK
HIGHWAY 59 PUMP STATION
W OLIVE DR
E OLIVE DR
99
WESTERN INDUSTRIAL PARK
48-INCH INTERCEPTOR
E SANTA FE DR
BEAR CREEK
DEDICATED HIGH STRENGTH/HIGH VOLUME INDUSTRIAL WASTE LINE
'R' ST
KIBBY RD
WEST AVE TRUNK
140
WEST AVE
MERCED MUNICIPAL AIRPORT
E CHILDS RD
S 'G' ST
E GERARD AVE
GERARD TRUNK
S THORNTON RD
E MISSION AVE
HARTLEY SLOUGH
MILES CREEK
COVE RD
REILLY RD
W REILLY RD
OWENS CREEK
CITY OF MERCED WWTF
LEGEND
EXISTING CITY LIMITS
MERCED VISION 2030 GP SUDP BOUNDARY
PROPERTIES DEVELOPED SINCE THE 2007 MASTER PLAN or CURRENTLY DEVELOPING
WESTERN INDUSTRIAL PARK
CREEKS
EXISTING SEWER SYSTEM
LIFT STATIONS
<8" DIAMETER
10" - 12"
14" - 18"
21" - 30"
33" - 39"
42" - 48"
EXISTING SEWERSHEDS

2.4 LAND USE DATA

The existing land uses within the City's current sewer service area are shown in **Figure 2-2**. **Table 2-1** summarizes the land uses within the existing service area. The existing annual average flow, as reported at the WWTF, from the existing service area (based on data from February 2013 through February 2014) is 7.35 Mgal/d.

Table 2-1 Land Uses within the Existing City Sewer Service Area

Land Use	Area (acres) [(a)]
Public	**1231.1**
Open Space - Park Recreation	352.0
Public / General Use	368.9
School	510.1
Commercial	**2,150.9**
Business Park	40.0
Commercial Office	270.3
General Commercial	349.1
Manufacturing / Industrial	843.1
Neighborhood Commercial	126.0
Regional Community Commercial	360.9
Thoroughfare Commercial	161.4
Residential	**6,315.5**
High Density Residential	92.2
High to Medium Density Residential	570.9
Low Density Residential	4,908.8
Low to Medium Density Residential	609.1
Mobile Home Park Residential	76.4
Residential Reserve	4.4
Rural Residential	3.2
Village Residential	50.5
Total	**9,697.4**

(a) Gross acreage is reported here.

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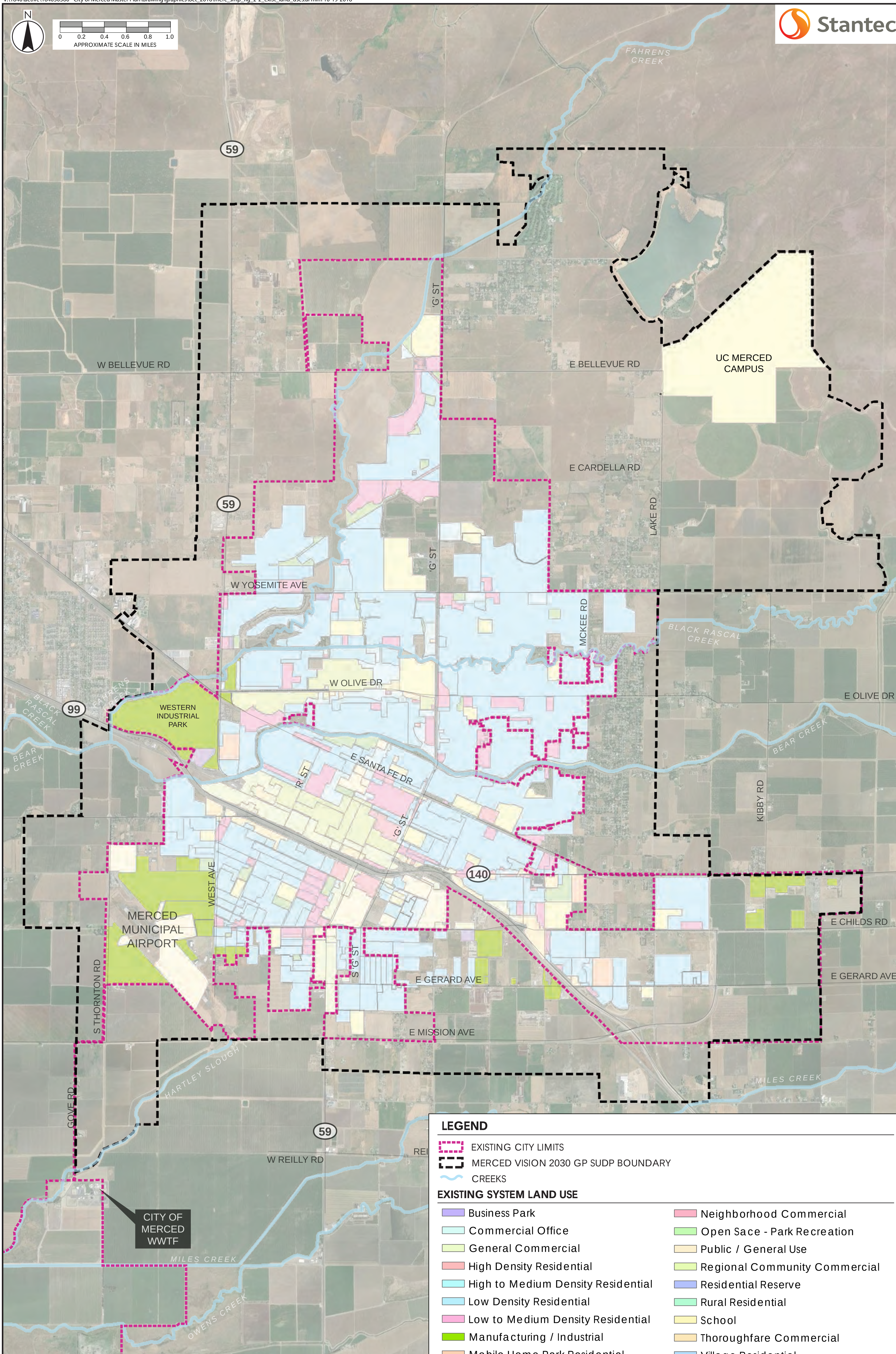

Figure 2-2
Existing Service Area Land Use

2.5 GIS DATA

Sewer system and land use data were provided to Stantec by the City in GIS format. Sewer system data included the following information:

- Pipe and manhole locations
- Pump station locations
- Manhole rim and invert elevations (limited)
- Pipe lengths and slopes

Where information was missing (such as specific manhole rim and invert elevations), data was supplemented from atlas maps of the City's system, as-built drawings and interpolation of existing data.

2.6 RELATIONSHIP TO 2002 NORTH MERCED SEWER MASTER PLAN, DRAFT 2007 SEWER MASTER PLAN AND MODEL

Servicing options for the North Merced area were considered in the 2002 North Merced Sewer Master Plan. The conclusions of those planning level analyses were carried over in the draft 2007 Master Plan, primarily the concept of the need for significant additional trunk sewer facilities to convey wastewater from areas of growth within North Merced to the WWTF located southwest of the City, as illustrated in **Figures 2-1** and **2-2**.

Prior to development of the draft 2007 Master Plan, a flow monitoring study was conducted. The purpose of this flow monitoring effort was to determine the level of non-wastewater flows (I/I) which are contributed by different portions of the system. This information was then used to calibrate the sewer model developed at that time. Calibration of the model allows the flows in particular segments of the system to be simulated such that they more accurately reflect existing conditions providing a higher level of confidence in the results. Although reductions in wastewater flows have been noted, as discussed in Section 2.3, for the purposes of this Master Plan, the results of the 2007 flow monitoring study were determined to be sufficient, reasonable and the most accurate data available to establish "reasonable" spatial flow distribution for level of service evaluation, therefore no new flow monitoring or re-calibration was conducted as part of this update.

3.0 FLOW ESTIMATES

3.1 PURPOSE

The purpose of this chapter is to correlate land use data with wastewater flow data and project average and peak wastewater flows for future development. The information presented here was used to model existing system performance, size interim system improvements as well as those needed to serve build-out of the SUDP.

Average sanitary flows were estimated by multiplying residential population, commercial or industrial acreage, as well as public use acreages (such as schools) by unit flow generation factors. Peak flows were estimated by applying a peaking factor to the average flows, as described in more detail in this chapter.

This chapter is divided into the following sections:

- Average Flow Estimates
- Land Uses and Flow Estimates for Future Planning
- Peak Flow Estimates
- Flow Estimation for Known Future Development

3.2 LAND USES AND FLOW ESTIMATES FOR FUTURE PLANNING

Land uses from the *Merced Vision 2030 General Plan* – January 2012 (General Plan) and supplemental information provided by the City were used in projecting wastewater flows for build-out of the City Limits and the SUDP. The land use mapping applicable to this Master Plan (the Planning Area) is presented in **Figure 3-1**.

For undeveloped parcels within the Planning Area, land uses were assigned per the General Plan. In specific cases, approved land uses were used for specific developments identified by City staff as either currently under construction or expected to develop in the near future. In particular, the City has identified approved developments on their "Tentative Subdivision Activity Map" for which specific counts of dwelling units were provided. In these locations the dwelling unit densities from the Tentative Subdivision Activity Map were used.

The density factors (units/acre) for Residential land uses were based upon assumed densities listed in **Table 3-1**. The resulting unit counts were then used to estimate future wastewater flow from residential areas using per unit flow factors discussed later in this chapter.

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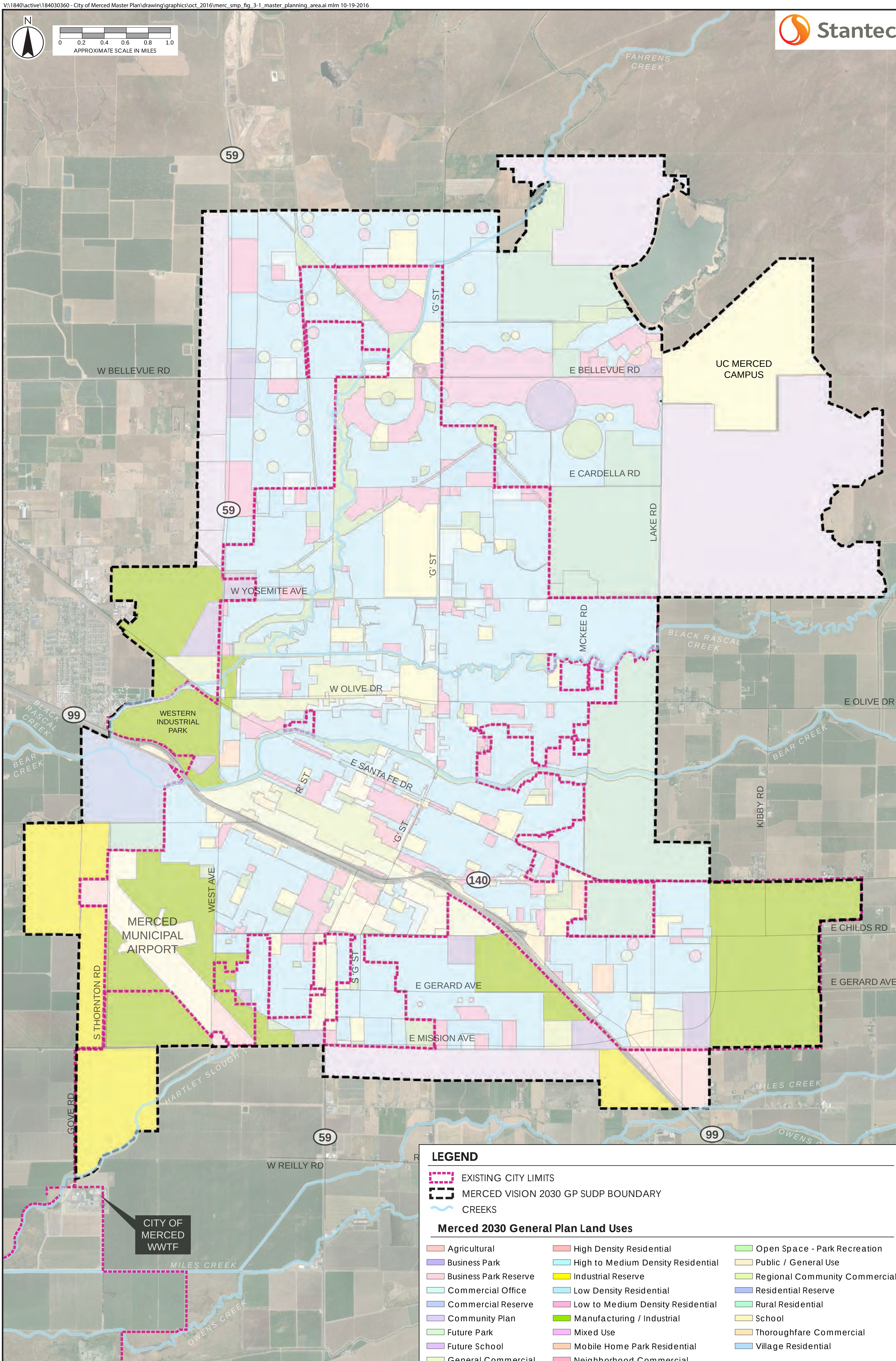

City of Merced
Sewer Master Plan

Figure 3-1
Master Planning Area

Table 3-1 General Plan Residential Density Definitions

Residential Land Use	General Plan Residential Density (units/acre) [a]	Residential Density Used in this Study (units/acre) [a]	Residential Density Used in the 2007 MP (units/acre)
Rural	1.0 to 3.0	2	2
Low Density	2.0 to 6.0	4.5	6
Low-Medium Density	6.1 to 12.0	8.5	9
High-Medium Density	12.1 to 24.0	18	18
High Density	24.1 to 36.0	28	30
Mobile Home Park	6.0 to 10.0	8	8
Village Core Residential	7.0 to 30.0	12	12
Residential Reserve	2.0 to 6.0	4.5	6
Community Plan	-	4.5 [b]	[c]

(a) A “unit” is defined as one housing unit with an average of 3.02 persons. The *Merced Vision 2030 General Plan*, January 2012 (General Plan) defines the average residential density within the City’s SUDP as 3.02 persons/housing unit.

(b) City Staff indicated that for Community Plan land use the Master Plan was to assume 4.5 units/acre consistent with the density assumption utilized for the Residential Reserve land use.

(c) The draft 2007 Master Plan included a number of specific development plans that were removed from the final General Plan. City staff indicated it was it appropriate to utilize the Tentative Subdivision Activity Map which they provided to Stantec for this purpose (Reference: e-mails and discussions August 2016).

3.3 AVERAGE FLOW ESTIMATES

The estimation of wastewater flows for planning purposes is based on the unit factors established in the draft 2007 Master Plan. After meeting with City engineering and planning staff, some of those factors were modified. The unit factors used in this Master Plan are presented in **Table 3-2** along with the factors used in the draft 2007 Master Plan for comparison purposes. The per capita wastewater generation used in the previous Master Plan remains unchanged.

Table 3-2 Recommended Wastewater Unit Factors

Land Use Definitions	Recommended Land Use Unit Flow	Previous 2007 MP Unit Flow	Units [a]
Commercial			
General Commercial	1,500	1,500	gpd/acre
Business Park	1,500	1,500	gpd/acre
Business Park Reserve	1,500	1,500	gpd/acre
Commercial Office	1,500	1,500	gpd/acre
Thoroughfare Commercial	1,500	1,500	gpd/acre

Land Use Definitions	Recommended Land Use Unit Flow	Previous 2007 MP Unit Flow	Units [(a)]
Commercial			
Regional Community Commercial	1,500	1,500	gpd/acre
Commercial Reserve	1,500	1,500	gpd/acre
Industrial			
Manufacturing/Industrial	2,000	2,000	gpd/acre
Industrial Reserve	2,000	2,000	gpd/acre
Schools/Public Use			
Schools			
Elementary/Middle schools	25	25	gpd/student
High school	50	50	gpd/student
Future School			
Elementary/Middle schools	25	25	gal/student
High school	50	50	gal/student
Public General Use	1,500	1,500	gpd/acre
Open Space			
Agricultural	0	0	gpd/acre
Open Space – Park Recreation	0	0	gpd/acre
Future Park[(b)]	0	0	gpd/acre
Residential [(c)]			
If number of dwelling units (DU) IS NOT known:			
Rural Residential	513	513	gpd/acre
Low Density Residential	1,155	1,540	gpd/acre
Low to Medium Density Residential	2,182	2,310	gpd/acre
High to Medium Density Residential	4,621	4,621	gpd/acre
High Density Residential	7,188	7,701	gpd/acre
Mobile Home Park Residential	2,054	2,054	gpd/acre
Village Residential	3,080	3,080	gpd/acre
Residential Reserve	1,155	1,540	gpd/acre
If number of dwelling units IS known:			
All Residential Categories	257	257	gpd/DU

(a) gpd/acre = gallons per day per acre

(b) For the purposes of this Master Plan, while there will be restrooms available and connected to all parks, the actual contribution to the system on a per acre basis from these facilities is negligible. These areas have been included and considered in the analysis of existing and future capacity needs.

(c) Unit flows based on residential densities and an occupancy rate of 3.02 as discussed in Chapter 3 from the Merced Vision 2030 General Plan, and a per capita flow of 85 gallons per capita per day (gpcd).

3.3.1 Future Schools

Unit flow factors from **Table 3-1** were used as the basis for determining contribution of school sites to the wastewater collection system. Since the values listed are based upon number of students, the estimated number of students attending the schools needed to be determined. The following breakdown lists the assumptions used to arrive upon the school contribution.

- It was assumed that an even distribution of students across all grades (i.e. approximately 2/3rd of students attend Elementary and Middle School, 1/3rd attend High School). Averaging out 25gpd/student (Elementary and Middle School) and 50gpd/student (High School) leads to approximately 33.3 gpd/student for schools.
- Based upon the 2010 census, the current population demographics for the City of Merced indicates approximately 31% of the population are under the age of 18. It was assumed that this distribution will not change as growth occurs.
- There is estimated to be growth of approximately 155,000 people through build-out of the SUDP, not including UC Merced or the UC Campus Community located to the south of the university. This results in approximately 48,000 K through 12 students using the 31% factor.
- The Merced GP 2030 Vision Plan adds approximately 435 acres of land for schools and future schools, which means there will be approximately 113 students per acre.
- The above assumptions result in approximately 3,765 gpd / acre for school and future school generation.

3.3.2 UC Merced

Future flow estimated for UC Merced and the Campus Community were obtained from the UC Merced and University Community Project Environmental Impact Report (*UC Merced and University Community Project, Draft EIS/EIR, November 2008 and Final EIS/EIR*, March 2009). **Table 3-3** summarizes the generation rates listed within the report. The wastewater flows from UC Merced and the Campus Community are identified separately because the methodology and statistical measures used in the March 2009 EIS/EIR to quantify flow differ from those for the City's SUDP as presented in this Master Plan.

Table 3-3 UC Merced and Campus Community Wastewater Generation Rates (a)

	Average DWF (Mgal/d)	Peak WWF (b) (Mgal/d)
UC Merced	1.13	2.54
Campus Community North	0.92	2.07
Campus Community South	1.04	2.34

(a) Excerpted from Table 2.0-8, *UC Merced and University Community Project Final EIS/EIR*, March 2009.

(b) A peaking factor of 2.25 has been accepted for UC Merced wastewater generation planning.

3.3.3 Bellevue Ranch

Future flow estimated for the Bellevue Ranch area was obtained from the Bancroft Drive Interim Sanitary Sewer Lift Station Design Study (January 2004). **Table 3-4** summarizes the generation rates listed within the report. An interim 14-inch forcemain has been designed to pump a peak flow of 1.95 MGD to the G Street Trunk. Once the capacity of the interim forcemain is exceeded, a permanent 16-inch forcemain (already installed) will be used to convey all flow from Bellevue Ranch to the R Street trunk line. The force main to G Street would be abandoned at the time the connection is made to R Street.

Table 3-4 Bellevue Ranch Wastewater Generation Rates [(a)]

	Average DWF (Mgal/d)	Peak WWF (Mgal/d)
Bellevue Ranch East Phases 1 and 2	0.378	0.747
Bellevue Ranch East Phases 3 and 4 (24% of total flow)	1.020	0.511
Bellevue Ranch West Phases 1 and 2	0.508	0.968
Total Flow	**1.131**	**2.226 (1.950)** [(b)]

(a) Excerpted from Section 2, *Bancroft Drive Interim Sanitary Sewer Lift station Design Study, January 2004*.

(b) A maximum of 1.950 Mgal/d will be conveyed to G Street Trunk. Once exceeded and all flow is diverted, it is estimated that 2.226 Mgal/d will be conveyed R Street Trunk.

3.4 PEAK FLOW ESTIMATES

Precipitation events in January and April of 2006 produced flows at the WWTF that were approximately 2.3 times the average dry weather flow at that time. For this Master Plan update, WWTF influent flow data since 2006 was reviewed by City staff who determined that peak wet weather flows have remained at 2.3 times average dry weather flows (or less).

3.4.1 Peaking Factor Formulas

The City utilizes the following equation to determine peak flows for sizing pipes and pump stations, although this methodology has never been officially adopted:

$$Q_p = 1.75 * Q_a^{7/8}$$

Where:

Q_p = peak flow, Mgal/d

Q_a = average flow, Mgal/d

Prior to the storm events of January and April 2006, this peaking factor provided reasonably conservative peak flows for planning purposes. The validity of this formula was verified through flow monitoring conducted in the winter of 2002/03 and August 2003 (*City of Merced August Flow Monitoring Report*, ECO:LOGIC Engineering, October 2003). As has been noted in previous reports, the only rain events which occurred during the flow monitoring that took place in 2002/2003 had return frequencies of 1 year or less.

The one location where flow has been estimated in this Master Plan using the formula above ($Q_p = 1.75{*}Q_a^{7/8}$) is the Bellevue Ranch development. The report entitled *Sanitary Sewer Study Chalk Hill Drive, Bellevue Ranch* (October 2003, GC Wallace) presents the above formula as the basis for flow estimates and design within Bellevue Ranch, as does the *Preliminary Interim Sanitary Sewer Lift Station Design Study, Bellevue Ranch* (January 2004, GC Wallace).

Since the January and April 2006 rainfall events ranged in frequency from 13 to 190 years, these storm events were considered to provide a conservative basis for a new peaking factor formula. The original peaking factor formula was adjusted to provide a minimum peaking factor (level of protection) of 2.3, dependent on generated average flow

3.4.2 Application of Peaking Factor – Build-out Flow Estimates

For each build-out area, unless there was more specific, approved information from a planned development provided by the City that deviated from the General Plan land uses, a peaking factor of 2.3 was applied to the average wastewater flow generation estimates.

Table 3-5 summarizes land use areas, population estimates and resulting wastewater flow generation data used in assessing collection system capacity needs which are discussed further in Chapters 4 and 5. Should the SUDP develop to full build-out as described in the Vision 2030 General Plan, the ultimate flows are estimated to be as presented in **Table 3-5**, including flows contributed from existing services.

Table 3-5 Summary of Acreages and Estimated Wastewater Flows at General Plan 2030 Full Build-out

Land Use	Total Area (ac)	Total EDUs	Total Population	DWF (Mgal/d)	PWWF (Mgal/d)	I&I (Mgal/d)
Commercial	2,883	16,848	-	4.3	9.9	5.6
Industrial	4,072	31,723	-	8.1	18.7	10.6
School	842	12,356	-	3.2	7.3	4.1
Rural Residential	2,303	4,603	13,901	1.2	2.7	1.5
Low Density Residential	8,699	39,142	118,208	10.1	23.1	13.1
Low to Medium Density Residential	1,172	9,959	30,075	2.6	5.9	3.3

Land Use	Total Area (ac)	Total EDUs	Total Population	DWF (Mgal/d)	PWWF (Mgal/d)	I&I (Mgal/d)
High to Medium Density Residential	826	14,869	44,903	3.8	8.8	5.0
High Density Residential	124	3,482	10,515	0.9	2.1	1.2
Mobile Home Park	80	636	1,921	0.2	0.4	0.2
Village Core Residential	444	5,323	16,076	1.4	3.1	1.8
Residential Reserve	360	1,621	4,896	0.4	1.0	0.5
Community Plan	1,617	7,278	21,978	1.9	4.3	2.4
Mixed Use	447	5,324	16,078	1.4	3.1	1.8
Other (c)	1,948	-	-	-	-	-
Sub-Total	**25,818**	**153,164**	**278,552**	**39.3**	**90.4**	**51.1**
UC Merced (a)	815			1.13	2.54	1.41
Campus Community (a)	1,951	13,585	41,026	1.96	4.41	2.45
Sub-total	**2,766**	**13,585**	**41,026**	**3.09**	**6.95**	**3.86**
Grand Total (b)	**28,584**	**166,749**	**319,578**	**42.4**	**97.4**	**55.0**

(a) Population and flows for UC Merced and the Campus Community are excerpted from Table 2.0-8, *UC Merced and University Community Project Draft EIS/EIR, November 2008 and Final EIS/EIR*, March 2009. A peaking factor of 2.25 has been accepted for UC Merced wastewater generation planning. UC Merced flows additional to existing flows.

(b) Flows presented are unattenuated sum totals. Actual flows seen at the WWTF would be expected to differ due to attenuation in the collection system.

(c) Land uses characterized as other include "Agricultural", "Future Park", "Open Space – Park Recreation", and "Public / General Use"

4.0 HYDRAULIC MODEL

4.1 PURPOSE

The purpose of this chapter is to outline details of the sewer collection system model construction and the scenarios analyzed.

This chapter is divided into the following sections:

- Modeling Software
- Model Inputs
- Model Validation
- Modeled Scenarios

4.2 MODELING SOFTWARE

Dynamic computer models are generally considered one of the most sophisticated means to assess sewer system capacity. For this study, Innovyze's *InfoWorks CS (version 15.0.2.28007)* software was used to analyze the City's sewer system prior to a recent upgrade to *InfoWorks ICM (version 6.5.5.13016)*. The *InfoWorks* software was used in 2007 to develop the model which Stantec has updated as part of the current master planning study.

4.3 MODEL INPUTS

The first step in constructing a collection system hydraulic model is to input the existing structural components of the system. These include:

- Pipes
- Manholes
- Pump stations (in this case, the Highway 59 pump station)

Other inputs include:

- Sub-catchments (land use and water generation)
- Rainfall data and/or design storm(s)

These components are described in greater detail in the sections which follow.

4.3.1 Pipes and Manholes

The model used to evaluate existing and future capacity needs was constructed using pipes in the existing trunk system that are 8-inches in diameter, and greater. **Figure 4-1** illustrates the pipes which were modeled in the existing collection system.

4.3.2 Highway 59 Pump Station

There is one major pump station in the City's existing wastewater collection system, which is referred to as the Highway 59 Pump Station. The station is shown on **Figure 4-1** and is located next to Highway 59 just north of Black Rascal Creek. The station is equipped with three (two duty, one standby) 2.200 gpm centrifugal pumps.

4.3.3 Subcatchments

Subcatchments are geographic areas within each flow monitoring basin (as defined in Chapter 2) that represent a composite of land uses such as residential, commercial, industrial, public, or school land uses. A population (as defined in Chapter 2) is associated with each catchment to represent a per capita flow rate based on the residential land use within the catchment. Commercial, industrial, school and public land use flows were calculated separately based on acreage and selected unit flows (gpd/acre). These flow projections were then imported into the computer model of the collection system to simulate both existing and future flow conditions.

4.3.4 Design Storm

To predict system performance and assess needed and available capacity in the wastewater collection system computational models, such as the *InfoWorks* software used for the system analysis for the City of Merced, relies on synthetic/simulated rainfall conditions. The synthetic/simulated rainfall selected and used to assess system capacity is typically referred to as the design storm. The design storm selected for many central valley systems has a 10-year return period.

In the case of the City of Merced's model, which was last updated in 2007, two storms which occurred in January and April of 2006 were considered. These events resulted in the highest wastewater flows recorded at the City's wastewater treatment facility (WWTF) up to that time. The assessment of the collection system performed in 2006/2007 relied upon a peaking factor of 2.3 times average flow. This is consistent with the peak flows seen at the WWTF during the January and April 2006 storm events. During the assessment of the City system conducted for this Master Plan update, more recent WWTF flows were evaluated and it was confirmed that 2.3 remains a reliable, conservative predictor of peak flow in the system relative to average flow. Therefore, this peaking factor was used in the collection system assessment conducted and presented in this Master Plan as opposed to a specific design storm.

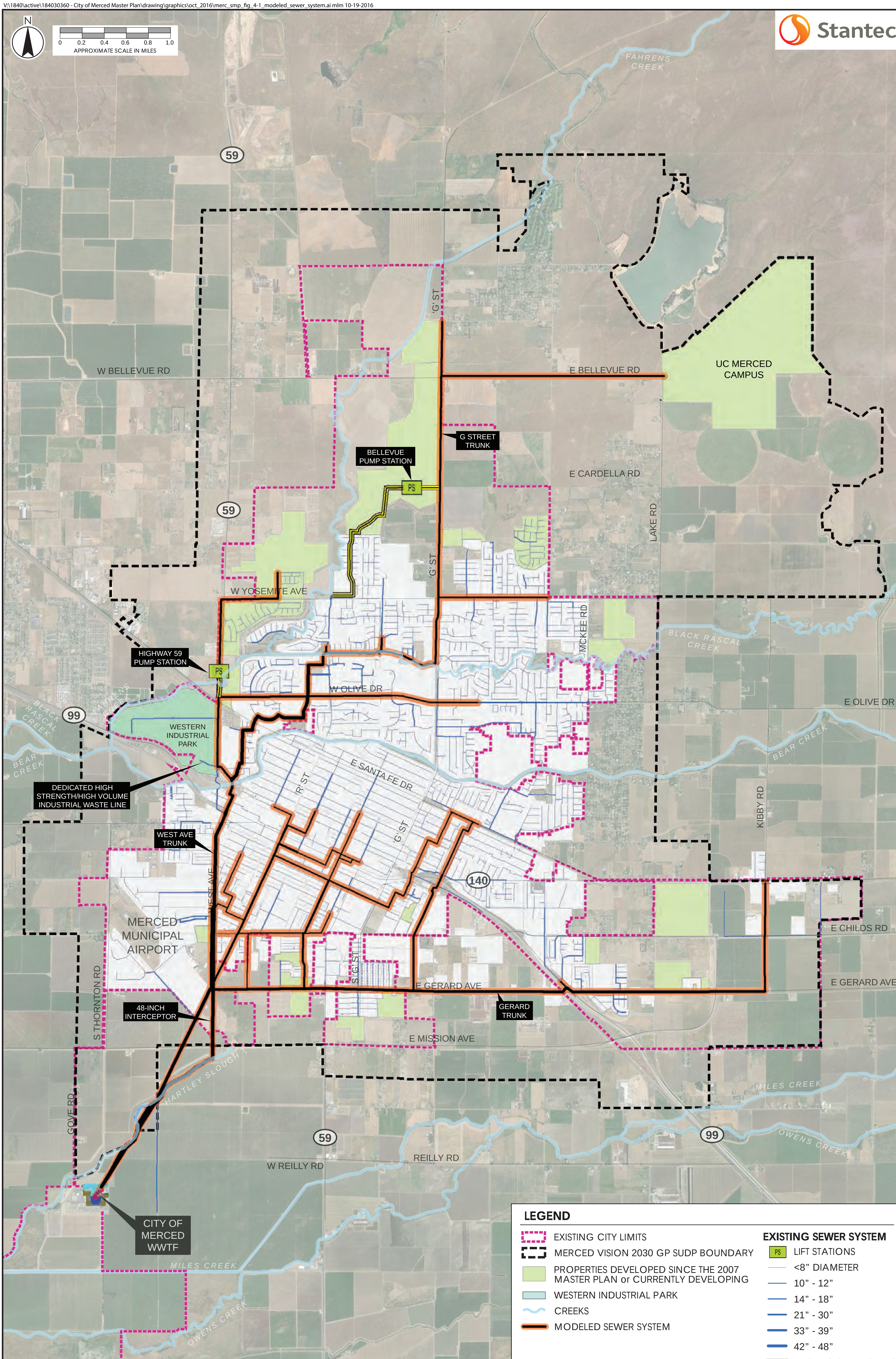

Figure 4-1
Modeled Sewer System

4.4 MODEL CALIBRATION

The model used for this evaluation was constructed and calibrated as part of the draft 2007 Master Plan process. Calibration (or validation) of the wastewater collection system computer model for both wet and dry weather conditions is necessary to ensure the accuracy of predicted flows are acceptable. In the case of the City's model, the version calibrated with the draft 2007 Master Plan effort was used. Due to the fact the model had been calibrated previously and was shown to produce acceptable results, the City decided not to revisit the calibration step with this Master Plan update. The previous dry weather calibration was conducted using flow monitoring data from selected locations within the collection system that was gathered at that time and flow data from the City WWTF influent flow meter. The model was also calibrated for wet weather conditions, at that time, to a peak flow of 2.3 times the average flow at the WWTF.

Note that the sewer diameters, slopes, and inverts were input in the model as part of the 2007 master planning process, and have not been confirmed or validated as part of this study. It is understood that some of the slopes and inverts where initially based upon record drawing information. It is recommended that prior to conducting any system improvements (see Chapter 5 for Master Plan recommendations), that the elevations of these sewers be confirmed, the sewer model updated and relevant simulations exercised (re-run) as appropriate. The City may wish to conduct limited surveying as part of any confirmation effort.

4.5 MODEL SCENARIOS SIMULATED

The computer model was used for analysis of a number of different scenarios:

- Existing system conditions – evaluation of capacity within the existing system with only existing connections producing wastewater flow
- Interim conditions – these are conditions defined by City staff which represent development that is expected to occur prior to construction of significant new trunk sewers either in the north or south Merced areas (presentation of results is limited to identifying the remaining capacity within existing trunk sewers)
- Build out of the SOI – Pipe size and slopes for future trunk sewers and pump stations were identified to serve the entire study area, as defined in Chapter 3 of this Master Plan report

4.5.1 Recommended Level of Service Evaluation Criteria

Level of service (LOS) criteria used to assess capacity of sewers include:

- the extent of surcharging in the manholes,
- minimum and maximum pipeline velocities, and
- pipe capacity.

4.5.1.1 Surcharging Criteria

Surcharging in a manhole is defined as the distance between the rim elevation and the hydraulic grade line (HGL). The manhole is considered to be surcharged when the HGL exceeds the pipe crown.

For surcharging in existing manholes, there are two deficiency criteria for this analysis:

1. When the rim elevation is less than or equal to 8-feet above the pipe crown:
   a. No surcharging is allowed.
2. When the rim elevation is more than 8-feet above the pipe crown:
   a. A pipeline is hydraulically deficient if there is less than 8-feet of freeboard or the surcharging is equal to or greater than 1-foot above the pipe crown.

For new improvements to the City's trunk system, no hydraulic surcharging is allowed in manholes.

4.5.1.2 Velocity

Gravity sewer shall allow a minimum flow velocity of 2.5 ft/s and a maximum of 7 ft/s. All sewers that have a velocity outside of these criteria shall be identified.

Force mains shall allow a minimum flow velocity of 2 ft/s and a maximum of 7 ft/s. All force mains that have a velocity outside of these criteria shall be identified.

4.5.1.3 Pipe Capacity

Sewer pipes shall conform to the following capacity criteria under design storm conditions, where d = depth of flow and D = pipe diameter.

- d/D shall be a maximum of 70% for pipe less than or equal to 24 inch
- d/D shall be a maximum of 100% for pipe greater than 24 inch

4.5.2 Existing System Simulation

Areas within the City's service area which were not previously (during development of the draft 2007 Master Plan) connected, but which have since developed and now contribute to the wastewater flows conveyed by the collection system were identified with assistance from City staff. These areas were added to the existing model and predicted flows checked against WWTF influent flow records.

The existing system simulation relied upon system configurations and data from the previously developed model. The evaluation of the existing system simulation produced results which are presented in Chapter 5 of this Master Plan report. Those results include identification of:

- Sewers which are not predicted to have capacity issues.
- Sewers that are predicted to surcharge due to downstream conditions, though have sufficient freeboard to meet the City's Level of Service (LOS) criteria.
- Sewers that are predicted to surcharge due to insufficient capacity though have sufficient freeboard to meet the City's LOS criteria.
- Sewers that are predicted to surcharge to an extent such that they do not meet the City's LOS criteria, and are resultant from downstream conditions and insufficient capacity, respectively.

The existing sewer collection system and service area extents are illustrated above in **Figure 4-1**. Among other things, Chapter 3 summarizes the land uses within the existing City service area assumed to contribute wastewater flow in the existing scenario. Results of this simulation are presented in Chapter 5 of this Master Plan report.

4.5.3 Interim Condition System Simulation

Similar to the existing system simulation, the results of the interim condition and SUDP build-out simulations identify predicted deficiencies in the existing collection system. However, the interim condition simulation does not include recommended system improvements for the reason that the simulation is intended to guide the City and development community as to the potential limits of the existing system to convey flow from "entitled" properties before new, large diameter trunk sewers can be constructed.

The findings of previous analyses (2002 North Merced Master Plan and draft 2007 Master Plan) indicate that investment in the existing system should be relatively limited, as the full build-out of the SUDP cannot be accommodated through those pipelines without major investments expected to cost significantly more than construction of new parallel trunks which would "bypass" the existing collection system.

The interim capacity scenario assesses the impacts upon existing sewers of areas that are considered likely to develop prior to construction of new trunk sewers. These areas are defined by the North Merced Sewer Assessment District (NMSAD). The analysis of the interim condition also includes those properties identified by the City on the Tentative Subdivision Activity Map (TSAM). The NMSAD was established in the 1980's (unknown) to finance construction of trunk sewers to serve areas within the boundary of the District, the majority of which is located north of Bear Creek. In addition to the NMSAD and TSAM parcels, the interim condition also assumed full build-out of the UC Merced campus as excerpted from the *UC Merced and University Community Project Draft EIS/EIR,* November 2008 and *Final EIS/EIR*, March 2009.

Figure 4-2 identifies the parcels which were added to those contributing to the existing system in order to estimate flows for the interim condition simulation. The acreages and estimated wastewater flows generated from the entitled parcels are summarized in **Table 4-1.**

The interim condition simulation does not anticipate any future trunk sewers, meaning that is was exercised in order to identify deficiencies in and remaining capacity available in the existing system trunk sewers if all of the areas identified in **Figure 4-2** were to develop. Results of this simulation are presented in Chapter 5 of this Master Plan report.

Table 4-1 Summary of Acreages and Estimated Wastewater Flows from Entitled Developments

Contributing Area	Total Area (ac)	Total EDUs	Total Population	DWF (Mgal/d)	PWWF (Mgal/d)	I&I (Mgal/d)
G Street Entitlements	642		14,163	1.2	2.8	1.6
R Street Entitlements	1,169		21,201	1.8	4.1	2.3
Highway 59 Entitlements	318		7,472	0.6	1.5	0.8
Highway 59 Pump Station Entitlements	543		10,879	0.9	2.1	1.2
42-inch Interceptor Entitlements	13		377	0.03	0.07	0.04
UC Merced	815			1.13	2.54	1.41
Sub-total (a)	**3,500**		**54,092**	**5.7**	**13.1**	**7.4**

(a) Flows reported within the table are total flows at buildout, and make no distinction between future development and developments already partially constructed.

4.5.4 SUDP Build-out System Simulation

The SUDP build-out simulation considered the area identified within the Vision 2030 General Plan SUDP. It also includes the current build-out (ultimate) development density for the UC Merced campus and the adjacent Campus Community. **Figure 4-3** illustrates the extent of the build-out service area for this simulation.

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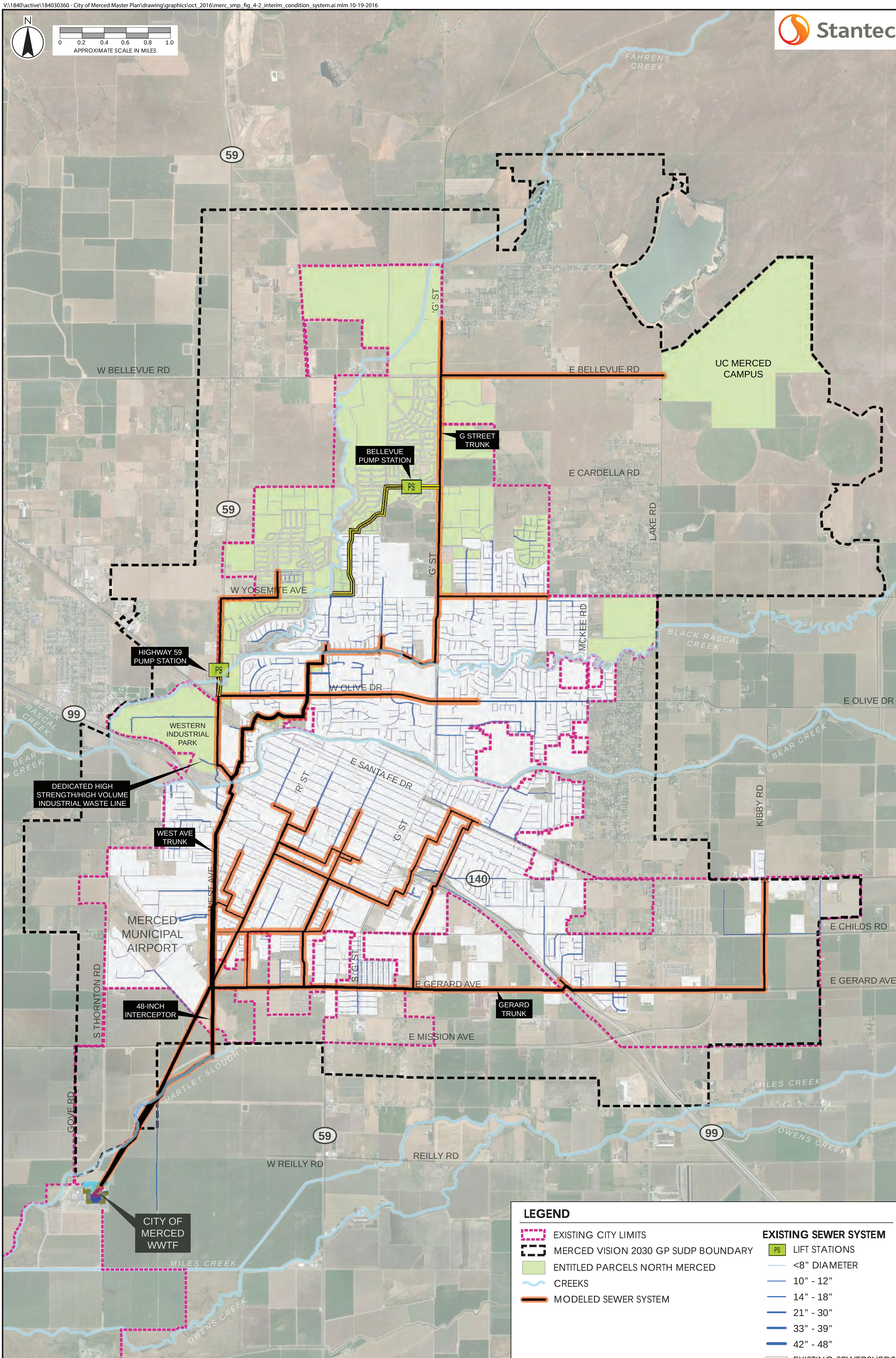

Figure 4-2
Interim Condition System Extents

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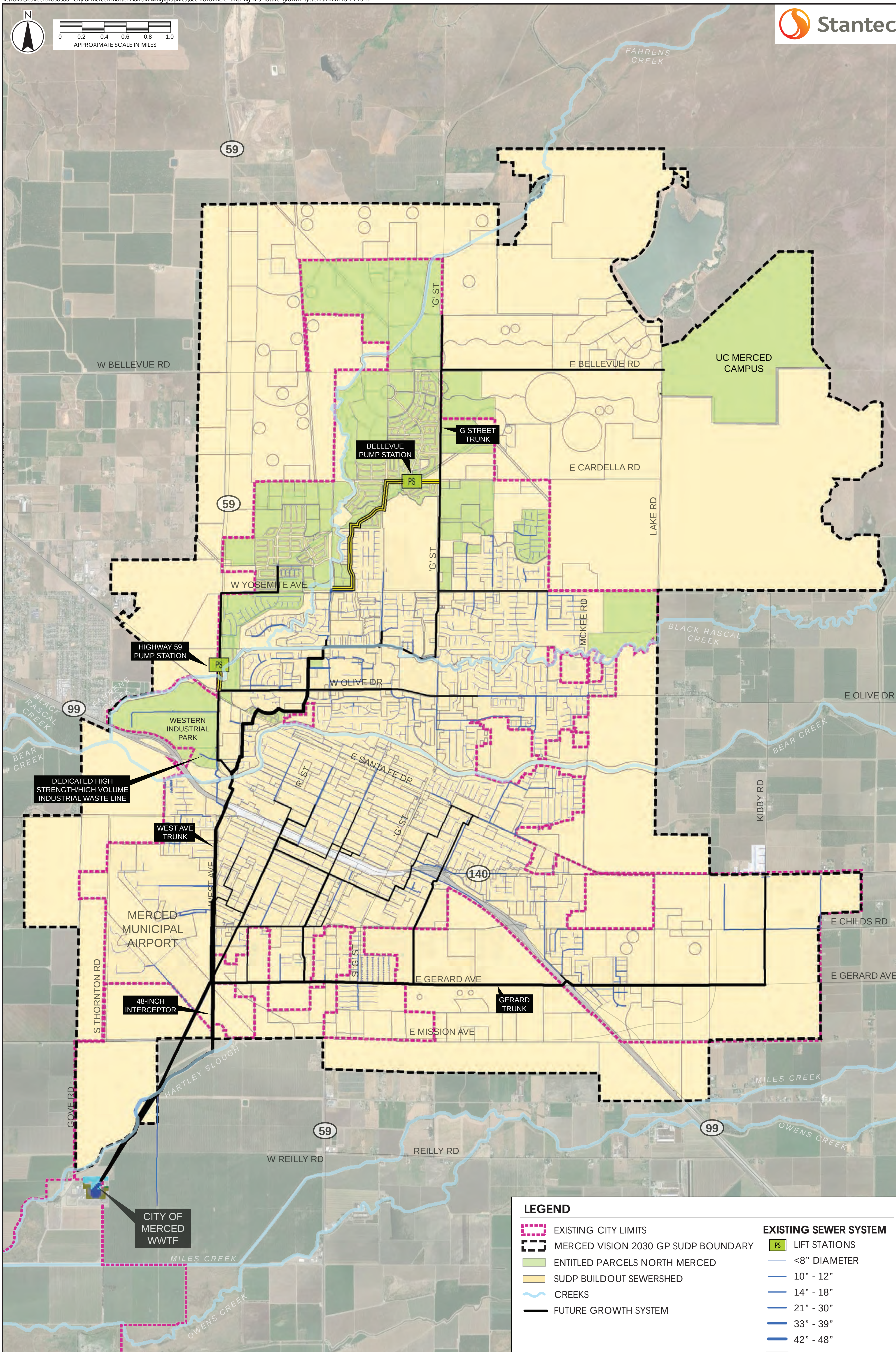

Table 4-1 summarizes the land uses and densities assumed to contribute wastewater flow in the SUDP build-out scenario. Unlike the existing service area and interim development condition simulations, for the SUDP build-out scenario, several alternative servicing options were considered. Some included all of the future areas identified in **Figure 4-3** and listed in **Table 4-2**, while others assumed certain areas did not contribute wastewater flow in the future. Still other simulations considered the timing of development within certain areas relative to construction of new, future trunk sewers. For example, one scenario considered the impact of participation by the Campus Community in new, future trunk sewers in a similar time frame as the balance of the UC Merced campus and the Vision 2030 SUDP, while another scenario considered the impact of the Campus Community participating in separate trunk sewers that would be planned and designed (separately) after trunks were planned and designed to serve the UC Merced Campus and the balance of the Vision 2030 SUDP.

The SUDP build-out scenarios which the City considers relevant to this Master Plan are described in more detail, along with the results of those simulations, in Chapter 5 of this report.

Table 4-2 Summary of Acreages and Estimated Wastewater Flows Under Existing Conditions and for SUDP Build-out Scenario

Land Use	Total Area (ac)	Total EDUs	Total Population	DWF (Mgal/d)	PWWF (Mgal/d)	I&I (Mgal/d)
Commercial	1,443	8,433	N/A	2.2	5.0	2.8
Industrial	3,217	25,068	N/A	6.4	14.8	8.4
School	313	4,593	N/A	1.2	2.7	1.5
Rural Residential	2,299	4,594	13,874	1.2	2.7	1.5
Low Density Residential	3,134	14,100	42,583	3.6	8.3	4.7
Low Medium Density Residential	340	2,890	8,729	0.7	1.7	1.0
High Medium Density Residential	159	2,864	8,649	0.7	1.7	1.0
High Density Residential	32	902	2,725	0.2	0.5	0.3
Mobile Home Park	3	25	75	0.01	0.02	0.01
Village Core Residential	304	3,643	11,002	0.9	2.2	1.2
Residential Reserve	356	1,602	4,837	0.4	0.9	0.5
Community Plan	1,620	7,291	22,018	1.9	4.3	2.4
Mixed Use	394	4,703	14,202	1.2	2.8	1.6
Other [(b)]	1,149	-	N/A	-	5.0	2.8
Campus Community [(a)]	1,951	13,585	41,026	2.0	4.41	2.45
Sub-Total	**16,715**	**94,293**	**169,720**	**22.7**	**52.1**	**29.4**

(a) Population and flows for UC Merced and the Campus Community are excerpted from Table 2.0-8, *UC Merced and University Community Project Draft EIS/EIR, November 2008 and Final EIS/EIR, March 2009*. A peaking factor of 2.25 has been accepted for UC Merced wastewater generation planning.

(b) Land uses characterized as other include "Agricultural", "Future Park", "Open Space – Park Recreation", and "Public / General Use".

5.0 SATELLITE TREATMENT FEASIBILITY ANALYSIS

5.1 INTRODUCTION

The purpose of this chapter is to evaluate the feasibility of servicing the North Merced area using satellite treatment facilities under the future flow scenarios presented in Chapter 4. It is recommended to provide an updated Treatment Facilities Plan, to provide comprehensive evaluation of satellite treatment and analysis of required City WWTF (centralized treatment) improvements.

For the purposes of this Sewer Master Plan update, the future servicing scenarios described in Chapter 4 are used to compare the option of satellite treatment, assuming the City continues to provide wastewater treatment at the existing WWTF site for existing users (at a minimum).

For each of the scenarios considered, an evaluation has been conducted to determine the potential incremental costs and cost savings of conveying a portion of North Merced flows to satellite reclamation facilities. This comparison of centralized treatment (expanding the City's existing WWTF) to the use of satellite facilities is developed for each flow scenario when significant collection system improvements can be avoided.

The cost estimates provided in this chapter are conceptual in nature and intended primarily for alternative comparison purposes. Satellite facility evaluation criteria is established below.

5.2 SATELLITE FACILITY EVALUATION CRITERIA

This satellite facility evaluation does not include a comprehensive evaluation of alternate treatment and disposal options, which is better suited for a Treatment Facilities Plan. Under an updated Treatment Facilities Plan, a detailed evaluation of the required improvements needed to increase the capacity at the existing centralized treatment plant can be done cohesively with the analysis of a satellite treatment option with alternative levels of treatment and solids handling for various disposal alternatives, as well as phasing and permitting requirements of new facilities.

It is assumed that the satellite facility will not be limited by disposal capacity or reclamation demand. This includes the assumption that such a facility can and would be permitted by the Regional Water Board. If satellite treatment appears viable for portions of North Merced, a detailed reclamation study would be required to more accurately assess the reclamation feasibility within North Merced, as no estimate of available recycled water demand has been determined in this Master Plan.

The evaluation which follows assumes that the level of treatment required at a satellite facility will be similar to the City's centralized WWTF because the apparent most cost effective option is a new facility that would (for purposes of simplifying the alternatives comparison) have a seasonal effluent discharge to Fahrens Creek when dilution is high, while effluent would be reclaimed on nearby lands (not specified in this analsyis) during the remainder of the year. Note that seasonal discharge into Fahrens Creek will be complicated to permit, as this goes against the Regional Board's policy favoring centralized treatment. The Regional Board's stated policy preference (Res. No. R5-2009-0028) is for wastewater regionalization, and is supported by the State Water Board Division of Financial Assistance's recent offer(s) of principal forgiveness and extended term financing for regional projects. If it is determined that surface water discharge from the satellite plant is not viable, the satellite plant will require year-round storage with summertime reclamation (as percolation is likely not permissible due to groundwater degradation concerns). This evaluation provides a cost estimate for a new disinfected tertiary facility that achieves the level of treatment necessary to meet anticipated surface water discharge requirements and produce recycled water of sufficient quality to allow Title 22 unrestricted reuse with BOD and TSS levels less than 10 mg/l and total Coliform levels less than 2.2 MPN/100mL.

Four important factors must be considered to determine the feasibility of satellite treatment and are presented in more detail below:

1. Collection system improvement costs or savings.
2. Treatment, disposal/reclamation, and storage construction costs (satellite versus central)
3. Wastewater system operation and maintenance costs.
4. Offsetting costs/credits for potable and non-potable water.

5.3 SATELLITE SYSTEM FLOWS

Future sewer system layouts and satellite plant sites evaluated and compared in this chapter will accommodate build-out flows from within the City's SUDP. A key assumption of this evaluation is that the existing City sewer service area, and some of the "entitled" communities detailed in the Chapter 4 Interim Condition scenario, will flow to the City's central WWTF, to fully utilize remaining capacity in the existing collection system. Because the existing collection system is estimated to be capable of conveying about 4 Mgal/d of additional peak wet weather flow, all the remaining flow from the Interim Condition scenario, in excess of the existing collection system capacity, will be sent to a satellite plant. The interim peak flow sent to the satellite facility is therefore estimated to be approximately 4.26 Mgal/d PWWF (0.82 Mgal/d from the North Western side of the entitled communities and 7.43 Mgal/d from the Northeastern side). If approximately 4.0 Mgal/d of that flow can sent through the existing collection system, as described above, the associated average dry weather flow is estimated be about 3.23 Mgal/d, ADWF.

In addition to accepting some of the entitled communities wastewater (3.23 Mgal/d ADWF), the satellite treatment facility will accommodate North Merced SUDP Build-Out future flow rates of approximately 11.0 Mgal/d ADWF (25.3 Mgal/d PWWF). The plant will be built in incremental phases to correspond to, as yet to be determined development timing. Phasing the satellite plant is possible, to accommodate staged growth and should be considered in detail in a separate Treatment Facilities Plan.

This Master Plan assumes that the City will maximize utilizations of existing sewer capacity in the existing collection system without incurring significant costs for additional conveyance improvements. All flows beyond that capacity will be sent to the satellite plant. While plant phasing is expected to take place in 3.5 Mgal/d incremental expansions, beyond the collection system capacity, this feasibility analysis is based on comparing ultimate build-out scenarios.

5.4 SATELLITE SEWER LAYOUTS

The sewer layouts for different flow scenarios anticipated by the City are presented in Chapter 4. The City's primary objective is to maximize the existing system capacity first and identify cost effective modifications to the system to accommodate additional flow where practical. Design criteria used to assist in sizing and locating future sewer systems are also described in Chapter 4. The only modification to the previously described sewer system is that the northeast and northwestern side of the SUDP will now flow to the satellite facility in this alternatives analysis (reducing the pipe and pump station sizing in the southwest build-out trunk).

Construction cost for comparison of scenarios are based on an Engineering New Record 20 Cities Construction Cost Index (ENRCCI) of 10,435, corresponding to October 2016 price levels. A contingency factor of 30 percent is added to base costs to reflect planning uncertainties.

5.4.1 Existing System Scenario

The existing system scenario described in Chapter 4 is not evaluated in terms of servicing with satellite treatment plant facilities. The existing system has certain deficiencies which are discussed in greater detail in Chapter 6 of this Master Plan. Those deficiencies are limited and the improvements necessary to address those are not considered significant enough to warrant consideration of satellite treatment as an option to those hydraulic upgrades. In addition, the City's WWTF has sufficient capacity to receive and treat the wastewater generated from the existing system.

5.4.2 Interim Condition System Scenario

The additional dry weather flow contribution from the build-out of the UC Merced campus and the entitled properties identified in Section 4.5.3 of this Master Plan is estimated to be approximately 3.6 Mgal/d. The corresponding peak flow is approximately 8.26 Mgal/d. The collection system and WWTF appears to have capacity to handle the additional (approximate)

4 Mgal/d from the Interim Condition scenario, but loading should be calculated and capacity assessed in a separate Treatment Facilities Plan to identify with a greater degree of certainty whether the treatment plant can handle the additional flows and loads without significant upgrades. Therefore, the option of constructing satellite treatment facilities to serve the approximately 4.26 Mgal/d flows beyond the existing system capacity for these entitled areas (which includes build-out of the UC Merced campus) is considered below.

5.4.3 SUDP Build-out System Scenario

This flow scenario accommodates flow from build-out of the SUDP, but only the portion in North Merced is assumed to be serviced by the satellite plant. The total ADWF generated from the North Merced SUDP in excess of that estimated from the Interim Condition scenario is approximately 11 Mgal/d. The corresponding peak flow contribution is approximately 25.3 Mgal/d. As discussed in prior master planning documents and in Chapter 6, the existing collection system cannot accommodate the flows estimated to be generated from build-out of the SUDP. With a new satellite plant located in close proximity to northern SUDP communities, there is a potential cost savings in trunk sewer improvements, as long, large diameter trunks would not be required to convey flow to the City's WWTF.

As shown in **Figure 5-1**, the collection system improvements necessary to service North Merced with a satellite treatment plant removes the need for about 2-miles of 54-inch pipe, eliminates a pump station, and replaces 3.3-miles of 60-inch pipe all of which are identified as necessary to serve North Merced SUDP build-out (See Chapter 6, Figure 6-10) with 12- to 24-inch pipes. Resulting in a cost of $36.1M to service the North Merced SUDP (or a $53.1M savings compared to the preferred alternative presented in **Table 6-4**). This cost savings is carried through the feasibility analysis presented below.

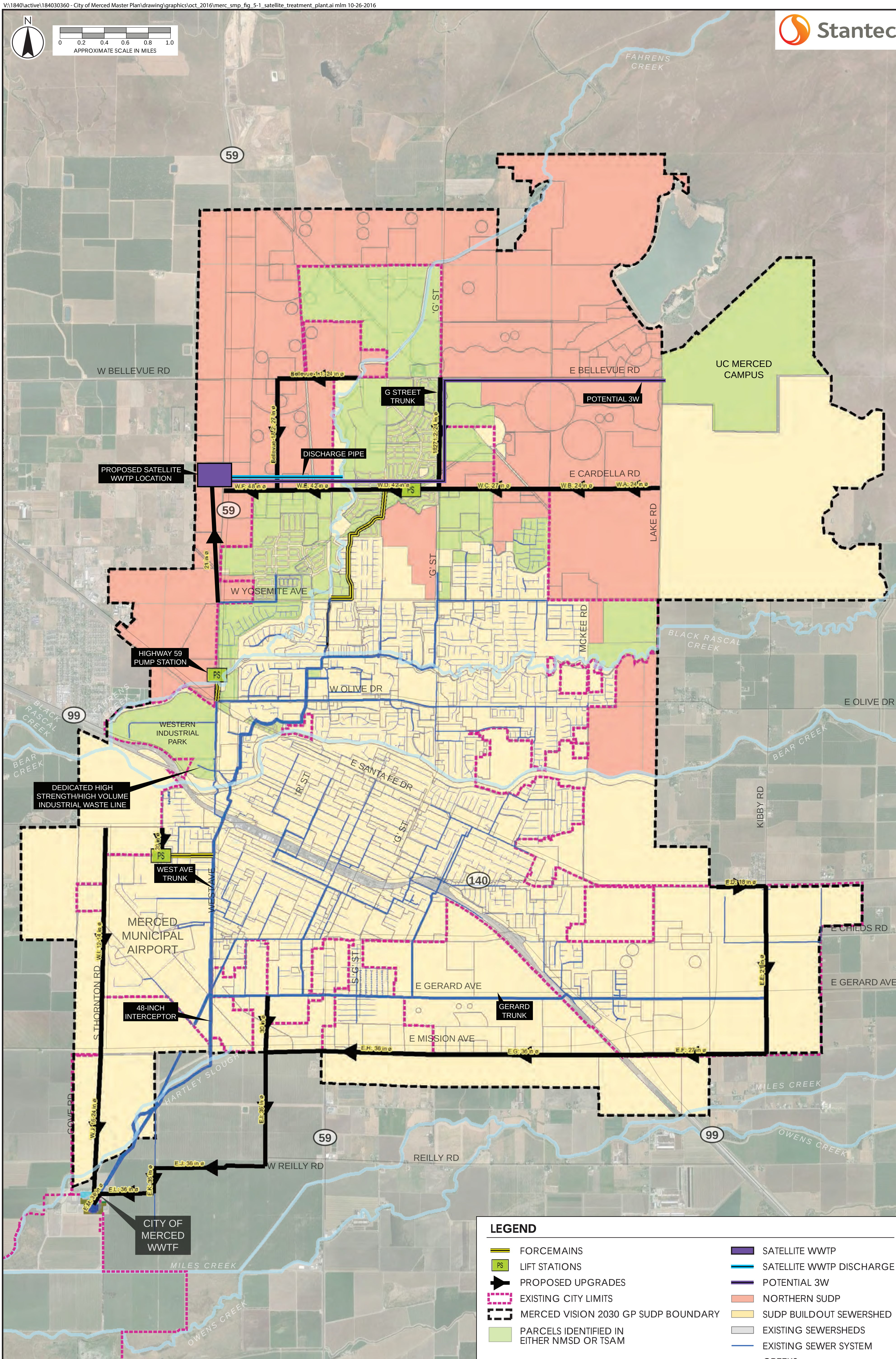

Figure 5-1
Satellite Treatment Plant & Collection System Layout

5.5 SATELLITE TREATMENT PLANT EVALUATION

The following sections evaluate the feasibility of using satellite treatment facilities in North Merced in lieu of conveyance and treatment to the City's WWTF. The location, size, and costs associated with satellite treatment are detailed below.

5.5.1 Potential Satellite Facility Locations

The most remote locations of the SUDP will be routed to the satellite facility because it is the farthest from the existing WWTF. To be cost effective, satellite facilities will need to be located in an area where the wastewater is both generated and reclaimed. Since the UC Merced Campus has considered the use of reclaimed water, a plant effluent piping will need to discharge into the Campus. This was discussed in the 2002 North Merced Master Plan. Based on the location of potential service and reclamation areas, the location that appears best suited for a potential satellite treatment plant is the area southwest of Lake Yosemite, on the intersection of a main sewer trunk near Cardella Road, between the UC Merced campus and the western corner of the SUDP (see **Figure 5-1**). Locating the satellite facility within the SUDP would require some adjustment to land uses identified in the City's 2030 Vision General Plan because most of the area has specific plans for development or is designated as residential or commercial land use. Consistency with the General Plan is an important consideration and alterations to the Plan may be difficult to accomplish.

Any satellite facility designed to serve North Merced SUDP build-out is assumed to require investment in the equivalent conveyance capacity as the system required for the WWTF, as shown in **Figure 5-1** and described in Section 5.4.

5.5.2 Satellite Facility Sizing

As stated previously, the Merced collection system can accommodate approximately 4.0 Mgal/d of additional flow from the North Merced area with limited modifications and improvements to the existing collection system. Satellite facilities could be sized to treat flows beyond 4.0 Mgal/d to maximize utilization of the existing collection system without incurring significant costs for additional conveyance improvements. This results in an ultimate satellite facility size of 14.25 Mgal/d ADWF (3.23 Mgal/d from currently entitled communities and 11.0 Mgal/d from the unentitled portion of the North Merced SUDP). Although phasing of plant construction is expected to take place in 3.5 Mgal/d incremental expansions, this report is not analyzing the anticipated rate of growth within the City. As such, the costs presented below are based on ultimate build-out of 14.25 Mgal/d (which will have benefits of economies of scale that will not exist with incremental phasing, but is a reasonable approximation for this level of analysis and appropriate for comparison with the collection system improvements recommended to serve SUDP build-out, as described in Chapter 6).

5.5.3 Satellite Facility Impact on Existing WWTF Expansion

Constructing a satellite treatment plant could also offset the need for future expansion of the existing WWTF, which directly corresponds to the flow treated at the satellite facility. The existing Merced WWTF capacity is 12 Mgal/d ADWF and will continue to expand in in 4 Mgal/d increments to accommodate South Merced SUDP build-out, with ultimate accommodation of up to 20 Mgal/d ADWF capacity (anything beyond 20 Mgal/d requires additional planning). To determine the true impact on WWTF capacity and future flow, it is recommended to prepare a separate Treatment Facilities Plan.

It is important to note that the type of satellite facilities constructed (i.e. zero discharge, seasonal discharge or hybrid/scalping facility) will impact the the centralized City WWTF and collection system in different ways. By observation, the hybrid scalping facility has been removed from the analysis because it does not decrease the needed collection system or centralized WWTF improvements required to handle the increased flow from the SUDP peak wet weather capacity. This is because a scalping plant is intended to use treated effluent (recycled water) in real-time to meet irrigation demands. In the wet season, when irrigation is lowest, all flow would need to be conveyed to the WWTF, which is the same time period during which peak wet weather flows are expected to occur. This alternative does not save the costs associated with collection system conveyance to the WWTF and is therefore cost prohibitive without additional incentives.

For the present worth analysis, it is assumed that an equal amount of flow capacity savings at the existing WWTF would result from a zero discharge or seasonal surface discharge satellite treatment plant construction because either of these alternatives will eliminate the need to convey wastewater to the WWTF during the wet season. The estimated capital costs to expand the existing WWTF in-kind is based on a unit cost of approximately $10/gpd (gallon per day capacity). This estimate was developed from the 2011 Wastewater Treatment Facility Expansion Final Design Report, by Stantec Consulting, escalated to October 2016 ENR.

5.5.4 Satellite Facility Construction Costs

A capital cost estimate is developed below for the two viable types of satellite treatment facilities (zero discharge and seasonal discharge facility). As described in Section 5.2, both facilities (zero discharge and seasonal discharge) will likely require the same level of treatment for unrestricted reuse, assuming full “Title 22” standards, to reclaim the wastewater during the dry season. The facilities differ only in how treated effluent is handled during the wet weather season. The zero discharge facility stores treated wastewater effluent during the wet weather season, when irrigation demand is met by precipitation events. The seasonal discharge facility discharges treated wastewater effluent to the closest surface water body during wet weather season, when dilution in the creek is high. Due to the excessive costs (far beyond the seasonal discharge facility) and land intensive requirements, which encroaches on either agricultural land outside the current City SUDP boundary or would require modification of the land uses in the North Merced SUDP, a zero seasonal discharge facility will not be evaluated as part of the present worth analysis.

For planning and cost comparison purposes, it is assumed that disinfected tertiary treatment (i.e. "unrestricted Title 22") will provide sufficient treatment to allow seasonal surface water discharge. Additional evaluation would eventually be needed to determine with certainty the level of treatment required. Prior to considering this alternative in greater detail, the City should consult the Regional Water Board to see if such a discharge is likely to be permitted given the proximity to the existing, permitted, WWTF.

While there would be beneficial economies of scale to install a satellite plant that can handle all the future flows (14.25 Mgal/d plant), the cost burden to the initial users would be unnecessarily cumbersome and unlikely to occur without phasing the plant. However, to make a fair comparison of overall project costs, the costs presented below are based on build-out (as the collection system improvements with either option should be constructed to accommodate build-out flows. Construction of collection system capacity in gravity systems is not typically cost effectively phased.) **Table 5-1** summarizes the estimated satellite plant construction costs, based on recently constructed facilities of similar size and level of treatment.

Table 5-1 Satellite Treatment Plant Facility Capital Cost Estimates (a)

Item	Cost, $M
WWTP	150,000,000
Land Purchase	16,000,000
Permitting	1,000,000
Land Use Change	1,000,000
Creek Discharge Pipe	2,500,000
3W Discharge Pipe	4,900,000
Subtotal	***175,400,000***
Contingency (30%)	52,600,000
Engineering (30%	52,600,000
TOTAL	**280,600,000**

(a) ENRCCI (20 cities average) = 10,435.
(b) Collection system costs are presented below.

5.5.5 Satellite Treatment Operation and Maintenance (O&M) Costs

As noted by reliable sources, including research by the WaterReuse Foundation, the operation and maintenance costs of satellite treatment is higher than operating a single centralized facility. Due to the high level nature of this feasibility study, O&M costs will be derived as being equivalent to 6-percent of treatment plant construction costs and 3-percent of collection system construction costs. A present worth cost analysis comparing costs for constructing a satellite facility versus modifying and expanding the existing collection system can be evaluated in a separate Facilities Plan.

Because the cost to construct a satellite treatment plant (presented in Section 5.5.4) is nearly double the price of upgrading the centralized treatment plant (depending on facility size and type, as presented in Section 5.5.3), the operation and maintenance costs will only exasperate the disparity between centralized and satellite plant costs. **Table 5-2** presents the preliminary O&M costs for the various options.

Table 5-2 Operation and Maintenance Costs (a)

Facility Location	Annual O&M: Facility, $M	30-year lifecycle cost(c), $M
Satellite	14.6	286.6
Central	13.2	259.5

(a) O&M assumed to be 6% of WWTP and 3% of collection system construction costs (excluding engineering).

(b) 3% annual inflation per year.

5.5.6 Present Worth Analysis, Satellite System

The life cycle costs associated with constructing a satellite facility versus expanding the centralized treatment plant are presented in **Table 5-3** below.

Table 5-3 Present Worth Costs for Satellite System (a)

Item	Satellite WWTP, $M	Central WWTF, $M
Collection System (b)	$36.1	$89.3
Treatment and Disposal	$280.6	$224.0
30-yr O&M	$286.5	$259.5
TOTAL	**$603.2**	**$572.8**

(a) Including engineering and contingency.

(b) South (east) Merced SUDP not included because the cost is the same regardless of satellite installation.

5.5.7 Potable/Non-Potable Water Offsets

The results of the present worth analysis indicate that there are additional costs associated with satellite treatment. However, the analysis did not consider the cost/benefit of offsetting potable and non-potable water supplies or water related projects. The cost of water typically drives the demand for water reclamation projects. The cost of water increases when potable water becomes scarce, due to natural or manmade causes (drought or increased demand due to growth). Many water reclamation facilities are located in Southern California and the San Francisco Bay Area because the cost of water is relatively expensive.

The City of Merced currently benefits from the use of reclaimed water (and biosolids) at their land application area, south of the WWTF, where the City grows and sells crops to local farmers. If a satellite facility is installed, the benefit of the reclaimed water use would be to the local users and not directly to offset the City's treatment plant costs. In the best case scenario, the City could sell the reclaimed water to local users, but this would still only directly offset the cost they spend to grow crops with water they will now need to purchase from Merced Irrigation District.

Even a most generous analysis that assumes the economies of scale for installation of a larger facility, still does not provide enough incentive to install a satellite plant.

5.6 SUMMARY

The following conclusions are drawn from the foregoing analysis:

- The existing Merced sewer system can be expanded to handle an additional 4 Mgal/d from the Interim Condition System Scenario with all the remaining North Merced SUDP and entitled properties flowing to a satellite treatment plant. Improvements are discussed in the following chapter.
- Construction of satellite treatment facilities is not cost effective compared to current costs for water for flows from the SUDP.
- In order to pursue the satellite treatment facility option further, an additional study is needed to confirm whether demand for recycled water is sufficient to handle the plant described herein.
- A separate Treatment Facilities Plan is recommended to provide a comprehensive evaluation of satellite treatment and to include an analysis of the required centralized treatment plant improvements.

6.0 MODEL RESULTS AND RECOMMENDATIONS

6.1 PURPOSE

This chapter summarizes and presents the results of the three general model simulations described in Chapter 4:

- Existing system simulation
- Interim condition system simulation
- SUDP build-out system simulation

In addition to the simulation results, where appropriate, additional detail is provided of the various simulations, including development timing and relevant alternative trunk alignments that were considered.

This chapter is divided into the following sections:

- Existing System Deficiencies
- Capital Improvement Projects
  - Existing Trunk System
  - Interim Capacity Needs
  - Long Term System Needs
- Cost Estimates

6.2 EXISTING SYSTEM DEFICIENCIES

The existing system was modeled to evaluate the extent of hydraulic deficiencies during peak flows. Current peak wet weather flows in the system, as predicted by the hydraulic model (updated with new developments which have occurred since the draft 2007 Master Plan analyses were conducted, as described in Section 4.5.2), are approximately 23.4 Mgal/d. As a frame of reference, peak flows into the WWTF have been measured around 14 Mgal/d in recent years. As described previously, the existing system is assessed using a synthetic 10-year, 24-hour design storm which does not precisely match historical rain event patterns or conditions and California's drought has made validation of peak flow estimates more difficult.

As a general note, the model currently assumes that I/I enters the collection system at a uniform rate across the entirety of the South Merced basins. This may or may not be an accurate assumption. Without additional site specific observation/monitoring within the system, it is not possible to pinpoint sources of I/I. It is recommended that City staff monitor areas of the system which are predicted to experience surcharge or otherwise are capacity deficient based on the level of service criteria established for this model in Chapter 4 of this Master Plan Report.

It is important to point out that if sources of I/I can be pinpointed, the City can diagnose the nature of the I/I and make necessary repairs. It is also possible that the I/I within the South Merced basin could be re-distributed in the model based on field observations and scenarios re-simulated with results which could affect recommendations for upsizing, or otherwise addressing capacity deficiencies in the existing collection system. It should be further noted, however, that a wet weather peaking factor of 2.3, as is estimated for Merced, is not considered excessive.

In general, new developments will not be added to existing sewers that are showing surcharging above the City's level of service criteria. As mentioned previously, however, the City will likely want to complete studies of the deficient sewers prior to validate these model predictions. For example, if the City's electronic mapping indicates slope of a particular sewer sufficient to predict surcharging in the model, but the actual conditions in the field differ enough to eliminate this concern, the City would want to confirm this prior to expending funds to upsize or parallel deficient sections, or to make final determinations as to the advisability of allowing additional development (flow) into the collection system in these areas.

6.2.1 South Merced

Figure 6-1 shows areas within the existing wastewater collection system in South Merced that are predicted to have hydraulic limitations based on analysis using the Innovyze model to simulate existing peak flow conditions.

While the hydraulic model identifies several locations with hydraulic restrictions, the most significant deficiencies occur in the major collectors along Canal Street and R Street. **Figure 6-2** shows the HGL profile along Canal Street and **Figure 6-3** shows the HGL profile along R Street. Due to the level of service criterion that no surcharging is allowed to occur in sewers with depths less than 8 feet, these two reaches are considered deficient.

It should be noted that while both locations of surcharging fail the Level of Service criterion, the surcharging located along Canal Street is of greater magnitude than along R Street. It is predicted that the surcharging along Canal Street will reach a peak surcharge of 1.8 feet above pipe crown (located at W Main Street and Canal Street). The peak surcharge along R Street trunk is predicted to be 0.3 feet (located at W 16th Street and T Street).

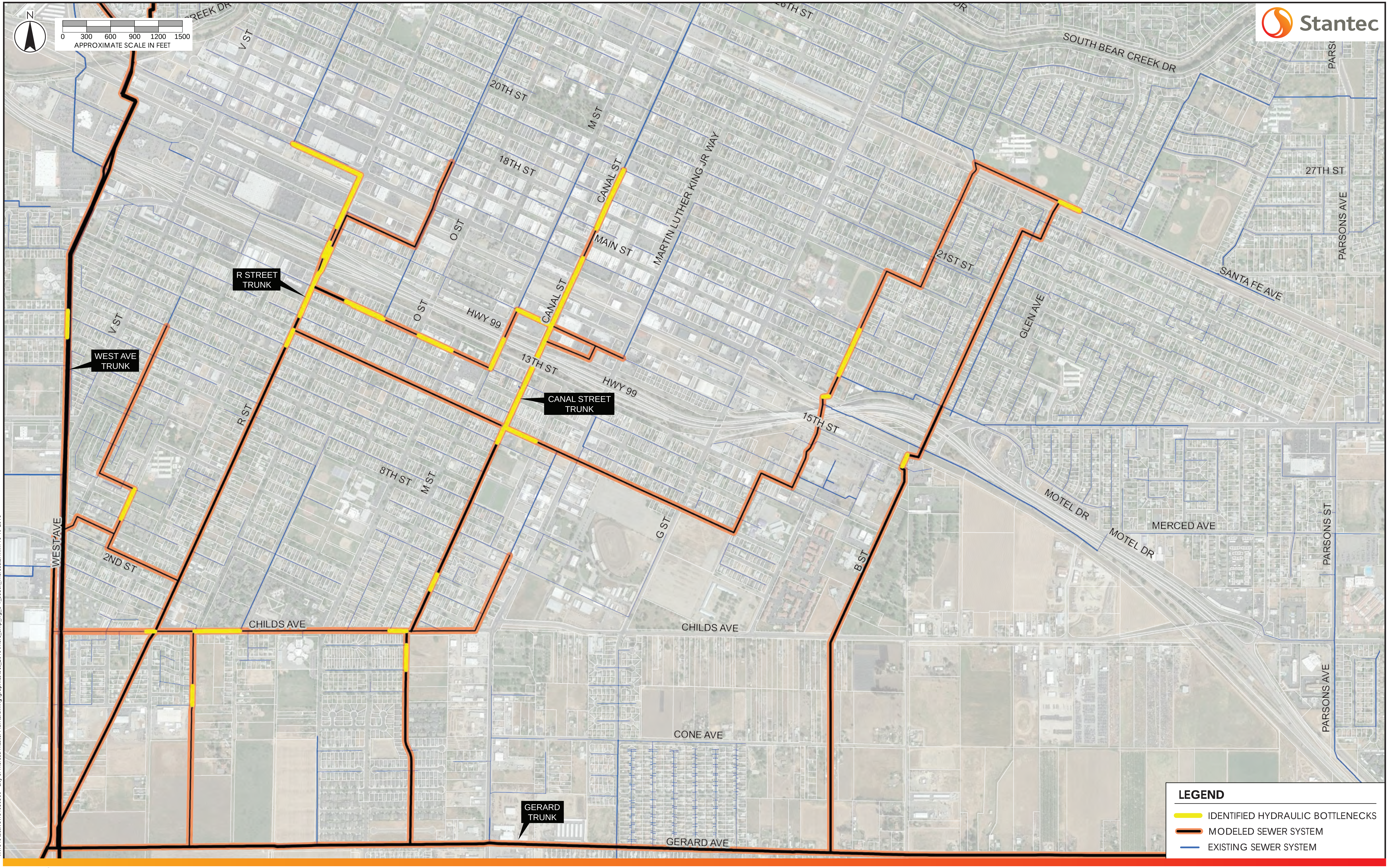

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Figure 6-1
Results of Capacity Assessment of Existing Trunk Sewers in South Merced

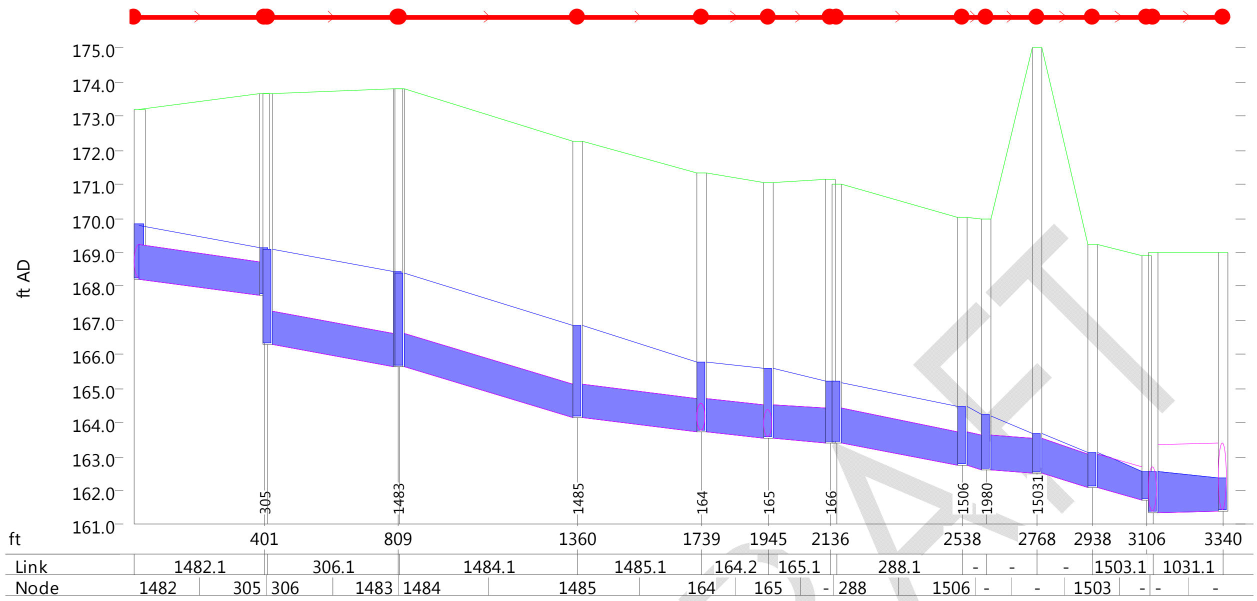

Figure 6-2 HGL Profile Along Canal Street Identifying Level of Service Failure

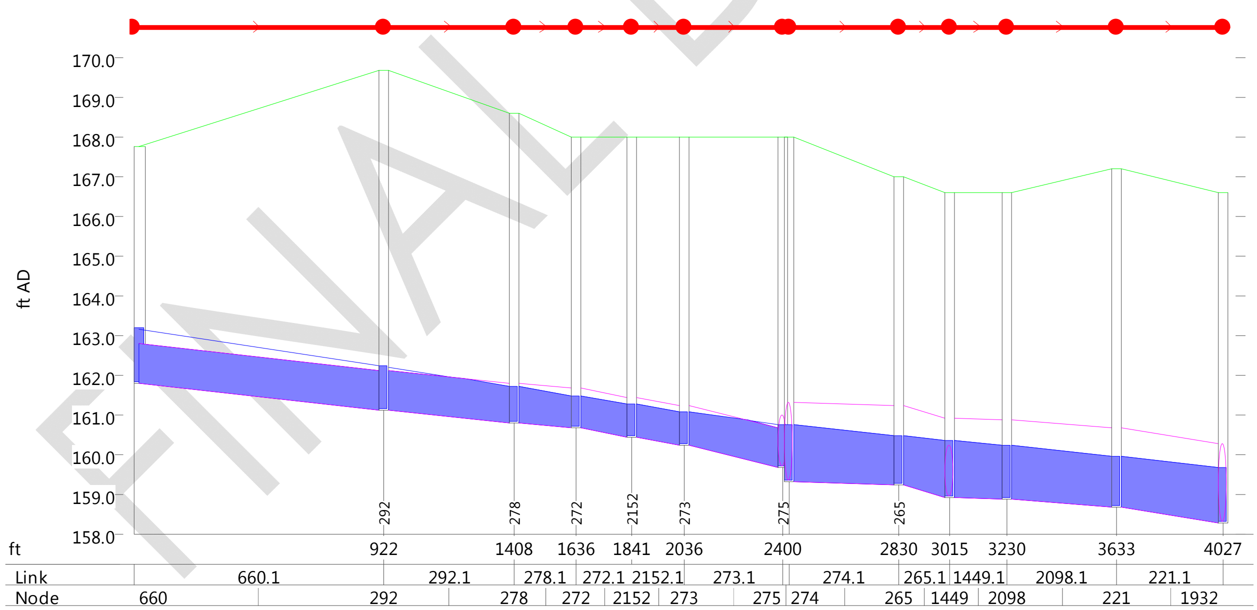

Figure 6-3 HGL Profile Along R Street Identifying Level of Service Failure

6.2.2 North Merced

Figure 6-4 shows areas within the existing wastewater collection system in North Merced that are predicted to have hydraulic limitations based on analysis using the Innovyze model to simulate existing peak flow conditions. The hydraulic model identified two primary locations of Level of Service failures within the North Merced sewer system:

- 1042 feet of 21-inch diameter sewer along W Olive Avenue from R Street to Meadows Avenue. The sewer is predicted to have minor surcharge (<0.1 feet).
- 1900 feet of 24-inch diameter sewer and 400 feet of 21-inch diameter sewer along Highway 59, from W Olive Avenue (discharge of the Highway 59 Pump Station) to approximately 600 feet north of Holiday Mobile Est. The surcharging is predicted to be approximately 1.1 feet above crown of pipe, resulting in approximately 5.2 feet of freeboard. The only connection to the trunk sewer at this location is from the Western Industrial area (12-inch sewer). Based upon the GIS information available, it appears that this LOS failure will not result in any residential surcharging.

6.2.3 Interim Condition System Results

A variation of the existing system evaluation was simulated, as described in Section 4.5.3. This simulation includes those properties entitled to develop, largely within the North Merced area (north of Bear Creek). The results of the simulation are presented in **Figure 6-5**.

The primary difference between the Existing System and Interim Condition System results is reflective of the greater number of sections shown to be deficient or at capacity in **Figure 6-5** when compared with **Figure 6-4**.

Segments of the Yosemite Avenue trunk are predicted be at or over capacity when the projects entitled to connect to that facility are built. Similarly, portions of the G Street trunk north of Black Rascal Creek and the 42-inch Interceptor along Devonwood Drive and Austin Avenue are predicted to be at or over capacity.

Of particular note, the portion of the Highway 59 trunk downstream of the pump station located north of Fehren's Creek is predicted to be over capacity along the entire length of the alignment southward to the intersection with the 42-inch Interceptor. In addition, the 42-inch Interceptor itself is surcharged a significant distance downstream of the intersection with the Highway 59 trunk. The impacts to the 42-inch Interceptor are technically within the level of service criteria established in Chapter 4 of this Master Plan, as the surcharging which is predicted to occur is greater than 8 feet below the various manhole rim elevations as this sewer alignment approaches the City's WWTF to the south.

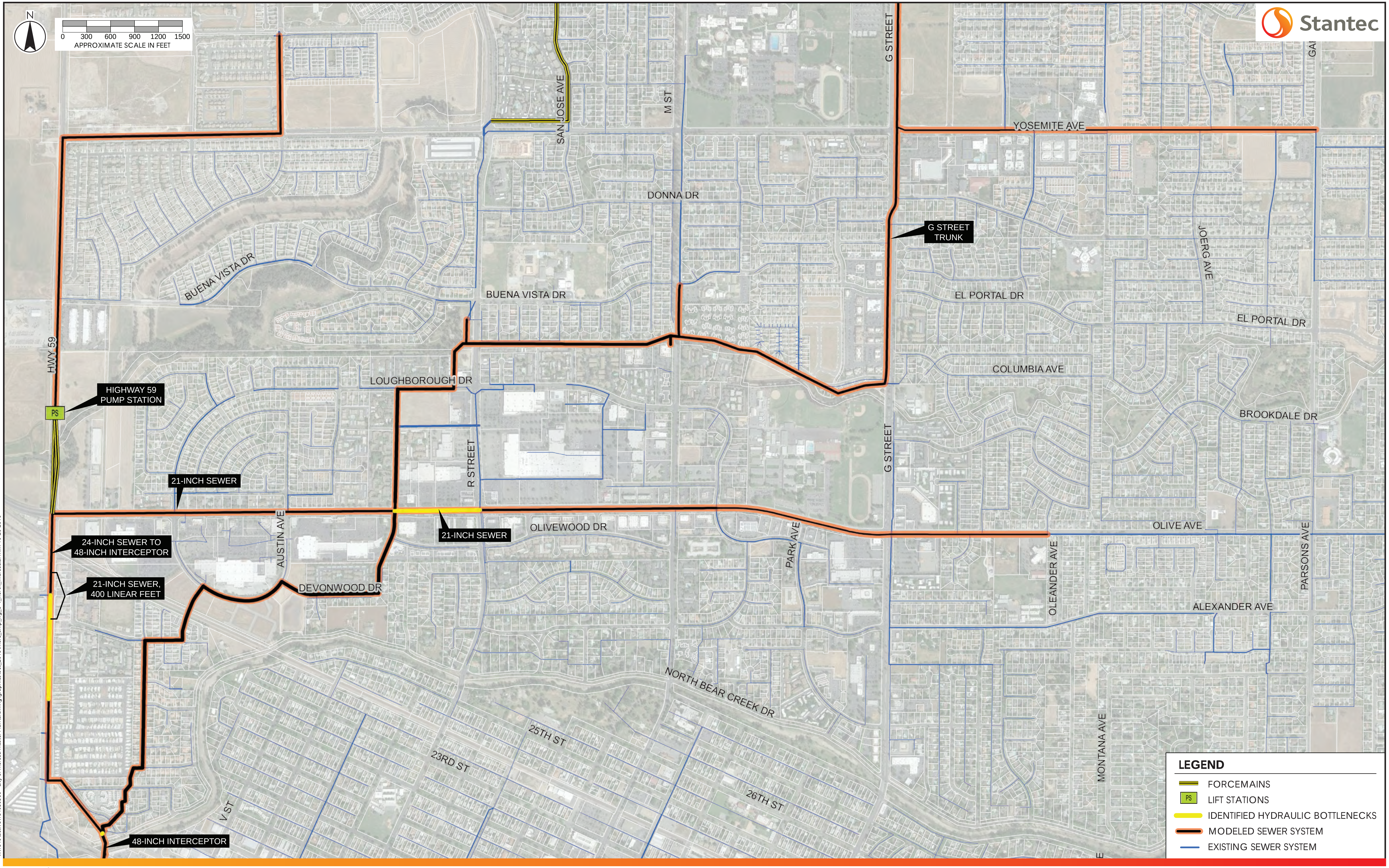

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Figure 6-4
Results of Capacity Assessment of Existing Trunk Sewers in North Merced

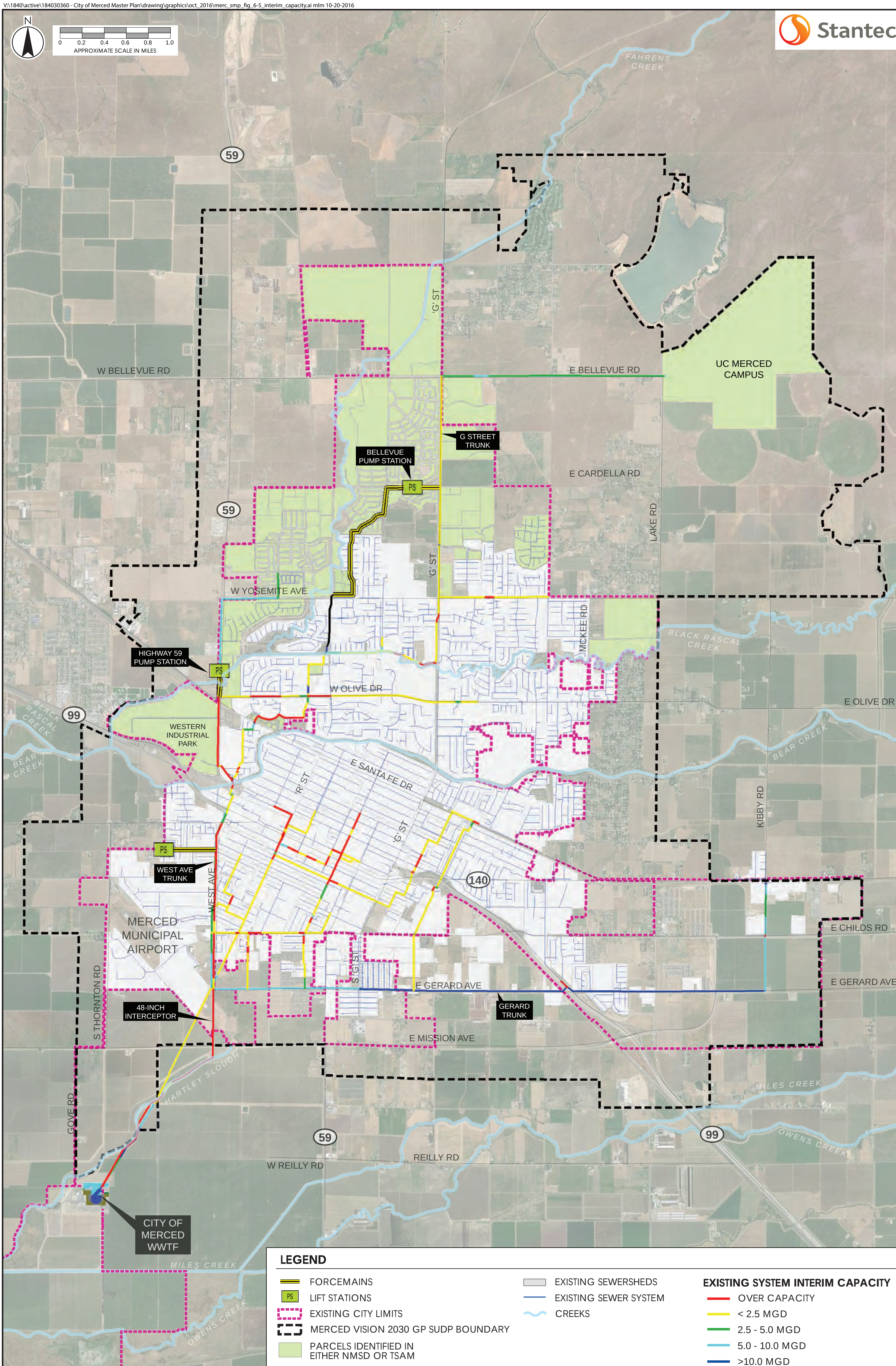

Figure 6-5
Results of Capacity Assessment of Existing Trunk Sewers Under Interim Conditions

6.3 CAPITAL IMPROVEMENT PROJECTS

This section describes the improvements which are recommended to address existing deficiencies in the trunk sewer system as well as suggested improvements to serve the interim and long-term system needs.

6.3.1 Existing Trunk System

The draft 2007 Master Plan described the age and condition of the Gerard Avenue Trunk and portions of the West Avenue Trunk as essentially poor. These are critical trunks in the existing collection system and will allow for interim servicing for some future connections. It is advised that the City consider the recommendations made in the draft 2007 Master Plan with regards to pipe rehabilitation.

In addition to the Gerard and West Avenue Trunk CMP segments, there are other capacity-related deficiencies in the South Merced system which should be addressed either with projects to increase capacity to allow the system to more sufficiently serve the existing areas served, or with projects to upsize or parallel pipes to serve interim conditions (the latter is discussed in more detail Section 5.3.2). The segments of trunk sewer identified as deficient in terms of capacity to serve existing flows are identified in **Figures 6-1** and **6-4**.

These trunks are summarized in **Table 6-1** along with the suggested diameter of replacement pipe necessary to mitigate the various capacity deficiencies.

Table 6-1 Recommended Sewer Upgrades for Existing System Under Existing Conditions (a)

Location	Total Sewer Length [feet]	Existing Sewer Diameter [inch]	Required Sewer Diameter [inch]
Canal Street	3,510	12-inch	15-inch
R Street	2,400	12-inch	15-inch
W Olive Avenue	1,040	21-inch	24-inch
Highway-59	2,300	24-inch	(b)

(a) Surveying and flow monitoring studies should be completed to validate model results prior to budgeting for these upgrades.

(b) The City is not currently intending to upsize or provide any capacity via parallel trunks or other upgrades to the Highway 59 Trunk.

6.3.2 Interim Condition System Needs

Results of system modeling suggest that the existing wastewater collection system is not sized sufficiently to provide capacity for flows to serve the entitled projects first identified in Section 4.5.3 of this report. By extension, the existing system does not have sufficient capacity to serve build-out of the City's SUDP. To serve these areas will require construction of several large trunk sewers. Financing, planning and designing large trunk sewers to serve these areas will take time. This means that large portions of the land outside the limits of the existing collection system service area will not be able to rely on these new large trunk sewers to serve their needs. Of particular concern are those areas which are entitled to develop, as discussed in Section 4.5.3.

This section outlines interim approaches to serving entitled development via existing collection system infrastructure with limited new facilities and system upgrades.

South Merced

There are two primary trunks serving the existing development in the South Merced area. These include the Gerard Avenue and West Avenue trunks, which were discussed previously in Section 5.3 in relation to their condition.

For the Interim Condition, the West Avenue trunk appears to be able to provide approximately 4 Mgal/d of additional capacity beyond existing demands. As mentioned previously, significant portions of this trunk were recommended for rehabilitation in the draft 2007 Master Plan. Serving areas north of Bear Creek via the West Avenue trunk would require a new pump station and force main. A similar pump station is discussed in greater detail in Section 5.3.3 (Long Term System Needs) and is recommended to be constructed as part of a new large-diameter trunk system to be constructed further to the west to serve the North Merced area. As a result, it is recommended that the rehabilitated West Avenue trunk be reserved to serve areas south of Bear Creek in the Interim Condition.

The Gerard Avenue Trunk is in the process of being rehabilitated. The section from West Avenue to Tyler Road has been completed to date. Flow monitoring prior to 2007 indicated elevated flows into this sewer. Although rehabilitation of the Gerard Avenue trunk may reduce I/I in this portion of the system, the benefit of that improvement cannot currently be quantified. As a result, the recommended Interim Condition approach assumes a limited service shed for the Gerard Avenue trunk. The area of potential additional service is limited to areas east and north of the trunk.

North Merced

Significant remaining capacity to serve the area north of Bear Creek on an interim basis is limited to the G Street trunk and Highway 59 trunk and pump station. The interim options for utilizing these sewers prior to construction of a new trunk crossing Bear Creek are described in more detail in the sections below. Aside from the G Street and Highway 59 sewers, the only trunk sewer of any significance north of Bear Creek is the trunk connecting the UC Merced Campus to the G Street trunk. This trunk is known as the Bellevue trunk as the sewer alignment runs along Bellevue Avenue.

Bellevue Trunk

The Bellevue sewer trunk is sized and was constructed to convey wastewater flows from the UC Merced campus at full build-out. The trunk has capacity to convey approximately 6.5 Mgal/d of wastewater. The plan for expanded enrollment at UC Merced is laid out in their Long Range Development Plan (2009). The enrollment at UC Merced during the 2014/15 school year was over 6,000 students. The Long Range Development Plan (LRDP) projects that enrollment will be approximately 10,000 students in 2020 and 25,000 in 2030. This type of planning gives the City some assurance that capacity exists in and will remain available in the Bellevue trunk over the near term.

G Street Trunk

The G Street sewer trunk has capacity to convey a total of approximately 4.14 Mgal/d of wastewater.

The available capacity in the G Street trunk and the commitment of capacity to parcels which previously contributed to the North Merced sewer assessment which funded, among other facilities, the G Street trunk, is not sufficient to convey flow from the entitled properties expected to utilize this facility. **Figure 6-5** illustrates the limitations in the G Street Trunk and the approximate locations. These capacity limitations suggest the City should begin to plan, fund, design and put into place new trunk sewers to serve the areas north of Bear Creek. This Master Plan represents the first step, albeit it a continuation of the draft 2007 Master Plan, toward describing and planning additional wastewater conveyance capacity for the North Merced area. **Figure 6-6** illustrates the approximate current available capacity (in EDUs; 257 gpd/EDU times a peaking factor of 2.3, as described in Chapter 3, or 591.1 gpd/EDU) in the G Street trunk.

As shown in **Figure 6-6**, part of the interim plan for serving the North Merced area includes extending the Bellevue trunk west to the Highway 59 trunk at R Street. As discussed in the draft 2007 Master Plan, entitled developments to the west of Fahren's Creek which move forward prior to construction of new large trunk sewers are anticipated to use the Highway 59 pump station and trunk.

Highway 59 Trunk and Pump Station

Figure 6-7 shows the approximate capacity remaining in the Highway 59 trunk and pump station. The current capacity of the pump station is 3.17Mgal/d (5,360 EDUs) with a remaining, unused capacity of approximately 2.52 Mgal/d (4,260 EDUs). The pump station is designed to allow a capacity expansion up to 6.34 Mgal/d (10,720 EDUs). If the City wished to realize the full, expanded capacity of the Highway 59 pump station, in addition to new pumps, the following would also need to be implemented:

1. A second, parallel force main may need to be installed from the pump station across Black Rascal Creek.

2. The trunk just downstream of the pump station force main discharge South of W Olive Avenue was identified in the prior two Master Plans as limiting capacity in the Highway 59 trunk system. To realize the full extent of the existing capacity (3.17 Mgal/d) in the pump station a 24 -inch parallel gravity relief line (approximately 4,300 linear feet) would need to be installed. In order to accommodate flow from an expanded Highway 59 pump station (6.34 Mgal/d), the parallel relief line would need to be a minimum of 30-inch in diameter. This assumes the sub-sheds draining to the existing gravity line or from the G Street trunk do not contribute additional flows, otherwise this could require a pipe larger than 24 inches in diameter.

3. In addition, a portion of the Highway 59 trunk north of the pump station (along Yosemite Avenue) has a limiting capacity of 5.3 Mgal/d (see **Figure 6-6**). Any flow in excess of 5.3 Mgal/d needs to be introduced to the trunk downstream of this limiting segment, upstream of the Highway 59 pump station, or a parallel sewer installed.

4. Furthermore, the main, common trunk (the 48-inch Interceptor) to which the G Street and Highway 59 trunks drain south of Bear Creek is limited in capacity to approximately 8,500 additional EDUs. If remaining capacity in the G Street trunk is maximized (5,600 additional EDUs), the 48-inch Interceptor would only be able to accept an additional 2,900 EDUs from the Highway 59 pump station and from the other shed areas draining to it. This EDU count is less than the remaining additional capacity of the Highway 59 pump station (4,260 EDUs or 2.52 Mgal/d) and much less than the additional capacity of an expanded Highway 59 pump station (9,600 EDUs; 5.69 Mgal/d). In order to accommodate the additional 9.600 EDUs an expanded Highway 59 pump station could serve, the full capacity of the G Street trunk and build-out of the other contributing sewersheds, the 48-inch Interceptor would need to be upsized to 54-inch diameter or a 30-inch diameter relief sewer installed parallel to the Interceptor. It is assumed that no upsizing or paralleling of the 48-inch Interceptor would be undertaken due to the length of the upsizing/paralleling required (~14,000 l.f.).

The extent of the upgrades required to fully realize the potential capacity in the Highway 59 trunk system is the primary reason it is recommended the excess capacity in the G Street sewer be utilized first. As mentioned in bullet 4, above, the complexity of expanding gravity sewer capacity south of W. Olive is problematic due to the number of existing utilities, which include two separate sewer trunks (48-inch Interceptor and the West Trunk). As such, the assumption is currently that the Highway 59 trunk has no additional (remaining) capacity.

It is understood that the City would prefer not to construct the 24-inch relief sewer parallel to the Highway 59 trunk , instead focusing on utilizing the remaining capacity in the G Street trunk and planning the future large diameter future trunk sewers described in Section 5.3.3, which follows.

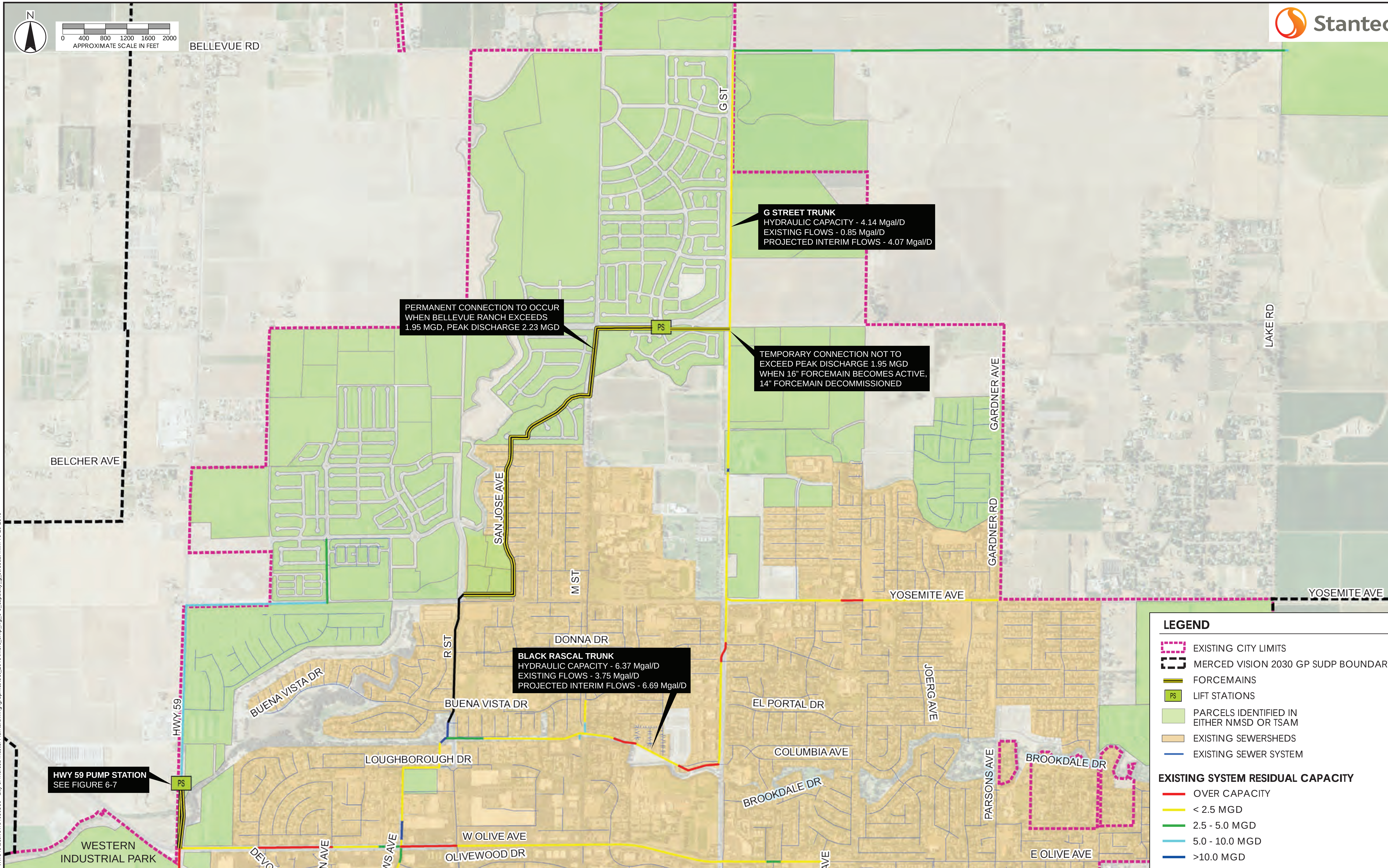

Figure 6-6
Capacity Remaining – G Street Trunk Under Interim Conditions

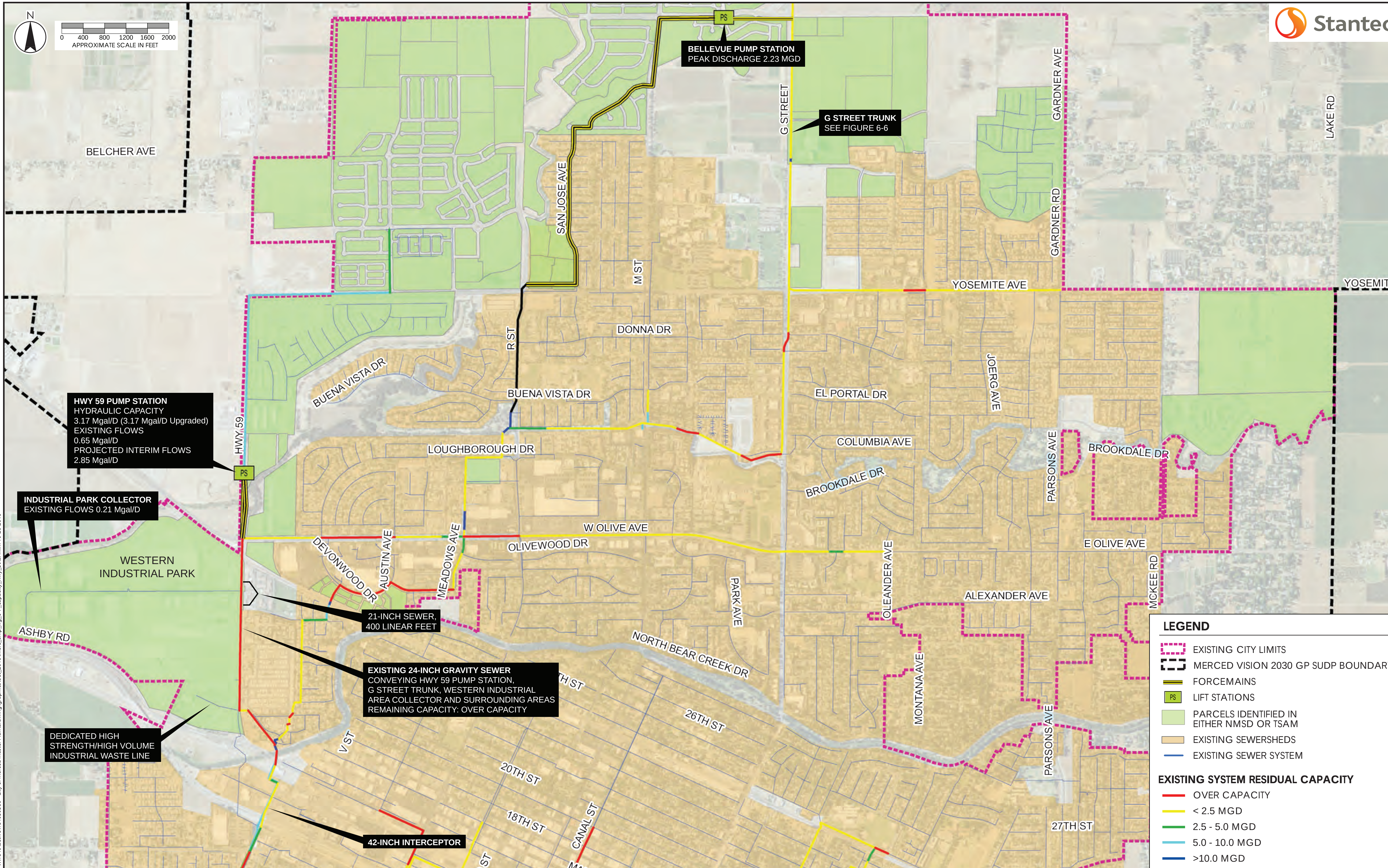

Figure 6-7
Capacity Remaining – Highway 59 Trunk Under Interim Conditions

6.3.3 Long-Term System Needs

Due to the capacity limitations of the existing wastewater collection system, large trunk sewers must be constructed to accommodate future development within the SUDP. This is similar to conclusions presented in previous master planning documents. Alignments for these trunk sewers were determined based on conversations with City Public Works and Planning staff.

In addition to these conversations internal to the Master Plan team, City staff also discussed these alignments with representatives of UC Merced, the Campus Community and other stakeholders within the SUDP including representatives of at least some of the entitled properties located in the North Merced area. The process of selecting the alignments discussed here involved evaluating a number of alternative configurations of pump stations, force mains and gravity sewers. The list of options was reduced to two primary alternatives. The primary difference between the two alternatives is the assumption of when Campus Community connects to the system. During Master Plan development there was some uncertainty as to when the Campus Community may connect, and the second alternative provides an option for the Campus Community to connect at a later date. These two alternatives are described, generally below (precise alignments will be determined at a later date):

1. This alternative would serve the entire SUDP at current build-out flow estimates (with density assumptions as described in Chapter 3). Servicing the North Merced area would occur via a large new trunk starting in the vicinity of the intersection of Cardella Road and Lake Road, running east to west along Cardella Road, then south along Thornton Road to a pump station just north of Black Rascal Creek. A force main discharging from the new pump station north of Sante Fe Drive would extend to just south of CA 140, then transition to a new 60-inch gravity trunk from that point south to the WWTF. Additionally, flow from the existing Highway 59 Pump Station would be diverted to the new pump station along Thornton Road, eliminating the long-term need to upgrade the existing forcemain and sewer along Highway 59 south of W Olive Avenue (one reason the City prefers not to invest in improvements in the pump station forcemain and downstream gravity trunk system). Servicing in South Merced would be via a new trunk running east to west along E. Mission Avenue which would intersect with a new trunk sewer running north to south west of Highway 59. This trunk would then turn west on Reilly Road and continue westward to the WWTF. Alternative 1 is depicted in **Figure 6-8**.

2. Under the second alternative, the Campus Community is assumed to develop at a later date which would preclude participation in the new Cardella and Thornton trunks described in Alternative 1. The Campus Community would beserved in Alternative 2 by a trunk line to the south from this special development area instead of to the west (the Cardella trunk) as shown in Alternative 1. Due to the uncertainty of when their share of the financing would be available under this scenario, a dedicated trunk would be constructed parallel to the new Alternative 1 South Merced trunk running along Mission which would be sized according to estimates of flow from the balance of the SUDP south

of Bear Creek, and consistent with the sizing described in Alternative 1 for this trunk. A trunk would be extended from the southern Campus Community boundary to along the proposed Campus Parkway road alignment and back into the City's SUDP where it would connect with the new east-west trunk parallel to the trunk in E. Mission Avenue. **Figure 6-9** illustrates Alternative 2.

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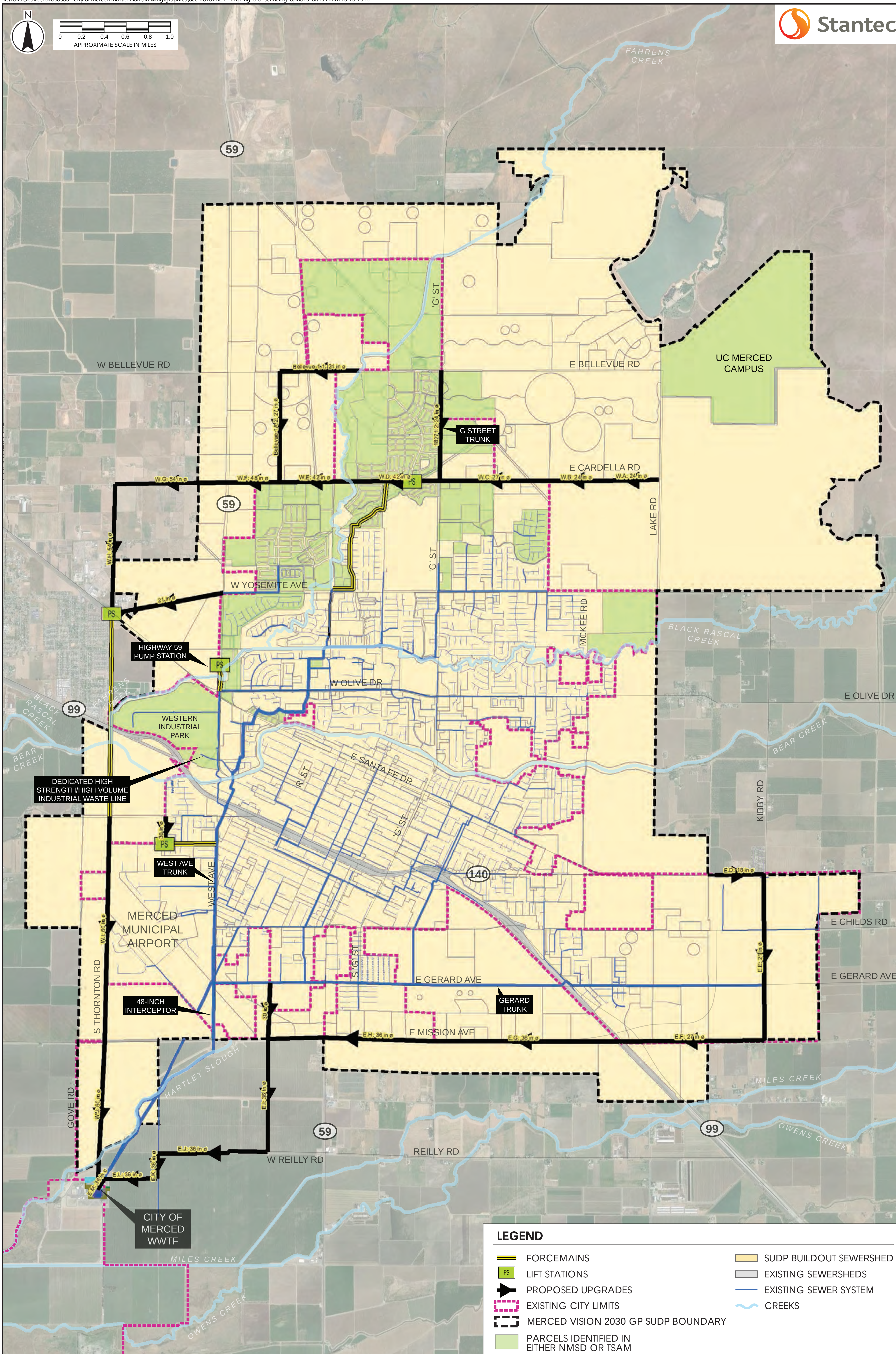

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Figure 6-8
North Merced Servicing Options – Alternative 1

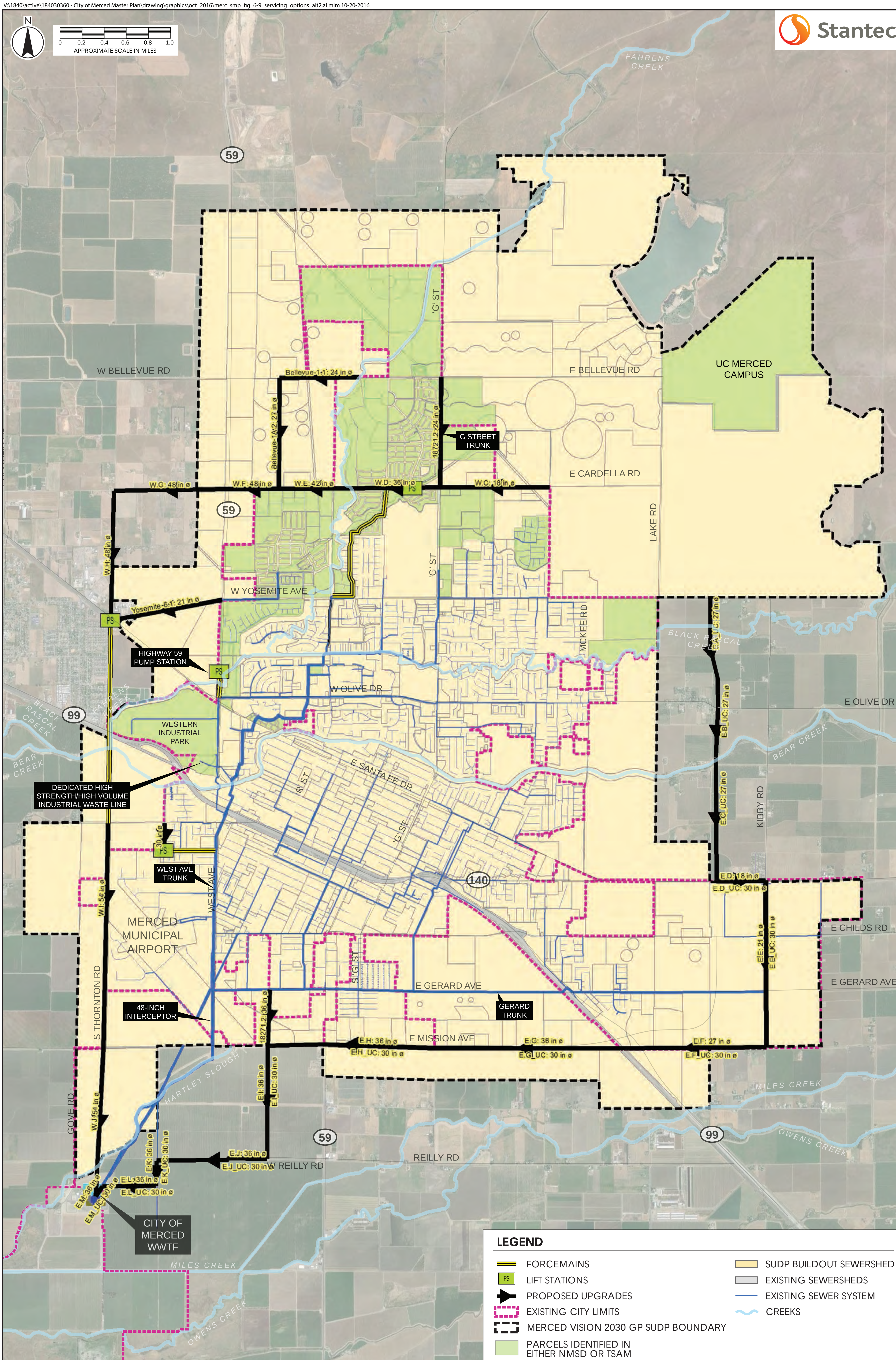

Figure 6-9
North Merced Servicing Options – Alternative 2

The City has selected Alternative 1 as the preferred Master Plan trunk alignment alternative. In addition to the facilities identified in the discussion above, and on **Figure 6-10**, further details of the new facilities proposed are provided in the following paragraphs.

As discussed, the servicing of North Merced would primary be provided by new gravity sewer along Cardella Avenue and Thornton Road, with a pump station to convey flows from Sante Fe Drive to south of CA 140. A breakdown of the required new gravity sewer is provided in **Table 6-2**.

Table 6-2 Required Gravity Sewer for North Merced – Preferred Alternative 1

Sewer Location	Sewer Diameter [inch]	Sewer Length [ft]	Upstream Rim Elev. [ft]	Upstream Invert Elev. [ft]	Downstream Rim Elev. [ft]	Downstream Invert Elev. [ft]
Cardella Road / Lake Road	24	5260	196.1	189.0	203.0	182.0
Cardella Road / Gardner Avenue	27	5270	203.0	182.0	181.3	171.6
Cardella Road / G Street	42	7660	181.3	171.6	177.7	159.6
Cardella Road / New Connection from Bellevue	48	2510	177.7	159.6	174.1	156.5
Cardella Road / CA 59	54	5370	174.1	156.5	172.1	151.0
Thornton Road / Cardella Road	54	6180	172.1	151.0	170	145.1
CA 59 / Yosemite Avenue	21	5400	167.3	145.4	170	142
Bellevue Road	24	3800	182	175	182.1	172.1
Bellevue Road	27	5290	182.1	172.1	177.7	159.6
Bellevue Road / G Street[(a)]	24	5270	185.6	175.8	181.3	171.6
Thornton Road / CA-140	60	20980	160	150.5	147	135

(a) New 24-inch sewer in parallel to existing 30-inch sewer.

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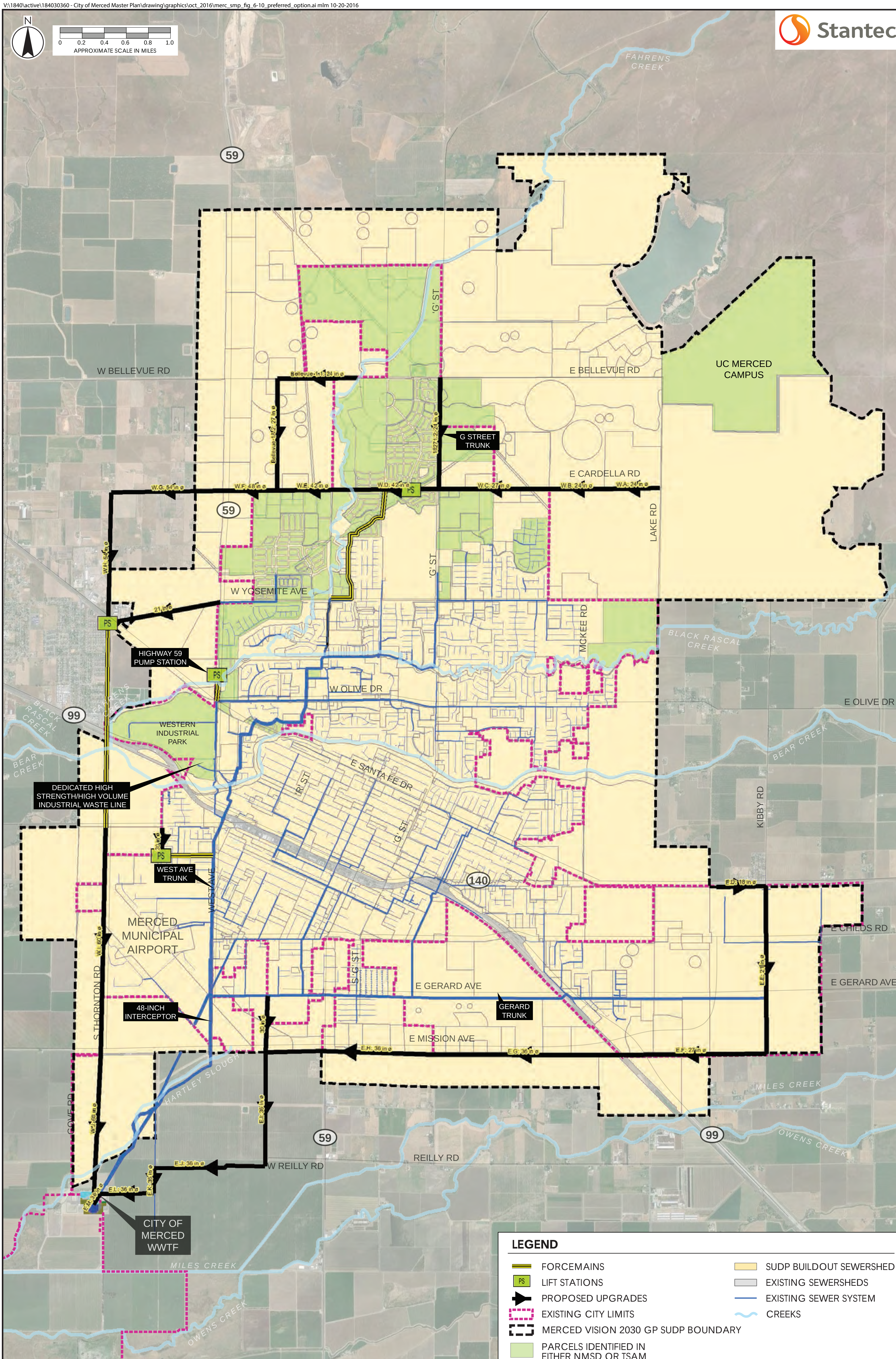

Figure 6-10
Proposed Master Plan Improvements

The servicing of South Merced would primarily be provided by new gravity sewer along Mission Avenue. A breakdown of the required new gravity sewer is provided in **Table 6-3.**

Table 6-3 Required Gravity Sewer for South Merced – Preferred Alternative 1

Sewer Location	Sewer Diameter [inch]	Sewer Length [ft]	Upstream Rim Elev. [ft]	Upstream Invert Elev. [ft]	Downstream Rim Elev. [ft]	Downstream Invert Elev. [ft]
CA 140 / End of Baker Drive	18	2180	190	175.7	194	174.6
Kibby Road / CA 140	21	7940	194	174.6	191	170.6
Mission Avenue / Miles Road	27	7160	191	170.6	180	165.6
Mission Avenue / Doppler Road	36	16640	180	165.6	170.1	153.9
Dickenson Ferry Road to WWTF	36	15032	170.1	153	147	134

6.4 CAPITAL COST ESTIMATES

Planning level opinions of probable cost for major trunk lines and pump stations have been developed. These planning level estimates include construction costs, a 30% contingency for unforeseen conditions, and a 20% allowance for design, construction management and contract administration. These costs have been estimated using a current ENR Construction Cost Index (ENRCCI) of 10435 (October 2016).

The growth rate of development within the City and the UC Merced campus will dictate the time horizon for build-out of the ultimate service area. However, it is possible this time horizon may be 50 years or more. As a result, the City may elect to phase all or a portion of the new large trunk sewers in North and South Merced which is beyond the scope of the analysis and discussion presented in this Master Plan. The City intends to work through possible options with the stakeholders in North and South Merced in order to come up with a detailed phasing plan for development of the new trunk sewers.

6.4.1 Capital Costs to Serve SUDP

Table 6-4 summarizes opinions of probable cost for serving build-out of the SUDP. These build-out projections are based on the density assumptions presented in Chapter 3. The infrastructure components are based on the discussion in Section 5.3.2 for the Interim Capacity Phasing plan and on Alternative 1 presented in Section 5.3.3 serving ultimate build-out. As mentioned in Section 6.3.3, the preferred long-term sewerage servicing plan could be (and likely would be) phased. This Master Plan does not attempt to identify the exact manner in which that phasing would occur. This phasing discussion is to be addressed in a separate document to be developed by the City in cooperation with affected stakeholders.

In addition to these costs, interim improvements to the Highway 59/G Street and 48-inch Interceptor system identified in Section 6.3.2 should also be factored into the City's plans, including identifying necessary revenue streams to fund those improvements.

Table 6-4 Opinion of Probable Cost – SUDP Servicing

Service Area	Construction Cost [(a)]	Engineering, CM, Admin (20%)	Contingency (30%)	Total Project Costs (rounded)
North Merced (West Trunk)	$58,520,000	$11,704,000	$17,556,000	$87,780,000
South Merced (East Trunk)	$24,400,000	$4,880,000	$7,320,000	$36,600,000

(a) The current servicing plan calls for a pump station on the west side of the City. This cost estimate assumes both a 24-inch and 36 inch diameter force main (anticipating some phasing) approximately 1.8 miles in length will be constructed. ENR CCI = 10435, October 2016.

6.4.2 Repair and Replacement Costs

Table 6-5 summarizes opinions of probable cost for addressing existing system deficiencies identified in Section 5.2. The improvement projects identified in **Tables 6-4** and **6-5** do not include repair and replacement (R&R) of City facilities. A robust R&R program is a key element of any properly managed public infrastructure system. The City's R&R program for the sewer utility includes an annual expenditure for the replacement of older, aging infrastructure. To replace all of the facilities in the City's sewer enterprise would require a significant sum of money. The annual R&R allocation is intended to reduce the impact of repairing and replacing critical portions of the City's sewer collection system by stretching them out over time.

As a result, to ensure the elements of these systems which are in place today remain in service for perpetuity, the City has elected to fund their R&R program sufficiently to allow replacement of all collection system mechanical components (valves, pumps and appurtenances) on a schedule which is consistent with industry standard expectations for service life. The City is budgeting for replacement of all pipelines assuming an 80 year service life. Pump stations are assumed to have 20 year service life for mechanical components (i.e. pumps and emergency power generation), with wet wells and control buildings assumed to have 80 year service lives.

At this time, the City is planning to budget $300,000 annually for repair and replacement of system assets. Prioritization of R&R projects will be done within the typical five-year CIP timeframe, updated accordingly, but the City also recognizes that unforeseen incidents may require adjustments in the specific projects identified in any particular year.

The five year CIP for the City is summarized in **Table 6-6**. Where possible, the City has attempted to include R&R components in the improvement projects identified previously in **Tables 6-4** and **6-5** where they overlap and it makes sense to do so.

Table 6-5 Opinion of Probable Cost – Addressing Existing System Deficiencies [a]

Scenario	Construction Cost	Engineering, CM, Admin (20%)	Contingency (30%)	Total Project Costs (rounded)
Address Existing Deficiencies	$2,390,000	$480,000	$720,000	$3,580,000

(a) Planning level costs assume replacement of pipelines. Costs for pipe bursting may be lower.

Table 6-6 Five Year CIP Budget for City of Merced Sewer Collection System [a]

System Component	Fiscal Year 2016/17	Fiscal Year 2017/18	Fiscal Year 2018/19	Fiscal Year 2019/20	Fiscal Year 2020/21
Address Existing Deficiencies	$250,000	$350,000	$350,000	$500,000	$500,000
Repair & Replacement Program	$300,000	$300,000	$300,000	$300,000	$300,000
Total Annual Cost	**$550,000**	**$650,000**	**$650,000**	**$800,000**	**$800,000**

(a) All costs include allowance for Engineering, Construction Management (CM) and Administration of 20% and a project Contingency of 30% of Construction cost.

(b) All annual costs are presented in October 2016 dollars

APPENDICES

Appendix A DETAILED COST BREAKDOWN