APPENDIX E

Wastewater Treatment Analysis

for

DUNNIGAN SPECIFIC PLAN

Revised April 29, 2013
January 9, 2012

Yolo County

Woodland, CA

Technical Appendix E – Wastewater Treatment

Preliminary Wastewater Treatment Planning
Dunnigan Development Specific Plan

April 23, 2013
(February 11, 2013) **- Revised**

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Introduction

This Wastewater treatment appendix describes the following information for the proposed 3,110 acre Dunnigan Development Area proposed by Elliot Homes, with 2,276 acres of proposed and existing developed land requiring sewer utilities:

1. **Average Wastewater Generated** - Overall wastewater generated from residential and non-residential development
2. **Peaking Wastewater Generated** - The maximum daily flow plus inflow-and-infiltration
3. **Sewer Collection Infrastructure** - Proposed sewer collection system and lift stations
4. **Wastewater Treatment** - Proposed wastewater treatment plant design
5. **Recycled Water Discharge** - Proposed disposal of Recycled water

The development will be divided into four phases of construction, referred to as Phases 1, 2, 3, and 4 throughout the report. Phase X refers to a potential future connection of existing Dunnigan residential and commercial to water and wastewater services provided by the new community.

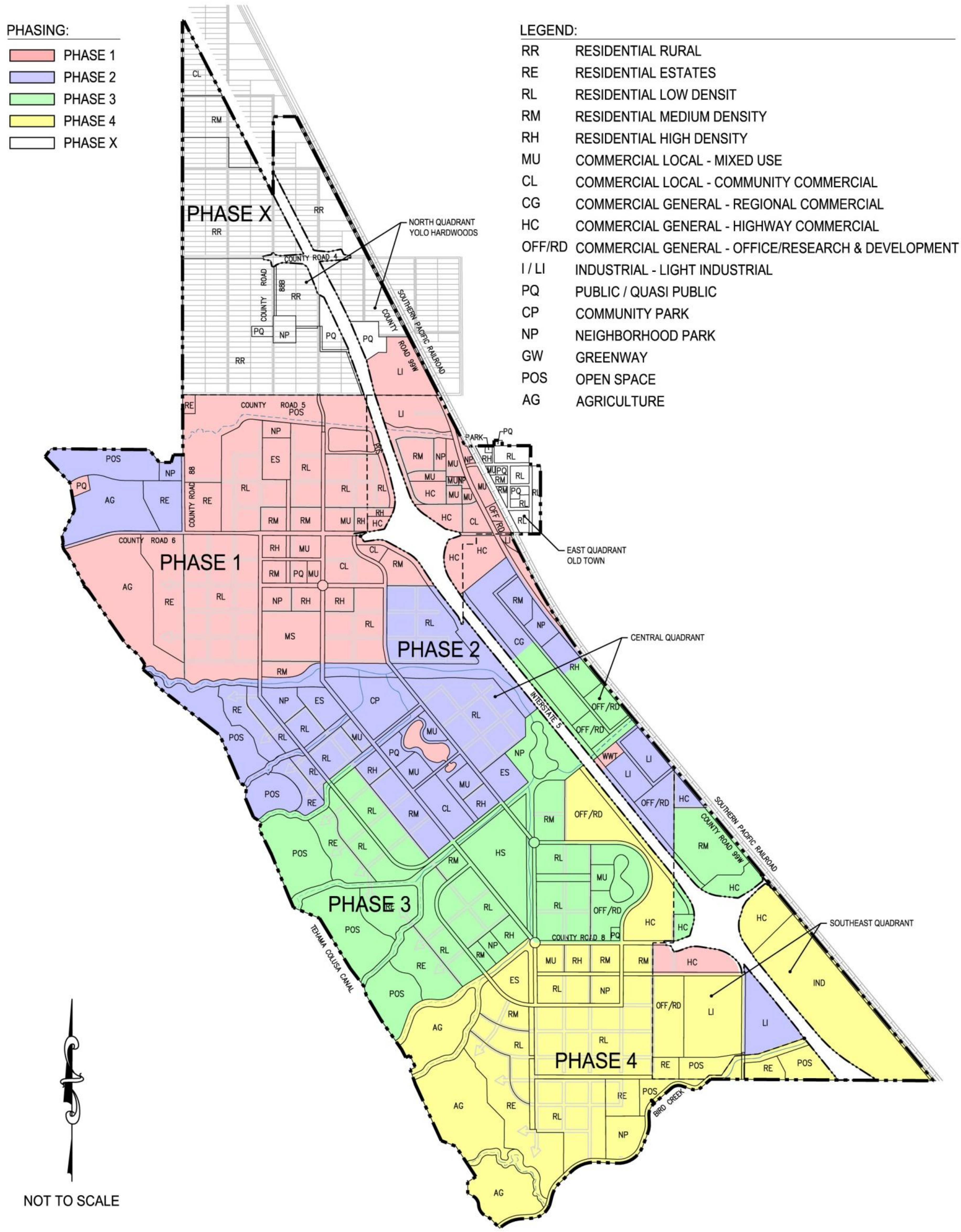

Figure 1: Proposed Phase Layout of Proposed Dunnigan Community Dev. & Major Features

DUNNIGAN
Specific Plan

1 Wastewater Generated

A major part of planning a new development is estimating the amount of wastewater that will need to be treated and discharged. It is estimated that at build out 2,276 acres of the total development will generate an average daily flow (ADF) of approximately 2.12 MGD of wastewater, summing 1.50 MGD plus 0.62 MGD non-residential. Due to the increased use of water conservation fixtures, the flow factors within the Yolo County Improvement Standards overestimated the amount of wastewater produced. Therefore, a new set of flow factors were proposed and approved by Tom Riddiough from County of Yolo Planning and Public Works; these values are shown in the supplemental information section. Tables 1 – 4 shows the wastewater generated per each land-use and per each phase of construction for the development.

Table 1: Average Daily Wastewater Produced By Residential Areas

Land Use (unit)	Area (Ac)	Units (DU)	Flow Factor* (Gal/day/unit)	Average Daily Flow (GPD)	Average Daily Flow (AF/yr)
Residential Rural (1 DU/Ac)	332.0	332.0	190	63,100	71
Rural Estates (1.74 DU/ac)	213.0	370.6	190	70,400	79
Low Density Residential (5 DU/ac)	663.7	3,318.5	190	630,400	706
Medium Density Residential (14.2 DU/ac)	179.9	2,554.6	190	485,400	544
High Density Residential (24 DU/ac)	55.5	1,332.0	190	253,100	283
Total Residential	**1,444.1**	**7,907.7**		**1,502,400**	**1,683**

***Based on June 15, 2012 Memo, see supplemental Information, and approved by Tom Riddiough, Senior Civil Engineer, County of Yolo Planning and Public Works

Table 2: Average Daily Wastewater Produced by Commercial Areas

Land Use (unit)	Area (Ac)	Flow Factor (Gal/day/unit)	Average Daily Flow* (GPD)	Average Daily Flow (AF/yr)
Commercial – Local Community(ac)	52.1	850	44,300	50
Commercial - Regional (ac)	38.2	850	32,500	36
Commercial - Highway(ac)	108.1	850	91,900	103
Mixed Use (ac)	57.5	2,300	132,200	148
Commercial – Office/R&D(ac)	103.1	850	87,600	98
Industrial/Light Industrial(ac)	219.1	850	186,200	209
Public/WWTP(ac)	32.6	660	21,500	24
High School(ac)	40.0	170	6,800	8
Elementary School(ac)	40.0	170	6,800	8
Middle School(ac)	23.3	170	4,000	4
Community/Neighborhood Park(ac)	117.9	10	1,200	1
Roads (Ac)	151.0	0	0	0
Irrigated Public Open Space/Greenways/AG.(ac)	84.2	0	0	0
Public Open Space/Greenways/AG.(ac)	569.7	0	0	0
Lake(ac)	28.8	0	0	0
Total Non-Residential	**1,665.6**		**615,000**	**689**

***** Based on June 15, 2012 Memo, see supplemental Information, and approved by Tom Riddiough, Senior Civil Engineer, County of Yolo Planning and Public Works

Table 3: Total Average Wastewater Generated

	Area (Ac)	Average Daily Flow (GPD)	Average Daily Flow (AF/yr)
Residential	1,444.1	1,502,400	1,683
Non-Residential	1,665.6	615,000	689
Residential + Non-Residential	**3,109.7**	**2,117,400**	**2,372**

Table 4: Average Daily Wastewater Generated By Each Phase

	Average Daily Waste (GPD)	Average Daily Waste (AF/yr)	Cumulative Average Daily Flow (GPD)	Cumulative Average Daily Flow (AF/yr)
Phase 1	600,800	673	600,800	673
Phase 2	419,700	470	1,020,500	1,143
Phase X	180,600	202	1,201,100	1,345
Phase 3	363,400	407	1,564,500	1,752
Phase 4	553,000	619	2,117,400	2,372

2 Peak Wastewater Generated

Peak Wastewater generated is calculated to estimate pipe sizing for the sewer collection system. The peak flow consists of peak daily flow and inflow-and-infiltration of wet weather conditions. Table 5 shows the average daily flow, inflow-and-infiltration, and the peak daily flow.

- Peak daily flow is an estimate of the maximum instantaneous sewage flow during a 24 hour time period. This flow is calculated by multiplying the average daily flow by a peak factor of 3 per Yolo County Standards.
- Inflow-and-Infiltration (I&I) is from rain water and ground water entering into sewer collection system through manholes and leaks in the piping. Inflow-and-infiltration is calculated by multiplying the service area by 600 Gal/day/acre per Yolo County Standards.

Table 5: Average Daily Flow, Inflow and Infiltration, and Peak Daily Flow

Phase	Average Daily Flow (ADF) (gpd)	Peak Daily Flow (gpd)	I & I (gpd)	Peak Instantaneous Flow with I&I (gpd)
Phase 1	600,800	1802400	357,480	2,159,900
Phase 2	419,700	1259100	302,340	1,561,400
Phase 3	363,400	1090200	262,440	1,352,600
Phase 4	553,000	1659000	356,760	2,015,800
Phase X	180,600	541800	254,520	796,300
Total	**2,117,500**	**6,352,500**	**1,533,540**	**7,886,000**

3 Sewer Collection Infrastructure

Figure 2 shows the proposed sewer system backbone infrastructure for the proposed Dunnigan Project. The sewer collection system consists of mostly 8" piping with the maximum trunk sewer main of is 30" located immediately upstream of the wastewater reclamation facility (WRF). The WRF is located near the eastern border of the new development at a centralized location, which allows for minimal pumping of recycled water and very little pumping for raw wastewater because phases 1, 2, 3, and X are able to flow by gravity. Phase 4 will require two lift stations; one on each side of the Interstate-5, which will pump to phase three where it will gravity flow to the WRF. The piping within the sewer collection system is designed to be able to convey the peak wastewater generated.

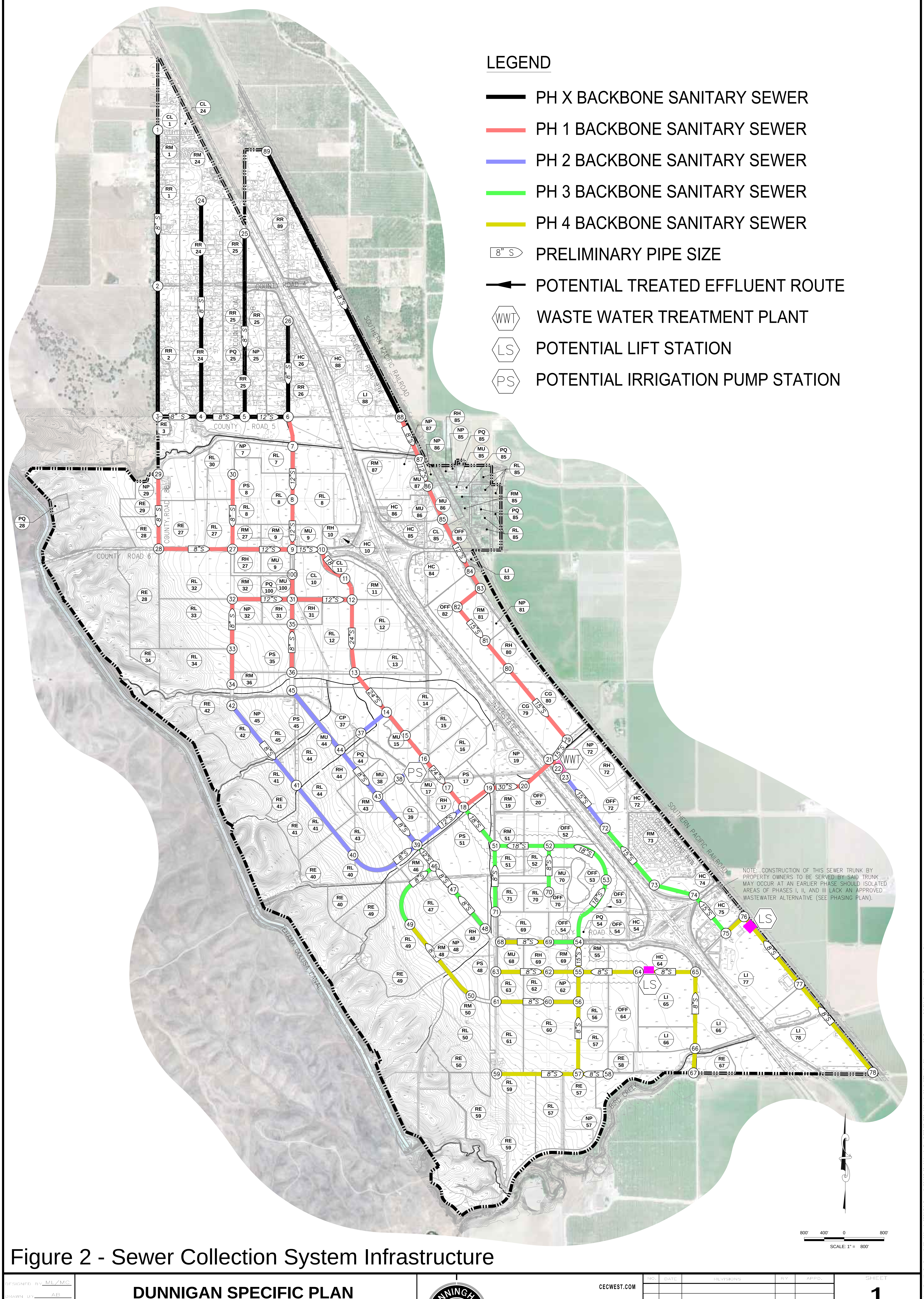

Figure 2 - Sewer Collection System Infrastructure

DESIGNED BY: ML/MC
DRAWN BY: AB
CHECKED BY: SG
SCALE 1" = 800'

DUNNIGAN SPECIFIC PLAN
SEWER MODEL EXHIBIT
FIGURE S-1

YOLO COUNTY CALIFORNIA

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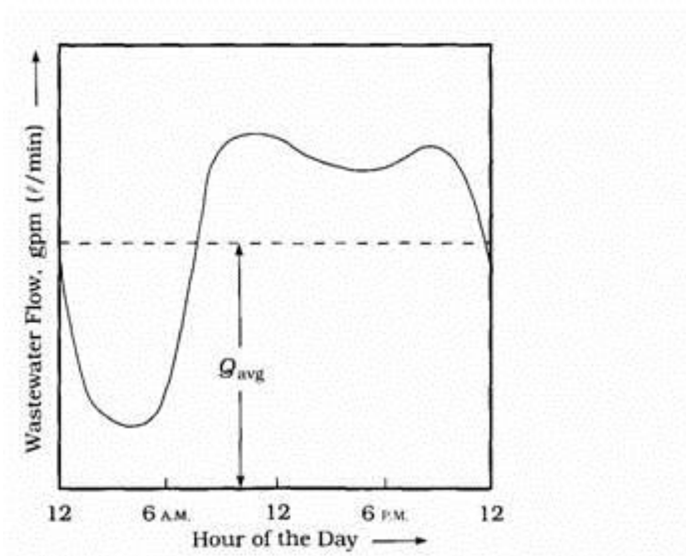
SHEET 1 OF 1
DATE: 09-24-12
JOB NO: 1069.10

4 Wastewater Treatment

The Wastewater Treatment Plant (WWTP) will be built in 3 phases of 0.75 MGD biological capacity each for a total of 2.2 MGD. The treated wastewater will be Title 22 recycled water for unrestricted reuse. In order to handle peak daily and wet weather flow, the hydraulic capacity of headworks equipment will be designed to be able to handle 7.9 MGD. The facility will have peaking mitigation through equalization storage using freeboard. The treatment of wastewater will be completed in a 6 step process described below. A conceptual layout of the wastewater reclamation facility is shown in Figure 3.

Step 1: Head Works: This step is designed to remove the larger particles within the influent. The headworks consist of a combined screening and grit removal unit.

Step 2: Anoxic Surge Basin: From the headworks, wastewater flows to the anoxic surge basin to provide a source of carbon for biological nutrient removal or denitrification. Sewer flow is generally diurnal, where there are two peak flows within 24 hours. The surge basin is used to equalize the amount of flow through the downstream system by storing water during high peak times and empting water during low flows.



Daily variation in wastewater flow in a typical city

Excerpt shows diurnal flow. Excerpted from: "Unit Operations and Processes in Environmental Engineering" by Tom D. Reynolds and Paul Richards 2nd edition Thomson – Brooks/Cole

Step 3: Sequencing Batch Reactor (SBR): After the anoxic surge basin, wastewater flows to the sequencing batch reactors, which to reduce biological oxygen demand (BOD) and provide nitrification. SBRs are also utilized as clarifiers; when a SBR enters settling mode all inflow is directed to another SBR allowing for no water movement during settling.

a. Sludge Storage Tank: After settling, in order to control the waste activated sludge (WAS) created in the SBRs. The WAS is pumped to the sludge storage tank where the WAS is digested, volatile solids are destroyed, and the sludge is stabilized for dewatering.

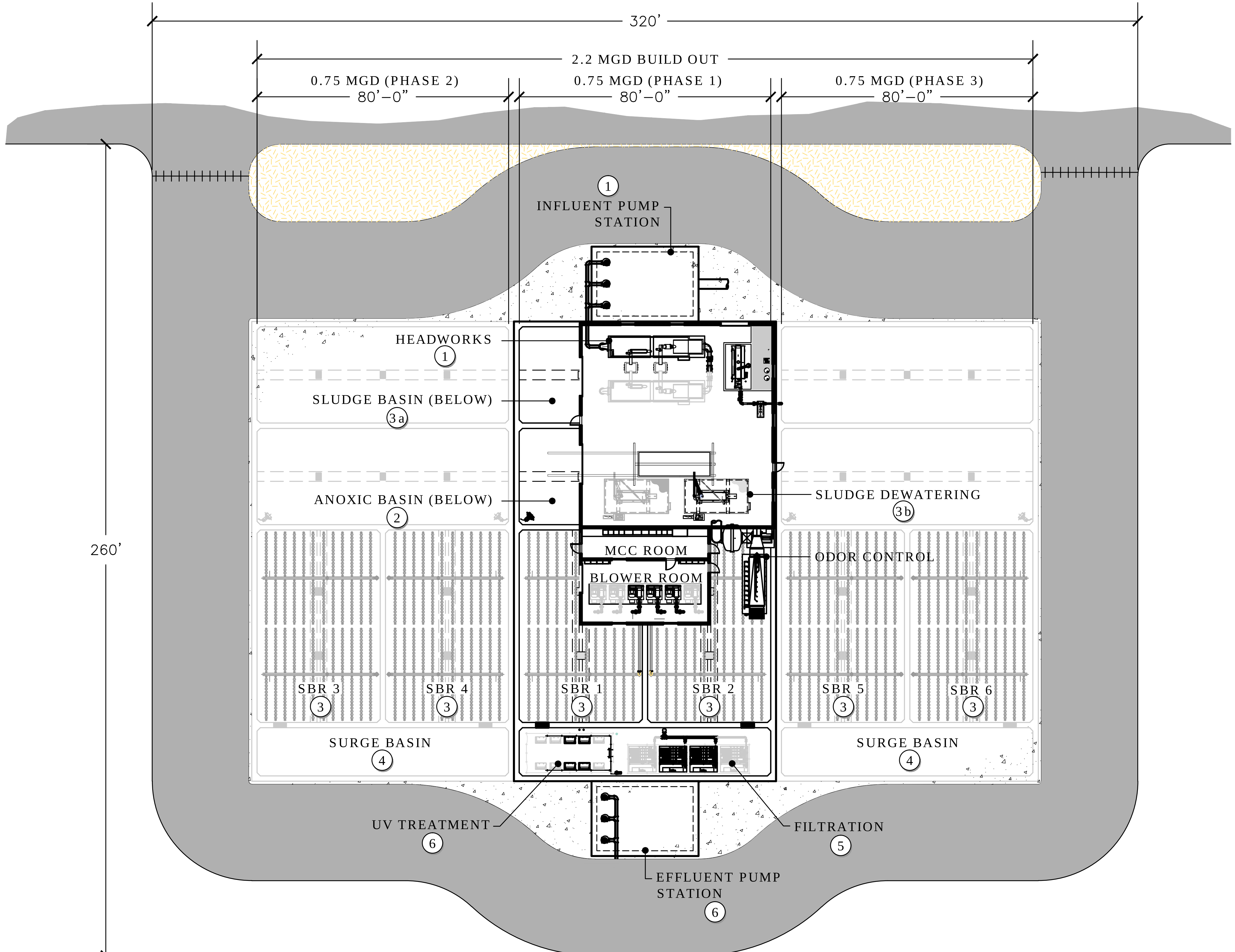
b. Sludge Dewatering: Sludge is then pumped from the sludge storage tank to a centrifuge to dewater. The sludge is dewatered to reduce the volume and weight of wet sludge prior to hauling to disposal.

Step 4: Surge Basin: After settling, wastewater is decanted into the surge basin. Sewer flow is generally diurnal, where there are two peak flows within 24 hours. The surge basin is used to equalize the amount of flow through the filter and UV treatment by storing water during SBR decant and metering the discharge to tertiary treatment.

Step 5: Filtration: The water is then pumped to gravity disk filters, where the secondary treated water uses gravity to flow through cloth media that collects the remaining particulate BOD and Total Suspended Solids (TSS).

Step 6: UV Treatment: For tertiary disinfection of the water, ultraviolet light disinfects the water by altering the DNA of bacteria and viruses to non-detect concentrations.

FIGURE 3 - CONCEPTUAL 3-PHASE WWTP LAYOUT



5 Recycled Water Discharge

Excess recycled water not applied to irrigation will be discharged into the Azevedo Drain. During the NDPES permitting period, anticipated to occur during phase 1 and possibly phase 2, all of the Recycled water will be stored in the winter and discharged through the recycled water system during the summer. At Phase 3 the NDPES permit will likely be obtained and the reservoirs used in phases 1 and 2 will be removed, and the excess Recycled water in the winter will be discharged into the Azevedo Drain. Table 6 shows the amount of Recycled water estimated to be discharged at each phase. Figure 4 shows the discharge pathway of the Recycled water being discharged into the Azevedo Drain during phases 3 and 4. Appendix D Figure 16 shows the proposed infrastructure of the recycled water storage. Refer to Appendix D, Section 3 for complete analysis for discharged Recycled water.

Table 6: Recycled Water Discharged

Phases	Cumulative Recycled Water Discharged Into Distribution (gpd)	Cumulative Recycled Water Discharged Into Distribution (AF/yr)	Cumulative Recycled Water Discharged Into Azevedo Drain (gpd)	Cumulative Recycled Water Discharged Into AzevedoDrain (AF/yr)
Phase 1	510,000	570	0	0
Phase 2	888,000	990	0	0
Phase 3 + X*	822,000	920	723,000	800
Phase 4	1,104,000	1,240	997,000	1,100

*Cumulative Recycled Water Discharged Into Recycled Distribution Value Decreases Because Unnecessary Land Use Irrigated In Phases 1 - 2 Is Discontinued In Phase 3.

Figure 04: Pathway of Recycled Water After Being Discharged into Azevedo Drain

Technical Memorandum

Date: June 15, 2012

To: Robert Capps, Doherty Partners 1750 and Price Walker, Elliott Homes, Inc.

From: Andrew T. Komor, PACE

Re: Proposed Water and Wastewater Reduction for Dunnigan # 8936E

OBJECTIVE

This memo illustrates that the 2008 Yolo County Improvement Standards significantly overestimate actual water and wastewater flows in new communities. 2008 Yolo County factors do not reflect the decreasing trend in potable water usage, the associated decline in wastewater generation, and the reduction of inflow and infiltration. Flow reductions are due to many factors including water conservation, development trends, improved system design, and newer construction materials. If the 2008 factors are used to size water and wastewater treatment facilities for a new development, the treatment facilities will be oversized and underutilized.

Dunnigan's water, wastewater, and inflow and infiltration flows will be significantly lower than Yolo County Standards. There will be a lower average occupancy than Yolo County Standards (2.62 people per household vs. 3.0 to 3.5 pph), with higher density home development on smaller lots with less irrigated space. The 3.0 and 3.5 persons per unit standard is about 20 percent higher than the average occupancy of 2.62 persons per household planned for Dunnigan.

Table 1 - Comparison of Occupancy Expectations

LAND USE CATEGORY	YOLO COUNTY 2008 Improvement Standards Table 7-1	DUNNIGAN, CA Expected Occupancy	Difference
Single Family Residential	3.5 persons per unit	2.62 persons per unit	- 25%
Multi-Family Residential	3.0 persons per unit	2.62 persons per unit	- 13 %

To conserve water, all homes will be equipped with code-compliant indoor water conservation fixtures. As a result, Dunnigan's overall water demand is expected to be almost 40 percent lower than the Yolo County Improvement Standards. With decreased indoor water usage, wastewater flow also declines. The wastewater flow for sizing the sanitary sewer system is expected to be almost 50 percent lower.

Table 2 – Overestimation of Water and Wastewater Flows

	YOLO COUNTY 2008 Improvement Standards	PROPOSED DUNNIGAN	Difference
Water Demand	8,934 AF/Year	5,420 AF/Year	- 39 %
Wastewater Flow for biological plant sizing	4.3 MGD	2.2 MGD	- 49 %

The proposed Dunnigan water and wastewater flows presented above were estimated using updated water and sewer planning factors from another utility district. Many nearby cities have responded to declining water and sewer flows in new residential developments by adjusting their water and wastewater planning factors downward. Such cities include Lincoln, Davis, Roseville, and many others. After a thorough review of several agencies, PACE recommends the planning guidelines from Placer County Water Agency and the South Placer Wastewater Authority. PCWA and SPWA planning factors are considered appropriate to use because of the proximity to Dunnigan, approximately 50 miles east, and because their planning numbers are supported by metering studies and have been thoroughly documented.

PROPOSED DESIGN FACTOR ADJUSTMENTS FOR DUNNIGAN

Table 3 – Proposed Design Factor Adjustments for Dunnigan

	Yolo County 2008 Improvement Standards		Proposed Dunnigan Design Factor	
LAND USE	**Water**	**Wastewater**	**Water**	**Wastewater ADWF**
Single Family Residential (<6 DU/ac)	728 gpd/DU	350 gpd/DU	750 gpd/DU	190 gpd/DU average for all residential units
Low Density Residential (6 DU/ac)	No standard	350 gpd/DU	348 gpd/DU	
Medium Density Residential (12.5 DU/ac)	521 gpd/DU	300 gpd/DU	179 gpd/DU	
High Density Residential (24 DU/ac)	No standard	300 gpd/DU	161 gpd/DU	
Mixed Use	No standard	2,500 gpd/ac	2,500 gpd/ac	2,300 gpd/ac
Public/Quasi Public (WWTP, Fire Station, etc.)	1,780 gpd/ac	200 gpd/ac	1,780 gpd/ac	660 gpd/ac
Commercial/Retail	2,598 gpd/ac	2,500 gpd/ac	1,937 gpd/ac	850 gpd/ac
Light Industrial	2,562 gpd/ac	2,500 gpd/ac	2,339 gpd/ac	850 gpd/ac
Elementary Schools	3,454 gpd/ac	50 gpd/student	2,500 gpd/ac	170 gpd/ac
Middle Schools		50 gpd/student	2,500 gpd/ac	170 gpd/ac
High Schools	4,068 gpd/ac	60 gpd/student	2,500 gpd/ac	170 gpd/ac
Parks/Greenways	2,988 gpd/ac	200 gpd/gross ac	2,988 gpd/ac	10 gpd/ac

PROPOSED DUNNINGAN WATER DEMAND

The proposed potable water demand factors are adapted from the 2010 Placer County Water Agency Urban Water Management Plan for the Roseville area. These factors closely match the housing density that is proposed for Dunnigan. For example, there are almost 4,000 units planned at Dunnigan in the Low Density category of 6 DU/Acre, which is the largest residential land use category. The Placer County Water Agency has a factor for a range from 5.1 – 7 DU/AC which closely matches the 6 DU/Acre density proposed at Dunnigan.

Residential water demand is largely affected by the amount of irrigated landscaping, and Yolo County residential water demand factors overestimate water usage by 50 to 70 percent in low to high density residential categories. For large rural residential lots; however, the proposed water demand factor proposed is actually higher than the current Yolo County factor due to the high outdoor water use from amenities such as swimming pools and large irrigated landscaped areas.

The following table presents the adjusted water demand calculation proposed for Dunnigan using water planning factors adapted from PCWA. The proposed changes are presented next to the current Yolo County Standards for easy comparison. Yolo County Standards are missing a few common land use categories. There are no specific design factors for low residential land use of 6 DU/acre; high density land use of over 12 DU/acre; or mixed use. These categories are marked with an asterisk and have been assumed. Using PCWA factors result in overall water demand that is 39 percent lower than the current Yolo County Standards.

Table 4 - Proposed Water Demand for Dunnigan

LAND USE CATEGORY		YOLO COUNTY 2008 Improvement Standards		DUNNIGAN, CA Proposed Water Demand	
	DU or Ac	Gal/day/unit	AF/YR	Gal/day/unit	AF/YR
Rural Residential (0.8 DU/ac)	730 DU	728	595	750	613
Low Density Residential (6 DU/ac)	3,982 DU	*728	3,247	348	1,552
Medium Density Residential (12.5 DU/ac)	2,248 DU	521	1,312	179	451
High Density Residential (24 DU/ac)	1,333 DU	*521	778	161	240
Mixed Use	57.5 ac	*2,598	167	2,500	161
Public/WWTP	18.8 ac	1,780	37	1,780	37
Elementary School	40.0 ac	3,454	155	2,500	112
Middle School	23.3 ac	3,454	90	2,500	65
High School	40.0 ac	4,068	182	2,500	112
Commercial - Regional	38.2 ac	2,598	111	1,937	83
Commercial – Local Community	52.1 ac	2,598	152	1,937	113
Commercial - Highway	101.2 ac	2,598	295	1,937	220
Commercial – Office/R&D	143.6 ac	2,598	418	1,937	312
Industrial/Light Industrial	199.3 ac	2,562	572	2,339	522
Community/Neighborhood Park	122.6 ac	2,988	410	2,988	410
Public Open Space (not irrigated)	130.7 ac	0	-	0	-
Non-Irrigated Greenways	49.8 ac	0	-	0	-
Irrigated Greenways	123.2 ac	2,988	412	2,988	412
Lake	28.8 ac	0	-	0	-
Total Water Demand (AF/YR)			**8,934**		**5,416**

* No 2008 Yolo County Standard for this land use category. Value has been assigned.

PROPOSED DUNNIGAN WASTEWATER GENERATION

Since all indoor water use flows directly to the wastewater treatment plant, it is not surprising that new communities equipped with water conservation fixtures also generate significantly less wastewater. Data from Northern California cities show substantial declines in wastewater flows after the introduction of water conservation fixtures.

The following table presents the adjusted water demand calculation proposed for Dunnigan using water planning factors adapted from South Placer Wastewater Authority (SPWA). SPWA is comprised of three separate agencies: the City of Roseville, the South Placer Municipal Utility District (SPMUD), and Placer County. The SPWA completed a study of the wastewater system to provide appropriate planning information based on actual characteristics of the flows. The final values represent the average dry weather flow (ADWF) – or the average of July, August, and September flows and include the Groundwater Infiltration (GWI) in their values.

The proposed changes are presented next to the current Yolo County Standards for easy comparison. Yolo County Standards are missing the mixed use land use category, which has been marked with an asterisk and assigned a value. Using SPWA factors result in overall water demand that is 63 percent lower than the current Yolo County Standards.

Table 5 - Proposed Wastewater Generation for Dunnigan

LAND USE CATEGORY		YOLO COUNTY 2008 Improvement Standards		DUNNIGAN, CA Proposed Wastewater Average Dry Weather Flow	
	DU or Ac	**Gal/day/unit**	**1,000 GPD**	**Gal/day/unit**	**1,000 GPD**
Rural Residential (0.8 DU/ac)	730 DU	350	256	190	139
Low Density Residential (6 DU/ac)	3,982 DU	350	1,394	190	757
Medium Density Residential (12.5 DU/ac)	2,248 DU	300	674	190	427
High Density Residential (24 DU/ac)	1,333 DU	300	400	190	253
Mixed Use	57.5 ac	*2,500	144	2,300	132
Public/WWTP	18.8 ac	200	4	660	12
Elementary School	40.0 ac	50 gpd/student	30	170	7
Middle School	23.3 ac	50 gpd/student	40	170	4
High School	40.0 ac	60 gpd/student	108	170	7
Commercial - Regional	38.2 ac	2,500	96	850	32
Commercial – Local Community	52.1 ac	2,500	130	850	44
Commercial - Highway	101.2 ac	2,500	253	850	86
Commercial – Office/R&D	143.6 ac	2,500	359	850	122
Industrial/Light Industrial	199.3 ac	2,000	399	850	169
Community/Neighborhood Park	122.6 ac	200	25	10	1
Public Open Space (not irrigated)	130.7 ac	0	0	0	0
Non-Irrigated Greenways	49.8 ac	0	0	0	0
Irrigated Greenways	123.2 ac	0	0	0	0
Lake	28.8 ac	0	0	0	0
ADWF Wastewater Flow (1,000 GPD)			4,310		2,193
ADWF Wastewater Flow (MGD)			4.3 MGD		2.2 MGD

* No 2008 Yolo County Standard for this land use category. Value has been assigned.

INFLOW AND INFILTRATION

An important component of wastewater is the contribution of clean water from inflow and infiltration, which is comprised of 1) dry weather groundwater infiltration, 2) wet weather groundwater infiltration (GWI), and 3) rainfall-dependent infiltration and inflow (RDI/I). The inflow and infiltration rates in older system are typically significant, sometimes as high as the base sanitary flow itself. Many older sewer systems are clay pipes installed beneath creeks or streams. Such poorly located sewer mains are prone to high infiltration as groundwater enters the sanitary sewer through pipe defects. Manholes in older systems are often poorly located and become inundated during rainfall events, allowing large inflows of runoff through the holes in manhole covers. The Dunnigan sanitary sewer system will be constructed with modern design standards to minimize inflow and infiltration.

Various methods to calculate I&I are employed by different utilities. Some have proposed to add I&I to the wastewater treatment plant capacity; however, since I&I is relatively clean water with low organics and low nutrients, it does not contribute significantly to the biological loading of the plant. The Yolo County inflow and infiltration allowance is 600 gallons per gross acre per day, which equates to 1.6 MGD for Dunningan. If added to the Average Dry Weather Flow, the Yolo County Improvement Standards wastewater flow increases from 4.3 MGD to 5.9 MGD.

An alternative method for addressing I&I is the method used by the SPWA. The SPWA method includes dry weather groundwater infiltration in the ADWF flow factors and does not add wet weather I&I to the biological sizing of the plant. Rather, wet weather I&I is considered when sizing the sewer collection system and the peak hydraulic capacity of the wastewater treatment plant.

Using the SPWA method yields a wet weather I&I of 1.6 MGD, which matches closely with the Yolo County standards; however, the treatment plant biological capacity remains at 2.2 MGD, with the hydraulic capacity to handle wet weather peaks of 3.8 MGD through flow equalization. The SPWA I&I method only affects the "up front" hydraulic systems in the plant, such as the lift station capacity, screening, equalization, etc., which results in a more efficiently designed wastewater treatment facility.

Table 6 – Wet Weather Inflow and Infiltration

I&I Type	YOLO COUNTY 2008 Improvement Standards	SPWA 2009 Wastewater Systems Evaluation
Dry Weather Groundwater Infiltration	1.6 MGD	Included in 2.2 MGD ADWF
Wet Weather Groundwater Infiltration (GWI)		0.5 MGD (not included in 2.2 MGD ADWF)
Rainfall Dependent Infiltration and Inflow (RDI/I)		1.1 MGD (not included in 2.2 MGD ADWF)

REFERENCES

2008, *Yolo County Improvement Standards, Section 8 – Water Systems*: dated August 5.

2008, *California Green Building Standards Code, California Code of Regulations, Title 24, Part 11*: effective August 1, 2009

2010, *California Green Building Standards Code, CAL Green, California Code of Regulations, Title 24, Part 11*: effective January 1, 2011

2011, AWWA Journal 103:2, *Residential Water Use Trends in North America*: Peer-reviewed study by Rockaway, et. al. published in February 2011

2011, *Placer County Water Agency, 2010 Urban Water Management Plan,* prepared by Tully & Young: adopted June 16.

2011, *City of Lincoln, 2010 Urban Water Management Plan,* prepared by Tully & Young: adopted July 12.

2012, PACE, *Proposed Residential Potable Water Demand Reduction for Dunnigan: dated June 12.*

2012, PERC, *Wastewater Generation Factors in Neighboring Communities: dated June 14.*

APPENDIX A – WATER REFERENCE

2012, PACE, *Proposed Residential Potable Water Demand Reduction for Dunnigan: dated June 12.*

APPENDIX B – WASTEWATER REFERENCE

2012, PERC, *Wastewater Generation Factors in Neighboring Communities: dated June 14.*

PACE

To: Robert Capps, Doherty Partners 1750 and Price Walker, Elliott Homes, Inc.

From: Erin E. Hubbard, P.E.

Date: June 14, 2012

Subject: Wastewater Generation Factors in Neighboring Communities

Executive Summary

The 2008 Yolo County sewer generation factors significantly overestimate actual wastewater generation that occurs within Yolo County. Applying the existing factors to new communities will result in sewer infrastructure that is oversized. This memo serves as a companion to the Technical Memo for the proposed potable water system that was authored by Janet Fordunski, P.E. at PACE. Like its counterpart, this memo provides a recommendation for sizing the Dunnigan infrastructure. Separate approaches are outlined for the sewer collection system and Water Recycling Facility (WRF).

For the most up to date wastewater generation rate unit planning factors, the 2009 South Placer Wastewater Authority (SPWA) study of actual flows was selected. SPWA encompasses the City of Roseville and unincorporated areas of Placer County. The generation rates adopted by the SPWA illustrate how one nearby city responded to wastewater generation assumptions that did not reflect actual wastewater flows. The values below reflect appropriate generation rates based on the research presented below.

Table 1: Proposed Wastewater Generation Factors for Dunnigan

LAND USE CATEGORY	YOLO COUNTY 2008 Improvement Standards	DUNNIGAN Proposed Wastewater Rates
Single Family Residential	350 gpd/DU	190 gpd/DU
Multi-Family Residential	300 gpd/DU	190 gpd/DU
Mixed Use	2,500 gpd/AC	2,300 GPD/AC
Public/Quasi Public	200 gpd/AC	660 GPD/AC
Elementary and Middle Schools	50 gpd/student	170 gpd/AC
High Schools	60 gpd/student	170 gpd/AC
Commercial, Office	2,500 gpd/AC	850 gpd/AC
Industrial	2,500 gpd/AC	850 gpd/AC
Recreation and Parks	200 gpd/AC	10 gpd/AC

Source: Table 7-1. 2008, *Yolo County Improvement Standards*, Section 7 – Sewer Systems: August 5.

Applying the proposed wastewater rates to the Dunnigan community, we recommend the Water Recycling Facility be designed for an Average Dry Weather Flow of 2.2 MGD. Peaking factors applied to the facility ADWF design will address peak day and hour flows. The peaking experienced at local facilities is discussed in later in the memo.

The collection system should be designed around the proposed wastewater generation rates above and the inclusion of 200 gpd/AC of wet weather flow infiltration plus inflow that relates to the R factor of 0.5% and the Yolo County design storm. This design is modeled after the 2009 SPWA findings. The current 2008 Yolo County Improvement Standard applies 600 gpd/AC which is significantly higher than area facilities experience. When communities that have taken steps to secure their sewer systems and measure actual I/I, they experience and plan for significantly lower flow rates.

Dunnigan

The Dunnigan master-planned community consists of approximately 3,000 acres of residential, commercial, industrial, mixed use, public facilities, and open space. Land use in for the proposed community is identified below. Approximately 406 acres is existing residential and commercial land use, comprised of 778 units of rural, low, and medium density housing. Existing land use makes up about 14% of the total area and 9% of the total residential units. 91% of the housing at Dunnigan will be new construction. Public open space, greenways and lakes are combined. These elements are not contributors to the wastewater flow; they will not be connected to the sanitary sewer system.

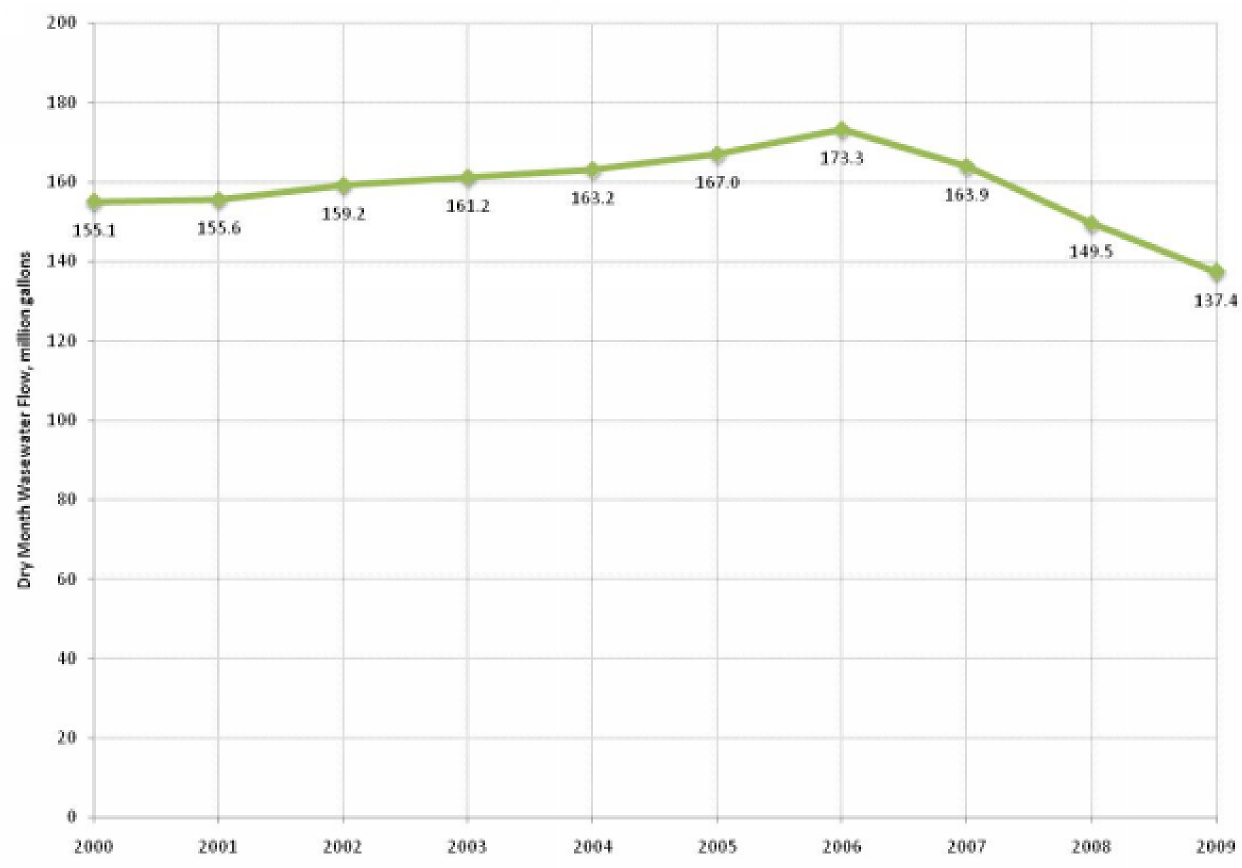
Table 2: Dunnigan Land Use

LAND USE CATEGORY	Acres	Units	Students
Rural Residential (0.8 DU/ac)	907.6	730	
Low Density Residential (6 DU/ac)	663.7	3,982	
Medium Density Residential (12.5 DU/ac)	179.7	2,248	
High Density Residential (24 DU/ac)	55.5	1,333	
Mixed Use	57.5		
Public/WWTP	18.8		
Elementary School	40.0		600
Middle School	23.3		800
High School	40.0		1,800
Commercial – Regional, local, highway and office	335.1		
Industrial/Light Industrial	199.3		
Community/Neighborhood Park	122.6		
Public Open Space, Greenways and Lake	332.5		
Totals	**2,975.6**	**8,293**	**3,200**

Declining Wastewater Generation

In his presentation "Wastewater Treatment Trends in the 21st Century – George Tchobanoglous, identified challenges for the wastewater infrastructure in the U.S. "Flow rates have decreased over the past decade and will continue to decrease." Directly linked to declining indoor water use outlined in the water memo, it is not surprising that communities who install conservation devices and find that wastewater generation decreases. The City of Davis UWMP shows that wastewater generation has declined by about 11% between 2000 and 2010 despite a 9% rise in population[1] .

Figure 1: Declining Wastewater Flow – City of Davis, CA



As with water use, the decline in wastewater generation has several contributing factors. The smaller average size of households and increasing efficiency standards were cited by AWWA. Local agencies have also identified the economic downturn and drought awareness among the public as significant. Regional and nationwide trends are reflected by the Dunnigan proposal. Though there are several home density categories at Dunnigan, all home types are expected to have an average occupancy of 2.62. This is lower than the 2008 Yolo County standard for single family housing at 3.5 and the multi-family assumption of 3.0 people per home.

[1] US Census: Davis population of 60,308 in 2000 and 65,622 in 2010

Table 3: Comparison of Occupancy Expectations for Dunnigan

LAND USE CATEGORY	YOLO COUNTY 2008 Improvement Standards Table 7-1	DUNNIGAN, CA Expected Occupancy
Single Family Residential	3.5 persons per unit	2.62 persons per unit
Multi-Family Residential	3.0 persons per unit	2.62 persons per unit

In itself this difference should result in a significant reduction in wastewater generation. Using the implied per capita use of 100 gallons per person the occupancy alone would accomplish a reduction of approximately 19% in average day flows. However, we do not recommend focusing only on projected population as an update to 2008 Improvement Standards. This represents only one component of wastewater generation.

Experiences of Local Wastewater Treatment Facilities

Mountain House, CA

The Mountain House community is located in San Joaquin County, CA. PERC Water designed and built the community's wastewater treatment facility with a capacity of 3.0 MGD in 2005. Subsequently, PERC Water operated the facility for several months. The current facility operator recently provided information regarding current flows to the facility that illustrates wastewater generation on a per home basis of approximately 160 gpd.

An interesting observation from this system is the comparatively low peak flow experienced at Mountain House. Even though this community is experiencing slowed absorption and has a very high groundwater table, a review of the past three years of meter data indicate that the peak day flow is just 1.3 times the average day flow. According to the operator, holiday celebrations create the greatest peaks seen at the facility. Rainfall events have a less significant effect.

Wild Wings, CA

The Wild Wings community in Yolo County offers a second data point for wastewater generation in new communities. By the end of 2006, residents had moved into the 327 homes that make up the final community footprint. An interview of Rick Fenaroli who served as the Chairman of the Wild Wings CSA provided information on the wastewater flow pattern from the community. Depending on the day of the week, the facility receives flows of 58,000 to 62,000 gpd. At any given time it is assumed that there are approximately 320 occupied units which indicate that the average household contribution is 180 gallons/day. Peak flows to the facility over this time have been between 75,000 to 80,000 gpd representing 250 gpd from occupied units. Mr. Fenaroli also indicates that the sewer system is very minimally impacted by wet weather flows. The maximum day peaking factor at the facility is approximately 1.4 since the beginning of operation approximately 5 and 1/2 years ago.

Table 4: Average and Peak Flows at Regional Facilities[2]

FACILITY NAME	Average Day Flow Gallons/EDU
Mountain House	160
Wild Wings	180

Since the information from these facilities includes flows from every day of the year, the values represent the Annual Average Day Flow or AADF. These values will be slightly higher than the type of value typically used for planning (i.e. the Annual Average Dry Weather Flow (ADWF)). The ADWF is the sewer volume expected in a 24 –hour period during periods of little or no rain.

Adjusted Wastewater Generation Rates

Given the importance of accurate wastewater generation rates a review of many local cities and wastewater service areas was conducted to identify which areas had taken steps to match the observable community flow rates to the wastewater generation factors[3]. Two nearby cities were identified. The two cities were Roseville (as part of the South Placer Wastewater Authority) and Winters. While several locations noted a reduction in standards was appropriate, only the two locations identified performed the analysis to create accurate wastewater generation rates for their community based on actual flows.

Located approximately 50 miles east of Dunnigan, the City of Roseville owns and operates two regional wastewater treatment facilities and the network of gravity sewers, pump stations, and force mains that serve customers within the City's limits. Winters is located approximately 25 miles south of Dunnigan. The City's sanitary sewer system collects the wastewater flows from approximately 1,980 acres within the City and conveys the flow to the City's Wastewater Treatment Facility.

Further investigation showed that Winters did not modify or assign new factors of wastewater generation based observations. The Winters ADWF factors were developed using the following formula:

ADWF Factor (gpd/net acre) = [Residential Density]*[Population Density]*[90 gpcd]

Though the population density was adjusted downward for one land use category, no other elements related to wastewater generation were adjusted. The study indicates that the factors were largely unchanged from 1992. Based on this assessment, application of the Winters assumptions is not expected to result in an accuracy improvement if applied to the Dunnigan community. Therefore, only the Roseville study and values were explored further.

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[2] Based on the type of information provided, all values are represented with just two significant figures.

[3] Other cities reviewed include Davis, CA; Dixon, CA; Lincoln, CA; and West Sacramento, CA.

Table 5: Comparison of AADF and ADWF for Single Family Residential Land Use

	Wild Wings, AADF	Mountain House, AADF	Roseville (SPWA), ADWF	Winters, ADWF
Single Family Residential	180 GPD/DU	156 + GPD/DU	190 GPD/DU	236 GPD/DU

South Placer Wastewater Authority, CA

Created in 2000, the South Placer Wastewater Authority (SPWA) is comprised of three separate agencies: the City of Roseville, the South Placer Municipal Utility District (SPMUD), and Placer County. In 2004 the organization noted a need for a baseline characterization of its wastewater and recycled water systems due to changes in boundaries, demographics and flow characteristics. A vigorous water conservation program had been credited with decreasing the volume per capita of wastewater conveyed by the sewers. Suburbanization was increasing densities and changing flow patterns. A baseline characterization of the area was needed to provide a long-term planning tool for identifying and implementing capital improvement projects.

The SPWA completed a study of the wastewater and recycled water systems to provide appropriate planning information based on actual characteristics of the flows. The "South Placer Regional wastewater and Recycled Water Systems Evaluation" records the outcomes of the study. The document was prepared by RMC in association with Brown & Caldwell in 2005 and then updated in the fall of 2009. The total service area covered by the boundary used for the survey is 52,039 acres.

Table 6: SPWA –Wastewater Generation Rates

LAND USE CATEGORY	SPWA 2009 Wastewater Systems Evaluation ADWF Generation
Single Family Residential	190 GPD/DU
Multi-Family Residential	130 GPD/DU
Commercial, Office	850 GPD/AC
Mixed Use	2,300 GPD/AC
Public/Quasi Public	660 GPD/AC
Industrial	850 GPD/AC
Heavy Industrial	850 GPD/AC
Schools	170 GPD/AC
Recreation and Parks (> 10 ACRES)	10 GPD/AC

*Source: 2009, South Placer Regional Wastewater and Recycled Water Systems Evaluation, RMC, September. Technical Memo 2a "*Dry Weather Flow Projection for the 2005 SPWA Regional Service Area".

The wastewater unit flow factors were identified by reviewing flow data from permanent flow monitoring sites in Roseville, SPMUD and Placer County from September and October 2004. Large point source contributors were removed. Then, the flow meter data was compared to water billing data. The unit flow factors created during this process provide the estimated wastewater flow generation rates for each of the consolidated land use categories. The final values represent the average dry weather flow (ADWF) – or the average of July, August, and September flows. Due to the method used to identify flow rates, the dry weather Groundwater Infiltration (GWI) is incorporated in these values.

Wastewater Generation Rate Comparison

The following table compares the variation in projected wastewater generation at the Dunnigan community using factors from Yolo County, and SPWA. The Minimum Average Daily Flow rate applied by the Yolo County standards is more than double the Roseville estimate for similar land use categories.

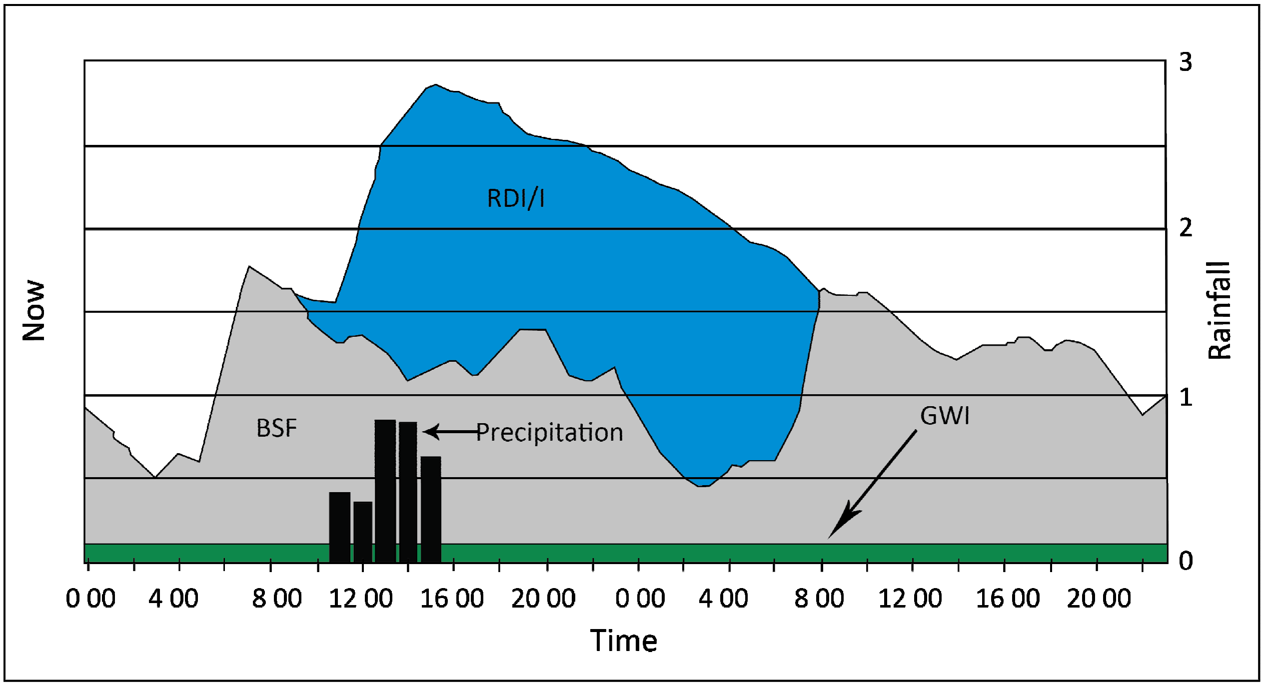
Table 7: Dunnigan Wastewater Generation Comparison (ADWF)

LAND USE CATEGORY	YOLO COUNTY 2008 Improvement Standards Min. Average Daily Flow	SPWA 2009 Wastewater Systems Evaluation Wastewater Generation
Single Family Residential	1,649	895
Multi-Family Residential	1,074	680
Commercial, Office	838	285
Mixed Use	144	132
Public/Quasi Public	4	12
Industrial	399	169
Heavy Industrial	NA	NA
Elementary and Middle Schools	70	11
High Schools	108	7
Recreation and Parks	25	1
Total (Thousand Gallons/Day)	**4,310**	**2,193**

Inflow and Infiltration Comparison

As an important component of wastewater flows, GWI and RDI/I must be taken under consideration when planning for new sewer infrastructure. Typically, wastewater consists of three components: base sanitary flow (BSF), groundwater infiltration (GWI), and rainfall dependent infiltration and inflow (RDI/I). These are illustrated in the figure below. BSF and GWI during dry weather constitute ADWF. Typically this is experienced in the summer months when precipitation is lowest.

Figure 2: Typical Components of Wastewater Flow



*Source: 2009, South Placer Regional Wastewater and Recycled Water Systems Evaluation, RMC, September. Technical Memo 2a "*Dry Weather Flow Projection for the 2005 SPWA Regional Service Area".

A review of available information on actual I/I information returned just the SPWA study from among neighboring communities.

South Placer Wastewater Authority, CA

Once again, we turned to the "South Placer Regional Wastewater and Recycled Water Systems Evaluation" for information on local infrastructure. The information below describes the study and findings.

To evaluate the impact of precipitation on the SPWA sewer system, a rain gauge network was installed to provide comprehensive coverage of the entire SPWA service area. Wet season GWI was determined by comparing ADWF flows at the permanent flow monitoring sites in Roseville, SPMUD and Placer County during the 2004 dry season to those from the 2005 wet season.

Based on the study results a set of standard wet season GWI values were created. Due to variations in flow, each of the two sewersheds was assigned a different Wet Weather GWI to be applied to developed areas. Wet season GWI is not applied to parks and open spaces for either sewershed. These values are used to calculate additional flows expected within the sewer collection system. SPWA does not apply these values to wastewater treatment facility capacity needs, instead using peaking factors to address precipitation effects.

Table 8: Precipitation Effects on Sewer Collection System Design

LAND USE	SPWA Wet Weather GWI
Developed Areas (Residential, Public, Commercial, Industrial areas)	100 and 200 GPD/AC
Non-Developed Areas (Parks and Open Spaces)	0 GPD/AC

Source: 2009, South Placer Regional Wastewater and Recycled Water Systems Evaluation, RMC, September. Technical Memo 2c "Wet Weather Flow Projection for Ultimate Service Area".

If the higher of these values were applied to Dunnigan, the wet weather contribution to the sewer collection system design would be half a million gallons and applied to the appropriate sewersheds.

Table 9: Dunnigan Wet Weather GWI Generation Based on SWPA

LAND USE	Build-Out Acreage	Wet Weather GWI, Applying SWPA
Developed Areas (Residential, Public, Commercial, Industrial areas)	2,520	0.5 MGD[4]
Non-Developed Areas (Parks and Open Spaces)	439	0 Gallons/Day
Total	**2,959 AC**	**0.5 MGD**

The final component of wastewater flow, Rainfall Dependent I/I was also considered for the study to calibrate a model of the system's response to rainfall.

An R Value is defined as the volume of infiltration and inflow (in gallons) resulting from the selected storm event divided by the value resulting from multiplying the basin area by the total rainfall. The R Value estimates the total volume of rainfall which fell on the basin that actually enters the collection system. The R-value, expressed as a percentage, can be computed using the following equation:

$$R = \frac{\text{RDI/I}}{\text{Area} * \text{Rainfall}}$$

where, RDI/I = volume of rainfall dependent I/I entering a system
Area = area of the system being analyzed (e.g. basin, flow shed, etc)
Rainfall = amount of rain falling on the area being analyzed (expressed in inches of rain)

R values of greater than 5% can be indicative of excessive infiltration. Relatively low R values less than 1.5% generally indicate a "tight" system with low rates of RDI/I.

[4] Uses the higher of the SPWA Wet Weather GWI rates, 200 GPD/AC

SPWA's process led to the development of 'R' factors that will be applied to future development based on the trends identified. The rate was developed with the acknowledgement that I/I from future development may not appear immediately, but most likely will occur over time as the system deteriorates. An R factor of 0.5%, which coincides with I/I rates in some of the newer developed areas within the SPWA service area has been adopted for new urban development areas. Areas of infill will be assigned a value to match the surrounding areas.

Table 10: Dunnigan RDI/I Generation Based on SWPA

SERVICE AREA TYPE	SPWA R Factor
Urban Development Areas	0.5%
Infill Areas	Match Surrounding Areas

Source: 2009, South Placer Regional Wastewater and Recycled Water Systems Evaluation, RMC, September. Technical Memo 2c "Wet Weather Flow Projection for Ultimate Service Area".

Conversations with Senior Engineer at Roseville, Mwah Polson, indicated that the City has taken several significant measures to maintain relatively low flows of GWI and RDI/I into the system. Eliminating roof drain connections to the sewer collection system and elevating manholes where appropriate were given as two examples of the efforts. Though it is estimated that greater than 90% of the collection system is clay pipe, and some portions of the collection system, especially those larger diameter pipes near the wastewater treatment facilities are impacted by groundwater, typical measures for limiting both inflow and infiltration have made a big difference.

RDI/I flows are typically projected using a design storm event. The design storm for Yolo County is not known, but applying a 10-year, 24-hour design storm that is applied by SPWA would create a RDI/I flow of 400 gallons/ac[5]. Applied to the 2,643 developed acres[6] would create a flow of 1.1 MGD of RDI/I. As illustrated in the diagram above, this flow is added to the GWI to create the total flow attributable to I/I.

Recommended I/I Approach

A second approach is given by Yolo County's 2008 Improvement Standards which mandate an infiltration and inflow allowance of 600 gallons per gross acre per day. Applied to the Dunnigan community, this would result in a similar flow rate in the collection system as that determined above using SPWA.

[5] The design storm has a total rainfall of 2.97 inches and a peak hour intensity of 0.77 inches.
[6] Does not include the proposed 332.5 acres of parks and open space at Dunnigan.

Table 11: Dunnigan I/I Design Level Comparison

DESIGN CRITERIA	YOLO COUNTY 2008 Improvement Standards	SPWA 2009 Wastewater Systems Evaluation
I/I	1.6 MGD	0.5 + 1.1 = 1.6 MGD (GWI+ RDI/I)

Based on the comparison, application of either the Yolo County or the SPWA I/I system is acceptable for sizing the sewer collection system. It is not known how the Yolo County values were developed but the SPWA work is well documented and reflects current wastewater trends measured in a nearby community. The experience of Mountain House and Wild Wings also supports reduced I/I values.

SPWA and the City of Roseville considered the significant I/I reduction impacts that plastic pipe materials have on sewer systems. The Wastewater Systems Evaluation also considered the impacts of eventual deterioration on the collection to come to a responsible design standard that is appropriate for sizing the sewer system proposed for the Dunnigan community.

References

2004, City of Winters – Sewer System Master Plan, Technical Memorandum 1B2; Wastewater Design Flow Criteria – FINAL, RMC, July 23rd.

2006, *City of Winters – Sewer System Master Plan,* RMC, December. Approved by the Winters City Council February 6th, 2007.

2008, *Yolo County Improvement Standards, Section 7 – Sewer Systems:* dated August 5.

2011, AWWA Journal 103:2, *Residential Water Use Trends in North America*: Peer-reviewed study by Rockaway, et. al. published in February 2011.

2009, *South Placer Regional Wastewater and Recycled Water Systems Evaluation,* RMC, September.

2012, Phone interview with Mountain House operation (J.J.) and Erin Hubbard and review of 2009-2011 operations data February.

2012, Tchobanoglous, George, University of California Davis Speaking May 3. *Wastewater Treatment Trends in the 21st Century,* Water and Wastewater Management Summit, Summerlin, NV.

2012, Rick Fernaroli, Phone interview with Erin Hubbard. May 18th.

2012, Mwah Polson , City of Roseville- Senior Engineer, Phone interview with Erin Hubbard. June 8th. 916-774-5773, mpolson@roseville.ca.us.

Waste Water Produced

Land Use (unit)	Flow Factor (Gal/day/unit)	Phase 1			Phase 2			Phase 3			Phase 4			Phase X		
		Acres	Units(DU or ac)	ADWF(1000*GPD)	Acres	Units(DU or ac)	ADWF(1000*GPD)	Acres	Units(DU or ac)	ADWF(1000*GPD)	Acres	Units(DU or ac)	ADWF(1000*GPD)	Acres	Units(DU or ac)	ADWF(1000*GPD)
Residential Rural (1 DU/Ac)	190	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	332	332	63.1
Rural Estates (1.74 DU/ac)	190	51.1	88.914	16.9	38.7	67.338	12.8	58.5	101.79	19.3	64.7	112.578	21.4	0	0	0.0
Low Density Residential (5 DU/ac)	190	217.1	1085.5	206.2	131.4	657	124.8	146.9	734.5	139.6	151.2	756	143.6	17.1	85.5	16.2
Medium Density Residential (14.2 DU/ac)	190	40.6	576.52	109.5	30.6	434.52	82.6	22.9	325.18	61.8	60	852	161.9	25.8	366.36	69.6
High Density Residential (24 DU/ac)	190	19.3	463.2	88.0	16.1	386.4	73.4	13.3	319.2	60.6	5.4	129.6	24.6	1.4	33.6	6.4
Mixed Use (ac)	2300	28.6	28.6	65.8	17.7	17.7	40.7	4.6	4.6	10.6	6	6	13.8	0.6	0.6	1.4
Public/WWTP(ac)	660	7.8	7.8	5.1	4.6	4.6	3.0	1	1	0.7	0	0	0.0	19.2	19.2	12.7
Elementary School(ac)	170	10	10	1.7	20	20	3.4	0	0	0.0	10	10	1.7	0	0	0.0
Middle School(ac)	170	23.3	23.3	4.0	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0
High School(ac)	170	0	0	0.0	0	0	0.0	40	40	6.8	0	0	0.0	0	0	0.0
Commercial - Regional (ac)	850	0	0	0.0	17.7	17.7	15.0	20.5	20.5	17.4	0	0	0.0	0	0	0.0
Commercial – Local Community(ac)	850	25	25	21.3	14	14	11.9	0	0	0.0	0	0	0.0	13.1	13.1	11.1
Commercial - Highway(ac)	850	51.1	51.1	43.4	3.9	3.9	3.3	17.4	17.4	14.8	35.7	35.7	30.3	0	0	0.0
Commercial – Office/R&D(ac)	850	3.1	3.1	2.6	13.3	13.3	11.3	37.1	37.1	31.5	49.6	49.6	42.2	0	0	0.0
Industrial/Light Industrial(ac)	850	42.4	42.4	36.0	43.5	43.5	37.0	0	0	0.0	133.2	133.2	113.2	0	0	0.0
Community/Neighborhood Park(ac)	10	15.2	15.2	0.2	46	46	0.5	31.3	31.3	0.3	19.2	19.2	0.2	6.2	6.2	0.1
Roads* (ac)	0	4.0	4.0	0.0	3.4	3.4	0.0	5.2	5.2	0.0	2.6	2.6	0.0	0	0	0.0
Irrigated Public Open Space/Greenways/AG.(ac)	0	3.1	3.1	0.0	48.9	48.9	0.0	11.0	11.0	0.0	21.2	21.2	0.0	0	0	0.0
Public Open Space/Greenways/AG.(ac)	0	144.6	144.6	0.0	131.7	131.7	0.0	120.3	120.3	0.0	170.1	170.1	0.0	3	3	0.0
Lake(ac)	0	16.1	16.1	0.0	0	0	0.0	12.7	12.7	0.0	0	0	0.0	0	0	0.0
Total	**-**	**702.4**	**-**	**600.786**	**581.5**	**-**	**419.745**	**542.7**	**-**	**363.430**	**728.9**	**-**	**552.951**	**418.4**	**-**	**180.566**

*Is the area of road that needs to be irrigated. There is 151 acres of road total.

Phase1+Phase2+Phase3+Phase4= **1.94** **MGD**

Phase1+Phase2+Phase3+Phase4+PhaseX= **2.12** **MGD**