Sewer Siphon Pre-Design Report for the Santa Clara River Crossing at Vista Canyon (2009)

SEWER SIPHON PRE-DESIGN REPORT
FOR THE
SANTA CLARA RIVER CROSSING
AT VISTA CANYON

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CHAPTER 1

INTRODUCTION

The purpose of this report is to present the preliminary design components for the proposed sewer siphon to cross the Santa Clara River at the Vista Canyon project. This report presents:

- The existing and ultimate flow rates to be carried by the siphon
- An analysis of these flows to determine the appropriate sizing
- Recommended construction techniques
- Recommended materials of construction
- Preliminary plan and profile with junction structures

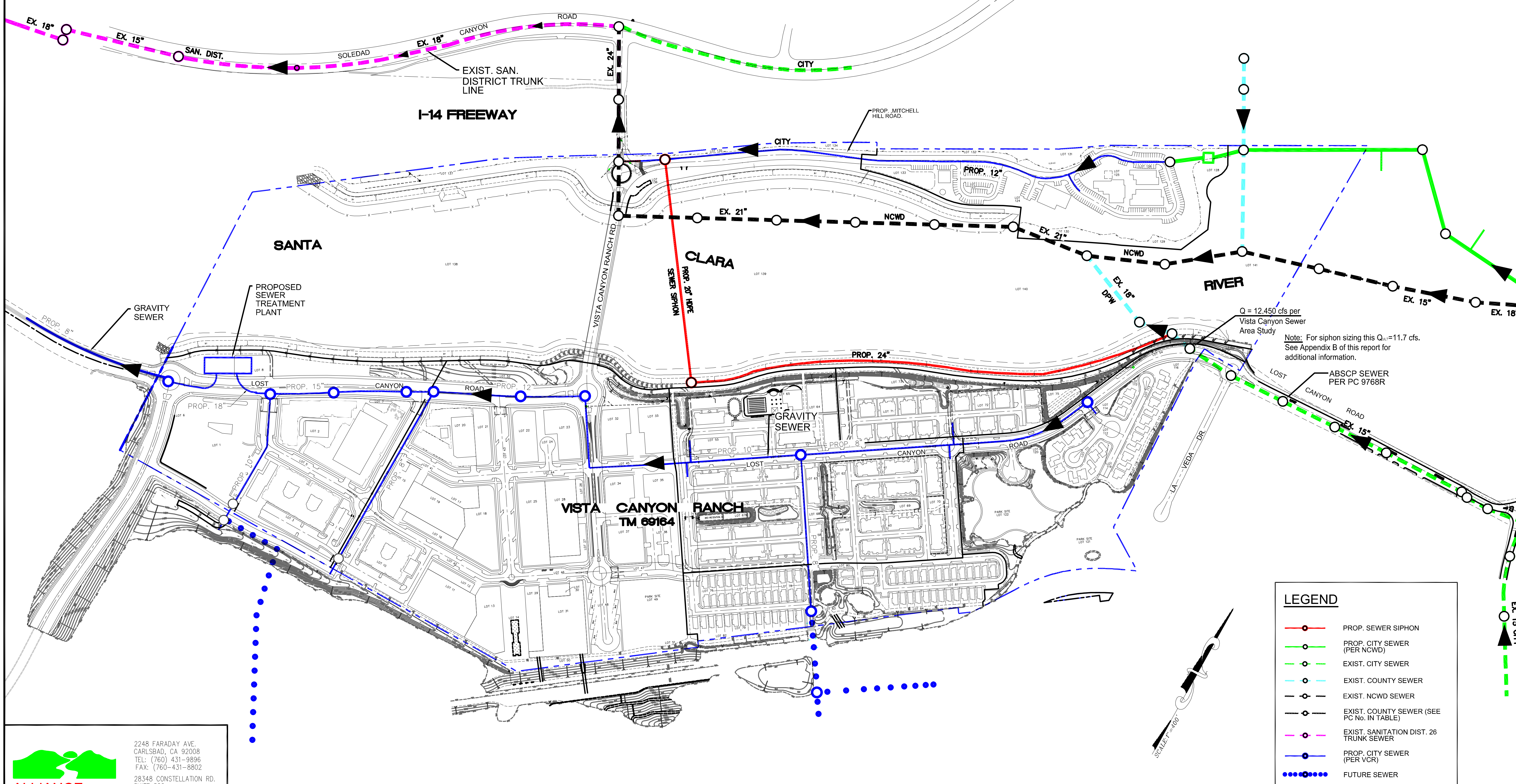
BACKGROUND AND EXISTING FACILITIES

The Vista Canyon project is located just south and west of the City of Santa Clarita boundary. It is bound by the Antelope Valley Freeway (SR 14) to the north, residential properties of La Veda Drive to the east, railroad tracks and Fair Oaks Ranch to the south, and the Colony Townhomes to the west. Vista Canyon is a mixed use development with residential, retail, office, hotel, recreational and open space areas.

The Vista Canyon project is located in the East Soledad Canyon Drain of the Santa Clarita Valley drainage basins. All of the flows from this drainage basin flow to the County Sanitation Districts of Los Angeles County (LACSD) existing 18-inch trunk sewer line in Soledad Canyon Road. There are two sewer pipes which discharge to the upstream start of the LACSD 18-inch trunk sewer at manhole SDM211, namely (1) a 15-inch pipe owned by the City of Santa Clarita (the City) which serves residential development on the north side of Soledad Canyon Road and the Santa Clara River and (2) a 24-inch pipeline owned by the Newhall County Water District (NCWD) which serves the remainder of the East Soledad Canyon Drain. See Figure 1-1 for the existing sewer systems and proposed sewer bypass line and siphon.

The 24-inch NCWD pipeline, located in the Santa Clara River, carries flow from the 18-inch NCWD pipeline and the 18-inch City pipeline. The agencies have expressed an interest in removing these facilities from the river. In doing so, flows carried by the 18-inch NCWD pipeline would be routed to the north side of the river. Flows through the18-inch City pipeline (between existing manholes 134 and 135) would be routed through the Vista Canyon project and cross the river via a siphon. This report addresses the pre-design components of this siphon.

VISTA CANYON
SEWER SIPHON EXHIBIT
FIGURE 1-1



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I:/CAD/0560/SEWER/SEWER AREA STUDIES/0560-SEWER-FIGURE-1-1.dwg 6/19/09

CHAPTER 2

DESIGN FLOWS

The proposed siphon will carry a significant portion of the wastewater flows generated within the East Soledad Canyon Drain. Construction of the siphon would begin in approximately three to five years and so must be designed to handle existing flows as well as the ultimate buildout flows of its drainage basin. The County of Los Angeles Department of Public Works (LADPW) approved on March 3, 2009 the *Sewer Area Study for the Soledad Commons Commercial Center LACounty:PC12084AS, Tract 45933*. This study evaluated the portion of the East Soledad Canyon Drain flows to be carried by the siphon. The study estimated existing and buildout flows using City flow coefficients for areas within the City and LADPW flow coefficients for areas within Los Angeles County. Appendix A contains key excerpts from this study.

To compare how different agencies would estimate the flow through the siphon, both existing and ultimate flows were estimated based on (1) using only City factors, (2) using only LADPW factors, and (3) using only LACSD's' factors. Table 2-1 first shows the land use designations and residential densities as approved in the Soledad Commons Sewer Study. It then presents the equivalent land use type and associated peak acreage-based generation factor, utilized for each agency. Tables 2-2 and 2-3 then provide the existing and ultimate peak flows to be carried by the siphon.

TABLE 2-1 PEAK COEFFICIENT COMPARISON									
Approved Soledad Commons Study				**City**		**DPW**		**LACSD**	
Land Use	**Peak Coefficient**	**Planning**	**Residential Density, DU/acre**	**Land Use**	**Peak Coef.**	**Land Use**	**Peak Coef.**	**Land Use**	**Peak Coef.**
A-1	0.001	City	-	A	0.0002	A	0.0010	HM	0.001
A-1-1	0.001	Reg. Plan	-	A	0.0002	A-1-1	0.0010	HM	0.001
A-1-10000	0.004	Reg. Plan	4	A	0.0002	A-1-10000	0.0040	RVL	0.001
A-1-2	0.0005	City	-	A	0.0002	A-1-2	0.0010	HM	0.001
A-2-1	0.0005	Reg. Plan	-	A	0.0002	A-2-1	0.0005	HM	0.001
A-2-1	0.001	Reg. Plan	-	A	0.0002	A-2-1	0.0010	HM	0.001
A-2-1	0.0008	Reg. Plan	-	A	0.0002	A-2-1	0.0008	HM	0.001
CC	0.015	Reg. Plan	-	CC	0.0150	CC	0.0150	CC	0.009
CC	0.015	City	-	CC	0.0150	C	0.0150	CC	0.009
OS	0.0002	City	-	OS	0.0002	A	0.0010	HM	0.001
R-1-10000	0.004	Reg. Plan	4	RS	0.0050	R-1-10000	0.0040	RS	0.004
R-1-11000	0.004	Reg. Plan	4	RS	0.0050	R-1-11000	0.0040	RS	0.004
R-1-7000	0.006	Reg. Plan	6	RS	0.0050	R-1-7000	0.0060	RS	0.004
R-1-9000	0.005	Reg. Plan	5	RS	0.0050	R-1-9000	0.0050	RS	0.004
RE	0.00075	City	<1	RE	0.00075	R-1-11000	0.0040	RE	0.001
RL	0.0015	City	2.2	RL	0.0015	R-1-11000	0.0040	RL	0.004
RM	0.012	City	11	RM	0.0120	Calc 0.001 cfs/ac	0.0110	RM	0.006
RS	0.005	City	5	RS	0.0050	R-1-9000	0.0050	RS	0.004
RVL	0.001	City	1	RVL	0.0010	R-1-11000	0.0040	RVL	0.001
SP *		Reg. Plan		-	-	-	-	-	-
W	0	Reg. Plan	-	-	0.0000	-	0.0000	-	0.0000

* Flow for specific plan (SP) area carried through all calculations

TABLE 2-2
EXISTING FLOW COMPARISON

Area	Acre	Zoning	Approved Soledad Commons Study Coefficients	Approved Soledad Commons Study Flow, cfs	Approved Soledad Commons Study Cumulative Flow, cfs	City			DPW			LACSD		
						Land Use	Peak Coef.	Peak Flow, cfs	Land Use	Peak Coef.	Peak Flow, cfs	Land Use	Peak Coef.	Peak Flow, cfs
5	9	CC	0.015	0.135	0.135	CC	0.0150	0.1350	CC	0.0150	0.1350	CC	0.009	0.0810
4A	71.1	RS	0.005	0.3555	1.329	RS	0.0050	0.3555	R-1-9000	0.0050	0.3555	RS	0.004	0.2844
4B	167.7	RS	0.005	0.8385		RS	0.0050	0.8385	R-1-9000	0.0050	0.8385	RS	0.004	0.6708
4C	386.6	RS	0.005	1.933	3.293	RS	0.0050	1.9330	R-1-9000	0.0050	1.9330	RS	0.004	1.5464
7	20.8	RL	0.0015	0.0312		RL	0.0015	0.0312	R-1-11000	0.0040	0.0832	RL	0.004	0.0832
4D *	14	RS	0.005	0.07	4.98	RS	0.0050	0.0700	R-1-9000	0.0050	0.0700	RS	0.004	0.0560
12	96.5	RL	0.0015	0.14475	5.12	RL	0.0015	0.1448	R-1-11000	0.0040	0.3860	RL	0.004	0.3860
** Note capacity of pump station is 4.98 cfs*														
14B	11.1	School		0.03	5.856			0.030			0.030			0.030
14A	140.3	RS	0.005	0.7015		RS	0.0050	0.7015	R-1-9000	0.0050	0.7015	RS	0.004	0.5612
13	165.3	RE	0.00075	0.123975	6.775	RE	0.00075	0.1240	R-1-11000	0.0040	0.6612	RE	0.001	0.1653
14C	116.3	RS	0.005	0.5815		RS	0.0050	0.5815	R-1-9000	0.0050	0.5815	RS	0.004	0.4652
16	54.4	RVL	0.001	0.0544		RVL	0.0010	0.0544	R-1-11000	0.0040	0.2176	RVL	0.001	0.0544
18	13.2	RM	0.012	0.1584		RM	0.0120	0.1584	Calc 0.001 cfs/ac	0.0110	0.1452	RM	0.006	0.0792
30B	3	RL	0.0015	0.0045	8.180	RL	0.0015	0.0045	R-1-11000	0.0040	0.0120	RL	0.004	0.0120
22	514.3	RE	0.00075	0.385725		RE	0.00075	0.3857	R-1-11000	0.0040	2.0572	RE	0.001	0.5143
23	294.5	RVL	0.001	0.2945		RVL	0.0010	0.2945	R-1-11000	0.0040	1.1780	RVL	0.001	0.2945
25	253.9	RVL	0.001	0.2539		RVL	0.0010	0.2539	R-1-11000	0.0040	1.0156	RVL	0.001	0.2539
26	240.5	A-1	0.001	0.2405		A	0.0002	0.0481	A	0.0010	0.2405	HM	0.001	0.2405
28	173.8	RVL	0.001	0.1738		RVL	0.0010	0.1738	R-1-11000	0.0040	0.6952	RVL	0.001	0.1738
29	23.2	OS	0.0002	0.00464		OS	0.0002	0.0046	A	0.0010	0.0232	HM	0.001	0.0232
30A	32	RL	0.0015	0.048		RL	0.0015	0.0480	R-1-11000	0.0040	0.1280	RL	0.004	0.1280
31	3.1	RL	0.0015	0.00465	8.237	RL	0.0015	0.0047	R-1-11000	0.0040	0.0124	RL	0.004	0.0124
32	15.9	School		0.03				0.030			0.030			0.030
33	4.5	RS	0.0050	0.0225		RS	0.0050	0.0225	R-1-9000	0.0050	0.0225	RS	0.004	0.0180
Total Peak, cfs					**8.237**			**6.428**			**11.553**			**6.164**

TABLE 2-3
ULTIMATE FLOW COMPARISON

Area	Acre	Zoning	Approved Soledad Commons Study Coefficients	Approved Soledad Commons Study Flow, cfs	City or Regional Planning	Residential Density, DU/acre	City			DPW			LACSD		
							Land Use	Peak Coef.	Peak Flow, cfs	Land Use	Peak Coef.	Peak Flow, cfs	Land Use	Peak Coef.	Peak Flow, cfs
5	9.0	CC	0.0150	0.135	Reg. Plan	-	CC	0.0150	0.135	CC	0.0150	0.135	CC	0.009	0.081
1	334.4	SP		2.429	Reg. Plan		-	-	2.429	-	-	2.429	-	-	2.429
2	2969.4	A-2-1	0.0005	1.485	Reg. Plan	-	A	0.0002	0.594	A-2-1	0.0005	1.485	HM	0.001	2.9694
3A	15.0	R-1-9000	0.0050	0.075	Reg. Plan	5	RS	0.0050	0.075	R-1-9000	0.0050	0.075	RS	0.004	0.060
3B	26.0	R-1-7000	0.0060	0.156	Reg. Plan	6	RS	0.0050	0.130	R-1-7000	0.0060	0.156	RS	0.004	0.104
3C	21.0	R-1-10000	0.0040	0.084	Reg. Plan	4	RS	0.0050	0.105	R-1-10000	0.0040	0.084	RS	0.004	0.084
3D	50.0	R-1-11000	0.0040	0.200	Reg. Plan	4	RS	0.0050	0.250	R-1-11000	0.0040	0.200	RS	0.004	0.200
3E	2.1	R-1-9000	0.0050	0.011	Reg. Plan	5	RS	0.0050	0.011	R-1-9000	0.0050	0.011	RS	0.004	0.008
4	968.0	RS	0.0050	4.840	City	5	RS	0.0050	4.840	R-1-9000	0.0050	4.840	RS	0.004	3.872
6A	4.7	R-1-7000	0.0060	0.028	Reg. Plan	6	RS	0.0050	0.024	R-1-7000	0.0060	0.028	RS	0.004	0.019
6B	15.2	R-1-10000	0.0040	0.061	Reg. Plan	4	RS	0.0050	0.076	R-1-10000	0.0040	0.061	RS	0.004	0.061
6C	9.3	R-1-11000	0.0040	0.037	Reg. Plan	4	RS	0.0050	0.047	R-1-11000	0.0040	0.037	RS	0.004	0.037
7	19.8	RL	0.0015	0.030	City	2.2	RL	0.0015	0.030	R-1-11000	0.0040	0.079	RL	0.004	0.0792
8A	14.8	R-1-9000	0.0050	0.074	Reg. Plan	5	RS	0.0050	0.074	R-1-9000	0.0050	0.074	RS	0.004	0.059
8B	4.6	R-1-10000	0.0040	0.018	Reg. Plan	4	RS	0.0050	0.023	R-1-10000	0.0040	0.018	RS	0.004	0.018
8C	0.8	R-1-9000	0.0050	0.004	Reg. Plan	5	RS	0.0050	0.004	R-1-9000	0.0050	0.004	RS	0.004	0.003
9	8.2	CC	0.0150	0.123	City	-	CC	0.0150	0.123	C	0.0150	0.123	CC	0.009	0.074
10A	62.4	A-2-1	0.0010	0.062	Reg. Plan	-	A	0.0002	0.012	A-2-1	0.0010	0.062	HM	0.001	0.062
11A	4.5	R-1-10000	0.0040	0.018	Reg. Plan	4	RS	0.0050	0.023	R-1-10000	0.0040	0.018	RS	0.004	0.018
11B	25.6	R-1-11000	0.0040	0.102	Reg. Plan	4	RS	0.0050	0.128	R-1-11000	0.0040	0.102	RS	0.004	0.102
12	268.0	RL	0.0015	0.402	City	2.2	RL	0.0015	0.402	R-1-11000	0.0040	1.072	RL	0.004	1.072
10B	11.0	A-2-1	0.0008	0.009	Reg. Plan	-	A	0.0002	0.002	A-2-1	0.0008	0.009	HM	0.001	0.011
10C	39.9	A-1-10000	0.0040	0.160	Reg. Plan	4	A	0.0002	0.008	A-1-10000	0.0040	0.160	RVL	0.001	0.040
13	214.8	RE	0.00075	0.161	City	<1	RE	0.00075	0.161	R-1-11000	0.0040	0.859	RE	0.001	0.215
14	362.0	RS	0.0050	1.810	City	5.0	RS	0.0050	1.810	R-1-9000	0.0050	1.810	RS	0.004	1.448
15	26.6	A-1	0.0010	0.027	City	-	A	0.0002	0.005	A	0.0010	0.027	HM	0.001	0.027
16	60.4	RVL	0.0010	0.060	City	1.0	RVL	0.0010	0.060	R-1-11000	0.0040	0.242	RVL	0.001	0.060
17	16.1	RS	0.0050	0.081	City	5.0	RS	0.0050	0.081	R-1-9000	0.0050	0.081	RS	0.004	0.064
18	20.6	RM	0.0120	0.247	City	11.0	RM	0.0120	0.247	Calc 0.001 cfs/ac	0.0110	0.227	RM	0.01	0.124
19	52.7	CC	0.0150	0.791	City	-	CC	0.0150	0.791	C	0.0150	0.791	CC	0.009	0.474
20	2787.0	W	0.0000	0.000	Reg. Plan	-	-	0.0000	0.000	-	0.0000	0.000	-	0.0000	0.000
21	94.2	RVL	0.0010	0.094	City	1.0	RVL	0.0010	0.094	R-1-11000	0.0040	0.377	RVL	0.001	0.094
22	791.0	RE	0.00075	0.593	City	<1	RE	0.00075	0.593	R-1-11000	0.0040	3.164	RE	0.001	0.791
23	203.0	RVL	0.0010	0.203	City	1.0	RVL	0.0010	0.203	R-1-11000	0.0040	0.812	RVL	0.001	0.203
24	117.1	A-1-1	0.0010	0.117	Reg. Plan	-	A	0.0002	0.023	A-1-1	0.0010	0.117	HM	0.001	0.117
25	283.0	RVL	0.0010	0.283	City	1.0	RVL	0.0010	0.283	R-1-11000	0.0040	1.132	RVL	0.001	0.283
26	593.0	A-1-2	0.0005	0.297	City	-	A	0.0002	0.119	A	0.0010	0.593	HM	0.001	0.593
27	14.8	RL	0.0015	0.022	City	2.2	RL	0.0015	0.022	R-1-11000	0.0040	0.059	RL	0.004	0.059
28	233.0	RVL	0.0010	0.233	City	1.0	RVL	0.0010	0.233	R-1-11000	0.0040	0.932	RVL	0.001	0.233
29	23.2	OS	0.0002	0.005	City	-	OS	0.0002	0.005	A	0.0010	0.023	HM	0.00	0.023
30	67.3	RL	0.0015	0.101	City	2.2	RL	0.0015	0.101	R-1-11000	0.0040	0.269	RL	0.004	0.269
Pump				0.330		-	-	-	0.330	-	-	0.330	-	-	0.330
31	3.1	RL	0.0015	0.005	City	2.2	RL	0.0015	0.005	R-1-11000	0.0040	0.012	RL	0.004	0.012
32	15.9	RL	0.0015	0.024	City	2.2	RL	0.0015	0.024	R-1-11000	0.0040	0.064	RL	0.004	0.064
33	4.5	RS	0.0050	0.023		5	RS	0.0050	0.023	R-1-9000	0.0050	0.023	RS	0.004	0.018
Total Peak, cfs				**16.048**					**14.756**			**23.204**			**16.966**

FLOW SUMMARY

To determine average daily flows, LACSD's peaking equation was applied to the peak flows. The peaking equation used, where Q is in millions gallons per day (mgd), is shown below.

$$0.3412 * Q_{peak}^{1.1038} = Q_{average}$$

The peaking factor to determine minimum flows, 0.35, was determined on a review of off-site flow data in the vicinity of the project. Table 2-4 summarizes the existing and ultimate flows based on the generation coefficients and the resulting average and minimum flows as a result of applying the peaking factors. These flows are then used in the following chapter to conduct the siphon sizing analysis.

TABLE 2-4
EXISTING AND ULTIMATE FLOW SUMMARY

Flow	Peak Factor	Approved Study	City	LADPW	LACSD
Existing Flows, cfs					
Average	Qpeak*0.40	3.3	2.5	4.9	2.4
Minimum	Qavg*0.26	0.9	0.7	1.2	0.6
Peak	-	8.2	6.4	11.6	6.2
Ultimate Flows, cfs					
Average	Qpeak*0.44	7.0	6.4	10.5	7.4
Minimum	Qavg*0.26	1.8	1.6	2.7	1.9
Peak	-	16.0	14.8	23.2	17.0

Shaded flows determined based on peaking factors
Unshaded flows calculated using generation factors

EXISTING FLOW DATA

From June 11 to June 25, 2009, a flow test was conducted at existing City manhole MH#136 to evaluate the existing average and peak flows which will be carried by the siphon. To determine the ultimate flows, the measured average flow was increased by 3.6 cfs and the measured peak flow was increased by 7.8 cfs. These increases correspond with the difference between existing and ultimate flows calculated in the Soledad Commons Sewer Study to account for future growth in the basin. Table 2-5 summarizes the flows utilized in the siphon sizing analysis. The results of the flow study and notes regarding the use of this data can be found in Appendix B.

TABLE 2-5 MEASURED EXISTING FLOW AND PROJECTED ULTIMATE FLOW (in cfs)			
Scenario	**Existing Flow**	**Increase to Ultimate**	**Projected Ultimate Flow**
Average	2.2	3.6	5.8
Peak	3.9	7.8	11.7

In comparing the ultimate flows from existing data in Table 2-5 to those estimated in Table 2-4, it is clear that the ultimate flows developed from the existing data are less. This could partially be due to water conservation efforts which are not captured within present generation factors.

CHAPTER 3

SIPHON SIZING ANALYSIS

The proposed siphon must be designed to accommodate existing flows as well as the projected ultimate flows for the basin. In sizing the siphon, the velocity through the siphon should achieve 2 feet per second at least once per day under the existing flow scenario. Additionally, the velocity should be at a maximum of approximately 7 feet per second in the ultimate scenario. This chapter presents the analysis used to size the siphon.

The following Tables 3-1 and 3-2 provide an analysis of flow velocity and headloss at Hazen-Williams “C” values of 140 and 160, respectively, for a 20-inch and 24-inch HDPE DR9 pipe. The tables compare these conditions for all of the design flows presented in Chapter 2.

If headloss through the siphon is less than the available head, then no surcharging occurs in the upstream junction structure/manhole. If the headloss through the siphon is greater than the available head on the siphon, the depth of surcharge into the upstream junction structure/manhole equals the available head to surcharge minus the headloss minus the available head on the siphon. Table 3-3 summarizes this calculation and Table 3-4 presents the surcharging for each flow scenario.

In reviewing all these elements, with focus on the measured (flow data) existing and ultimate flows, a 20-inch siphon (16.512-inch ID) best accommodates all scenarios. This ID is for a nominal 20-inch pipe with a 21.6-inch OD (outside diameter) at a dimension ratio (DR) of nine (9). The selection of this DR is discussed further in Chapter 5.

Velocities for a 20-inch siphon would be just below 8 fps under the flow data ultimate condition, but would insure that the siphon sees a minimum cleansing velocity of 2 fps under the existing scenario. The headloss and surcharging of the upstream junction structure calculations confirm this choice.

TABLE 3-1
VELOCITY AND HEADLOSS FOR EXISTING AND ULTIMATE SIPHON FLOWS, C = 140

EXISTING FLOWS

Flow Velocity, ft/s *ID (in) = 16.512*
DR-9, OD (in) = 20

Flow	Approved Study	City	LADPW	LACSD	Flow Data
Average	2.2	1.7	3.3	1.6	1.5
Minimum	0.6	0.4	0.8	0.4	0.4
Peak	5.5	4.3	7.8	4.1	2.6
Headloss Calculations, ft					
	L (feet) = 980		C = 140		
Average	0.5	0.3	0.9	0.3	0.2
Minimum	0.0	0.0	0.1	0.0	0.0
Peak	2.5	1.6	4.7	1.5	0.6

Flow Velocity, ft/s *ID (in) = 19.722*
DR-9, OD (in) = 24

Flow	Approved Study	City	LADPW	LACSD	Flow Data
Average	1.6	1.2	2.3	1.1	1.0
Minimum	0.4	0.3	0.6	0.3	0.3
Peak	3.9	3.0	5.4	2.9	1.8
Headloss Calculations, ft					
	L (feet) = 980		C = 140		
Average	0.1	0.1	0.2	0.1	0.0
Minimum	0.0	0.0	0.0	0.0	0.0
Peak	0.5	0.3	1.0	0.3	0.1

ULTIMATE FLOWS

Flow Velocity, ft/s *ID (in) = 16.512*
DR-9, OD (in) = 20

Flow	Approved Study	City	LADPW	LACSD	Flow Data
Average	4.7	4.3	7.1	5.0	3.9
Minimum	1.2	1.1	1.8	1.3	1.0
Peak	10.8	9.9	15.6	11.4	7.9
Headloss Calculations, ft					
	L (feet) = 980		C = 140		
Average	1.8	1.6	3.9	2.1	1.3
Minimum	0.1	0.1	0.3	0.2	0.1
Peak	8.6	7.4	17.1	9.6	4.8

Flow Velocity, ft/s *ID (in) = 19.722*
DR-9, OD (in) = 24

Flow	Approved Study	City	LADPW	LACSD	Flow Data
Average	3.3	3.0	4.9	3.5	2.7
Minimum	0.8	0.8	1.3	0.9	0.7
Peak	7.6	7.0	10.9	8.0	5.5
Headloss Calculations, ft					
	L (feet) = 980		C = 140		
Average	0.4	0.3	0.9	0.5	0.3
Minimum	0.0	0.0	0.1	0.0	0.0
Peak	1.9	1.6	3.7	2.1	1.0

TABLE 3-2
VELOCITY AND HEADLOSS FOR EXISTING AND ULTIMATE SIPHON FLOWS, C = 160

EXISTING FLOWS (DIPS)

Flow Velocity, ft/s — ***ID (in) = 16.512, DR-9, OD (in) = 20***

Flow	Approved Study	City	LADPW	LACSD	Flow Data
Average	2.2	1.7	3.3	1.6	1.5
Minimum	0.6	0.4	0.8	0.4	0.4
Peak	5.5	4.3	7.8	4.1	2.6
Headloss Calculations, ft					
	L (feet) =	980	C =	160	
Average	0.4	0.2	0.7	0.2	0.2
Minimum	0.0	0.0	0.1	0.0	0.0
Peak	2.0	1.2	3.7	1.1	0.5

Flow Velocity, ft/s — ***ID (in) = 19.722, DR-9, OD (in) = 24***

Flow	Approved Study	City	LADPW	LACSD	Flow Data
Average	1.6	1.2	2.3	1.1	1.0
Minimum	0.4	0.3	0.6	0.3	0.3
Peak	3.9	3.0	5.4	2.9	1.8
Headloss Calculations, ft					
	L (feet) =	980	C =	160	
Average	0.1	0.0	0.2	0.0	0.0
Minimum	0.0	0.0	0.0	0.0	0.0
Peak	0.4	0.3	0.8	0.2	0.1

ULTIMATE FLOWS

Flow Velocity, ft/s — ***ID (in) = 16.512, DR-9, OD (in) = 20***

Flow	Approved Study	City	LADPW	LACSD	Flow Data
Average	4.7	4.3	7.1	5.0	3.9
Minimum	1.2	1.1	1.8	1.3	1.0
Peak	10.8	9.9	15.6	11.4	7.9
Headloss Calculations, ft					
	L (feet) =	980	C =	160	
Average	1.4	1.2	3.1	1.6	1.0
Minimum	0.1	0.1	0.2	0.1	0.1
Peak	6.7	5.8	13.3	7.5	3.8

Flow Velocity, ft/s — ***ID (in) = 19.722, DR-9, OD (in) = 24***

Flow	Approved Study	City	LADPW	LACSD	Flow Data
Average	3.3	3.0	4.9	3.5	2.7
Minimum	0.8	0.8	1.3	0.9	0.7
Peak	7.6	7.0	10.9	8.0	5.5
Headloss Calculations, ft					
	L (feet) =	980	C =	160	
Average	0.3	0.3	0.7	0.4	0.2
Minimum	0.0	0.0	0.1	0.0	0.0
Peak	1.5	1.3	2.9	1.6	0.8

TABLE 3-3 SURCHARGE CALCULATION ELEVATIONS, in feet	
Downstream Siphon Discharge, IE	1482.25
Downstream Siphon Discharge, TOP	1484.25
Upstream Siphon Start, IE	1489.40
Upstream Siphon Start, TOP	1491.40
Upstream Manhole Start, top of manhole	1500.93
Available head on siphon = Start - Discharge	7.15
Available head to surcharge = Top of manhole - Discharge, TOP	16.68

TABLE 3-4 UPSTREAM JUNCTION STRUCTURE SURCHARGING ANALYSIS						
Upstream Junction Structure Surcharging, C = 140						
Pipe Size, OD	**Headloss & Surcharge**	**Approved Study**	**City**	**LADPW**	**LACSD**	**Flow Data**
Existing Peak Flow, cfs		***8.2***	***6.4***	***11.6***	***6.2***	***3.9***
20	Headloss, ft	2.5	1.6	4.7	1.5	0.6
	Feet of Surcharge	0.0	0.0	0.0	0.0	0.0
24	Headloss, ft	0.5	0.3	1.0	0.3	0.1
	Feet of Surcharge	0.0	0.0	0.0	0.0	0.0
Ultimate Peak Flow, cfs		***16.0***	***14.8***	***23.2***	***17.0***	***11.7***
20	Headloss, ft	8.6	7.4	17.1	9.6	4.8
	Feet of Surcharge	1.5	0.2	Too high	2.4	0.0
24	Headloss, ft	1.9	1.6	3.7	2.1	1.0
	Feet of Surcharge	0.0	0.0	0.0	0.0	0.0
Upstream Junction Structure Surcharging, C = 160						
Pipe Size, OD	**Headloss & Surcharge**	**Approved Study**	**City**	**LADPW**	**LACSD**	**Flow Data**
Existing Peak Flow, cfs		***8.2***	***6.4***	***11.6***	***6.2***	***3.9***
20	Headloss, ft	2.0	1.2	3.7	1.1	0.5
	Feet of Surcharge	0.0	0.0	0.0	0.0	0.0
24	Headloss, ft	0.4	0.3	0.8	0.2	0.1
	Feet of Surcharge	0.0	0.0	0.0	0.0	0.0
Ultimate Peak Flow, cfs		***16.0***	***14.8***	***23.2***	***17.0***	***11.7***
20	Headloss, ft	6.7	5.8	13.3	7.5	3.8
	Feet of Surcharge	0.0	0.0	6.2	0.3	0.0
24	Headloss, ft	1.5	1.3	2.9	1.6	0.8
	Feet of Surcharge	0.0	0.0	0.0	0.0	0.0

CHAPTER 4

SIPHON CONSTRUCTION

This chapter presents discussion of the recommended construction techniques, phasing, and materials. This chapter also presents calculations regarding the material selection. At the end of this chapter is a preliminary plan and profile of the sewer siphon.

CONSTRUCTION TECHNIQUES

Horizontal directional drilling (HDD) is the proposed method of construction for the sewer siphon to cross under the Santa Clara River. In comparison to other trenchless installation techniques, jack and bore would be used for shorter installations. In comparison to micro tunneling, HDD is a more cost effective installation method.

The minimum depth of the sewer siphon is governed by the scour depth of the river and the soil cement bank stabilization that will be installed on the north and south sides of the river. The design and installation of the soil cement for bank stabilization is governed by the scour depth. The sewer siphon will be installed a minimum of five (5) feet below the soil cement bank stabilization and thus below the scour depth of the river.

HDD is a trenchless method of construction that uses specialized drilling equipment. A bore hole will be drilled from the north side of the river, at the "entry pit", to the south side of the river, at the "exit pit." Drilling mud is used for lubrication of the bore hole, stabilizing the bore and transporting the cuttings to the surface for extraction. The siphon will have a "belly" to it, as shown in the profile. This will help to keep the drilling mud in the bore hole for ease of installation and maintaining the bore hole prior to placement of the sewer pipe. The second pass will go from the exit pit to the entry pit with a reamer head which expands the bore hole. The pipe to be installed follows the reamer head and is pulled through. The reamer head typically opens the bore hole an additional 6-inches or so to keep the space full of water, thus reducing the drag on the pipe.

The exit pit was chosen for the south side of the river as it will provide more space for construction staging and fusing pipe material prior to installation.

CONSTRUCTION PHASING

The sewer siphon is proposed to be installed prior to the soil cement being placed for bank stabilization, but after excavation has been completed for the soil cement. The entry and exit pits are shown on the plan and profile and will be located at a minimum of five feet below the soil cement. The HDD will enter the ground at a small gradual slope at the bottom of the soil cement excavation and create a slight belly at the bottom along its approximate 800 foot length. The up leg and down leg portions of the siphon behind the soil cement will be installed using standard open trench construction methods.

CONSTRUCTION MATERIALS

Common pipe materials used in HDD are steel and high density polyethylene pipe (HDPE). For deep installations, buckling of the pipe is of greatest concern, where steel would be preferred. In shallow installations, the bending radius is usually the limiting factor. The proposed installation of the siphon is relatively shallow, approximately 32 feet to top of pipe at its deepest point. Additionally, starting the HDD at the base of the soil cement excavation will limit the bend radius that the pipe is subjected to when installing the product.

The appropriate wall thickness for the pipe is determined based on the long term allowable ring deflection, or ovalization, of the pipe. This is first accomplished by determining the anticipated earth pressure on the pipe and considering the long term elasticity of the pipe, confirming that the pipe does not deflect more than allowable. Based on the calculations, provided in Appendix C, a dimension ratio of nine (DR-9) is recommended.

The most conservative characteristics were utilized to confirm this DR. In proceeding to final design, further soil investigations should be done for more definitive characteristics of earth load on the pipe. Additionally, more detailed calculations should be completed to account for internal and external pressures on the pipe and their impact on deflection and DR rating of the pipe.

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APPENDIX A

EXCERPTS FROM THE *SEWER AREA STUDY FOR THE SOLEDAD COMMONS COMMERCIAL CENTER,* APPROVED BY LADPW MARCH 3, 2009 AND THE CITY OF SANTA CLARITA

CRC Enterprises
Civil Engineering • Surveying
Construction Management • Planning

CRC 1915

SEWER AREA STUDY

JANUARY 21, 2009

Conditional Approval Only

SEWER AREA STUDY
~~APPROVED~~

APPROVED BY: AM RCE NO. 54340 DATE 3/3/09

CHECKED BY: [signature] DATE 3/3/09

COUNTY OF LOS ANGELES
DEPARTMENT OF PUBLIC WORKS
LAND DEVELOPMENT DIVISION

Project Site:

Soledad Commons Commercial Center
14630 Soledad Canyon Road
Santa Clarita, CA, 91387

LA County : PC 12084 AS
Tract 45933

Prepared For:

Soledad Commons, LLC
28212 Kelly Johnson Parkway, Suite 275
Santa Clarita, CA. 91355

27600 Bouquet Cyn. Rd, Ste. 200 • Santa Clarita, CA 91350 • Tel: (661) 297-2336 • Fax (661) 297-2331 • E-Mail: crc@socal.rr.com

INTRODUCTION

This Sewer Area Study has been prepared by CRC Enterprises for the Soledad Commons, LLC Commercial Development site located at 14630 Soledad Canyon Road, Canyon Country, CA. The site lies within the jurisdiction of the County of Los Angeles, just outside of the boundary of the City of Santa Clarita. This study is being prepared at the request of the County of Los Angeles, Department of Public Works and the City of Santa Clarita, Engineering Department to evaluate the capacity of the existing sewer system that will serve this proposed development located at the east end of the Santa Clarita Valley, just outside of the City's jurisdiction. The purpose of this study is to evaluate the capacity of the existing off-site downstream sewer sections from our development to the Los Angeles County Sanitation District maintained trunk sewer, and to determine if the existing sewer facilities can adequately serve the proposed development.

References used in the preparation of this study include: Los Angeles County Sewer Maintenance Division Maps, Los Angeles County Department of Public Works as-builts, Los Angeles County Sanitation District as-builts, Los Angeles County Department of Regional Planning land use zoning map, City of Santa Clarita zoning map, off-site Sewer Area Study for Spring Canyon (PC 11961 AS) currently in review by the City of Santa Clarita, and the Los Angeles County Department of Public Works standards.

This study evaluates the downstream off-site facilities and includes all tributary flows to the existing sewer system from the proposed and existing developments within the overall tributary area. This study will show and determine the potential impacts of our proposed development.

SITE and PROJECT DESCRIPTION

The Soledad Commons project is a development of restaurants or businesses that consist of six separate buildings being constructed upon a site that is approximately 9 acres in size. The building square footage and type of occupancy for each building has been proposed as follows:

Building A	4384 SF	Commercial Shop
Building B	2692 SF	Restaurant
Building C	16,366 SF	Office
Building D	6021 SF	Commercial Shop
	6100 SF	Restaurant
	10,358 SF	Office
Building E	9315 SF	Daycare
Building F	1816 SF	Restaurant
	3444 SF	Commercial Shop

Sewer discharge calculations based on square footage has been included in Appendix C.

This development lies at the east end of Santa Clarita bounded by the Antelope Valley Freeway to the south and east, by Soledad Canyon Road to the north and east and by a proposed future commercial development site on the west. The boundary of the City of Santa Clarita bounds this site along the westerly and northerly sides. The property information is APN 2854-044-041, TG 4462-G7, and CSMD Index No. N-1513. See Exhibit 1 for the project location and surrounding areas.

DESCRIPTION OF PROPOSED SEWER SYSTEM

The proposed on-site sewer system improvements for this commercial development will be to construct a total of four 6" sewer lines that will connect into the existing sanitary sewer system within Soledad Canyon Road, CSMD Index No. N-1513. The on-site sewer lines will provide service to the proposed buildings and make connections into the existing public sewer system as described below:

6" sewer line: providing service to Building F, with a connection downstream of MH #36.

6" sewer line: providing service to Building A, with a connection downstream of MH #35.

6" sewer line: providing service to Buildings B, C, and D, with a connection at MH #34.

6" sewer line: providing service to Building E, with a connection downstream of MH #33.

Sanitary Sewer Plans PC No. 12084 can be found in Appendix C. Exhibit 4 depicts the proposed on-site sewer for the project site and illustrates the proposed connections into the existing public sewer system as described above.

DESCRIPTION OF EXISTING SEWER SYSTEM

The existing downstream sewer system consists of approximately 19,300 linear feet of gravity sewer pipe ranging in size from 8 inches to 36 inches. Maps for the existing sewer lines can be found in Appendix E.

Analysis of the existing sewer system begins at the City of Santa Clarita manhole 36, located east of the Mammoth Land and Soledad Canyon Road intersection, and terminates at the LACSD trunk line at the intersection of Lost Canyon Road and Soledad Canyon Road. The sewer lines under consideration and review run within Soledad Canyon Road, Oak Spring Canyon Road, and Lost Canyon Road. Portions of the existing sewer line cross through the Santa Clara River.

The sewer lines that will convey sewerage from our Soledad Commons development to the LACSD trunk sewer are owned and maintained by either the Newhall County Water District, owned by the City of Santa Clarita and maintained by the Los Angeles County Department of Public Works or owned and maintained by the Los Angeles County Department of Public Works.

A change in sewer line jurisdiction occurs in four different locations. The City of Santa jurisdiction runs from the upper sewer manhole 36 to the Shadow Pines Lift Station, where Newhall County Water District takes over.

Newhall County Water District jurisdiction runs from the Shadow Pines Lift Station, continuing down Soledad Canyon Road as a forced main, to manhole NC 4, where the flow transitions to gravity flow, continuing down Soledad Canyon Road to manhole NC-23, where the City of Santa Clarita takes over.

The City of Santa Clarita jurisdiction runs from manhole NC-23, down Oak Spring Canyon Road, Lost Canyon Road, to La Veda Avenue, manhole 135, where Los Angeles County Department of Public Works takes over.

Los Angeles County Department of Public Works jurisdiction runs from manhole 135, continuing down Lost Canyon Road to manhole 132, where Newhall County Water District takes over.

Newhall County Water District jurisdiction runs from manhole 132, continuing down Lost Canyon Road to Los Angeles County Sanitation District trunk sewer manhole 211.

The existing Shadow Pines Sewerage Lift Station mentioned earlier herein, is an existing lift station that is owned, operated and maintained by Newhall County Water District. This lift station will receive the flows from our proposed commercial development. Flow from the lift station is pumped through a force main by two pumps, at a designed flow rate of 4.98 cfs. The Lift Station is designed to operate the pumps when sewer flow into the Lift Station reaches a designated height and/or pressure. See Appendix F, for the operation and maintenance information relating to this lift station.

SEWER CAPACITY ANALYSIS

The first step in performing the sewer capacity analysis was determining the tributary area that contributes to the downstream sewer that will be impacted by the proposed development. The Los Angeles Department of Public Works Sewer Maintenance Division (SMD) maps were used to identify the existing tributary areas, as shown on Exhibit 1. In addition, City of Santa Clarita parcel information was used to identify the existing tract boundaries and the City of Santa Clarita zoning map and the Los Angeles County Department of Regional Planning (LACDRP) zoning map and Santa Clarita Valley Area Plan were used to establish the land use zone boundaries. Once the tributary areas were delineated, an aerial image was converted to CADD format. Using the aerial image, the City parcel data, and the City and LACDRP zoning maps, the sub-area boundaries were delineated using CADD. The sub-area boundaries are defined by parcel boundaries per City of Santa Clarita parcel information as well as the City and LACDRP zone boundaries. Please refer to Exhibit 1 for the parcel and zone information. Please see

Appendix B for the City and LACDRP zoning maps and Santa Clarita Valley Area Plan used for this analysis.

Once the sub-areas were defined, the land use zone designations were incorporated into the CADD drawing. The land use zone designations were obtained from the City of Santa Clarita as well as the Los Angeles County Department of Regional Planning. The sewer area study accounted for tributary flow from both the City of Santa Clarita as well as the unincorporated areas of Los Angels County. The City of Santa Clarita zoning map was utilized to determine the land use zones within the City boundary and the LACDRP zoning maps were utilized for areas located in unincorporated Los Angeles County.

There are two existing schools within the tributary area. Data for these schools was obtained from the California Department of Education enrollment reports for the 2007-2008 school years. Please see Appendix B for this reference material. The total student count for each school was multiplied by the appropriate flow generation factor per County Standards.

Next, the flow generation calculations were performed. Flows generated by sub-areas within the City were calculated using the City's Flow Coefficients based on zoning descriptions. Flows generated by sub-areas within the County were calculated using the flow coefficients established by the Los Angeles County Department of Public Works. Please see Appendix B for the City of Santa Clarita and Los Angeles County Department of Regional Planning zoning descriptions, land use conversions and land use maps.

Flow generation calculations include all of the sub-areas, and include the existing Shadow Pines Sewage Lift Station. It should be noted that the flow entering the pump station was calculated to be 3.36 cfs. The flow leaving the existing Shadow Pines Lift Station will pump at a flow rate of 4.98 cfs, based on the operation and maintenance manual per Essco Pumps.

Once each sub-area flow generation was calculated, the flow was "routed" through the existing sewer lines in the tributary area and the existing downstream sewer pipes were analyzed per County Standard S-C4, as found in Appendix A. Pipe slope and diameter information obtained from as-builts from the Los Angeles Department of Public Works were used to determine the capacity of the existing sewer system. Please see Appendix E for copies of these as-builts as well as the Sewer Maintenance Division (SMD) maps for the tributary area. Appendix D contains the flow calculations for the existing downstream sewer from the project location to the LACSD trunk sewer line. Each table calculates the "capacity" of each segment of sewer from manhole to manhole based on the tributary flow area that contributes flow to that section of sewer.

PROPOSED MITIGATION

Based upon the determinations of this study a majority of the existing downstream sewer system has adequate capacity to accommodate the proposed Soledad Commons

Development. However, some of the existing sewer lines exceed the allowable capacities and have been listed as follows:

PIPES WITHIN CITY OF SANTA CLARITA JURISDICTION

Street Name	Segment MH	MH	Current Pipe Size	Ultimate Flow (cfs)	Mitigated Pipe Size	New Capacity Q/Qcap
Lost Canyon Road	260	259	18"	*Mitigation will not be part of this project; refer to the Conclusions Section.		
Lost Canyon Road	259	258	18"	13.72	36"	74%
Lost Canyon Road	258	142	18"	13.72	36"	74%
Lost Canyon Road	142	141	18"	16.00	36"	66%
Lost Canyon Road	141	140	18"	16.03	36"	67%
Lost Canyon Road	140	139	18"	16.03	36"	67%
Lost Canyon Road	139	138	18"	16.03	36"	67%

Mitigation is not required for pipes located within Los Angeles County or Newhall County Water District jurisdictions. Please refer to Table 1 for all existing and mitigated pipe information.

CONCLUSIONS

The Soledad Commons Sewer Area Study indicates seven sewer segments that exceed the allowable capacity. Through negotiations with the City, the Soledad Commons project will provide mitigation for six of the pipe segments as part of the project's fair share contribution. The mitigating pipe sizes are based upon the existing slope and length of each mitigated pipe remaining the same as currently existing.

With respect to pipe segments within the jurisdiction of Los Angeles County, these pipe segment will be part of a future annexation from the County to the City of Santa Clarita. The annexation will include segments 135-134, 134-133, and 133-132, and is anticipated to occur when conditions are approved for the proposed Vista Canyon Ranch development.

Flow tests may be required to determine actual flow conditions. The City and County will verify if the project is to allow flow testing before mitigation is determined. Flow test locations will be determined based upon this analysis and at the direction of the above mentioned agencies.

TABLE 1- PIPE C. ,CITY RESULTS

CRC 1915
14-Nov-08

	Existing + Project																	Ultimate Condition								
	Street Name	Segment M.H.	Segment M.H.	Pipe PC #	Pipe Size (in)	Pipe Slope (ft/ft)	Capacity Q 1/2 full (cfs)	Capacity Q 3/4 full (cfs)	Area #	Area (Acres)	Zone	Zone Coeffficient	Qcalc (cfs)	Qcumulative (cfs)	d (in)	% Full (d/.75*D)	% Full (Q/Qcap)	Area #	Area (Ac)	Zone Coeff	Qcalc (cfs)	Ult Flow (cfs)	New Pipe Size	New Capacity Q 1/2 (cfs)	New Capacity Q 3/4 full (cfs)	% Full (Q/Qcap)
CITY OF SANTA CLARITA	Soledad Cyn.	36	35	PC 11056	12	0.004	1.1		5	9.0	CC	0.015	0.14	0.135			12.3%	5	9.0	0.015	0.14	0.14				
	Soledad Cyn.	35	34	PC 11056	12	0.0288	2.8							0.135			4.8%									
	Soledad Cyn.	34	33	PC 11056	12	0.004	1.1							0.135			12.3%									
	Soledad Cyn.	33	32	PC 11056	12	0.0172	2.1		4A	71.1	RS	0.005	0.36	1.329			63.3%	1	Spring Cyn		2.429	9.42				
									4B	167.7	RS	0.005	0.84					2	2969	0.001	1.48					
																		3A	15	0.005	0.08					
																		3B	26	0.006	0.16					
																		3C	21	0.004	0.08					
																		3D	50	0.004	0.20					
																		3E	2.1	0.005	0.01					
																		4	968	0.005	4.84					
	Soledad Cyn.	32	31	PC 11056	12	0.0272	2.8							1.329			47.5%									
	Soledad Cyn.	31	SC-18	PC 11026	15	0.1216		15	4C	386.6	RS	0.005	1.93	3.293			22.0%	6A	4.7	0.006	0.03	9.79				
									7	20.8	RL	0.0015	0.03					6B	15.2	0.004	0.06					
																		6C	9.3	0.004	0.04					
																		7	19.8	0.0015	0.03					
																		8A	14.8	0.005	0.07					
																		8B	4.6	0.004	0.02					
																		8C	0.8	0.005	0.004					
																		9	8.2	0.015	0.12					
	Soledad Cyn.	SC-18	NC-1	PC 11026	18	0.004		5.3						3.293			62.1%									
	Soledad Cyn.	NC-1	NC-2	PC 11026	18	0.004		5.3						3.293			62.1%									
	Soledad Cyn.	NC-2	Station	PC 11026	18	0.01		8.5	4D	14.0	RS	0.005	0.07	3.363			39.6%									
NEWH	Soledad Cyn.	Station	NC-4	PC 11026	Force Main					Pump Capacity=4.98 cfs				4.98												
	Soledad Cyn.	NC-4	NC-5	PC 11026	15	0.0252		6.9						4.98			72.2%									
	Soledad Cyn.	NC-5	NC-6	PC 11026	15	0.0164		6.6						4.98			75.5%									
	Soledad Cyn.	NC-6	NC-7	PC 11026	15	0.0204		7.3	12	96.5	RL	0.0015	0.14	5.12			70.2%	10A	62	0.001	0.06	10.38				
																		11A	4.5	0.004	0.02					
																		11B	25.6	0.004	0.10					
																		12	268	0.0015	0.40					
	Soledad Cyn.	NC-7	NC-8	PC 11026	15	0.0324		9.3						5.12			55.1%									

* Sanitation District Manhole
** Connects directly to the Sanitation Sewer Trunk Line
***The capacity of the existing Lift Station, PC 88-9, has been included as part of the pipe upsizing calculations.

		Segment		Pipe			Capacity															Ult	New	New		
					Size	Slope	Q 1/2 full	Q 3/4 full	Area	Area	Zone	Zone	Qcalc	Qcumulative	d	% Full	% Full	Area	Area	Zone	Qcalc	Flow	Pipe	Q 1/2	Q 3/4 full	% Full
	Street Name	M.H.	M.H.	PC #	(in)	(ft/ft)	(cfs)	(cfs)	#	(Acres)		Coefficient	(cfs)	(cfs)	(in)	(d/.75*D)	(Q/Qcap)	#	(Ac)	Coeff	(cfs)	(cfs)	Size	(cfs)	(cfs)	(Q/Qcap)
NEWHALL WATER DISTRICT	Soledad Cyn.	NC-8	NC-9	PC 11026	15	0.0148		6.3						5.12			81.3%									
	Soledad Cyn.	NC-9	NC-10	PC 11026	15	0.0118		6.5						5.12			78.8%									
	Soledad Cyn.	NC-10	NC-11	PC 11026	15	0.0244		8.0						5.12			64.1%									
	Soledad Cyn.	NC-11	NC-12	PC 11026	15	0.044		10.8						5.12			47.5%									
	Soledad Cyn.	NC-12	NC-13	PC 11026	15	0.0792		14.5						5.12			35.3%									
	Soledad Cyn.	NC-13	NC-14	PC 11026	15	0.014		6.8	14B	11.1	SCHOOL		0.03	5.8543			86.7%	10B	11.0	0.0008	0.01	12.52				
									14A	140.3	RS	0.005	0.70					10C	39.9	0.004	0.16					
																		13	214.8	0.001	0.16					
																		14	362	0.005	1.81					
	Soledad Cyn.	NC-14	NC-15	PC 11026	15	0.014		6.8						5.8543			86.7%									
	Soledad Cyn.	NC-15	NC-16	PC 11026	15	0.03		8.9						5.8543			65.8%									
	Soledad Cyn.	NC-16	NC-17	PC 11026	18	0.016		10.7						5.8543			54.7%									
	Soledad Cyn.	NC-17	NC-18	PC 11026	18	0.018		11.3						5.8543			51.8%									
	Soledad Cyn.	NC-18	NC-19	PC 11026	18	0.012		9.3						5.8543			62.9%									
	Soledad Cyn.	NC-19	NC-20	PC 11026	18	0.012		9.3						5.8543			62.9%									
	Soledad Cyn.	NC-20	NC-21	PC 11026	18	0.0104		8.6						5.8543			68.1%									
	Soledad Cyn.	NC-21	NC-22	PC 11026	18	0.008		7.6						5.8543			77.0%									
	Soledad Cyn.	NC-22	NC-23	PC 11026	18	0.008		7.6						5.8543			77.0%									
CITY OF SANTA CLARITA	Soledad Cyn.	NC-23	381	PC 11026	18	0.004		6.0						5.8543			97.6%									
	Oak Spring	381	380	PC 00-23	18	0.0456		29.4	13	165.3	RE	0.00075	0.12	6.7725			23.0%	15	26.6	0.001	0.03	13.72				
									14C	116.3	RS	0.005	0.58					16	60.4	0.001	0.06					
									16	54.4	RVL	0.001	0.05					17	16.1	0.005	0.08					
									18	13.2	RM	0.012	0.16					18	20.6	0.012	0.25					
									19	22.0	Note **							19	52.7	0.015	0.79					
	Oak Spring	380	379	PC 00-23	24	0.0024		9.0						6.7725			75.3%									
	Oak Spring	379	267	PC 00-23	18	0.0064		8.0						6.7725			84.7%									
	Lost Cyn Rd.	267	266	PC 10484	18	0.0052		6.9						6.7725			98.2%									
	Lost Cyn Rd.	266	265	PC 10484	18	0.0052		6.9						6.7725			98.2%									
	Lost Cyn Rd.	265	264	PC 10484	18	0.0052		6.9						6.7725			98.2%									
	Lost Cyn Rd.	264	263	PC 10484	18	0.0052		6.9	30B	3.0	RL	0.0015	0.005	6.7770			98.2%									
	Lost Cyn Rd.	263	262	PC 10484	18	0.006		7.1						6.7770			95.5%									
	Lost Cyn Rd.	262	261	PC 10484	18	0.0116		9.1						6.7770			74.5%									
	Lost Cyn Rd.	261	260	PC 10484	18	0.0072		7.9						6.7770			85.8%									
	Lost Cyn Rd.	260	259	PC 10484	24	0.0012		6.3						6.7770			**107.6%**									
	Lost Cyn Rd.	259	258	PC 10484	24	0.0012		6.3						6.7770			**107.6%**					13.72	36		18.6	74%
	Lost Cyn Rd.	258	142	PC 10484	24	0.0012		6.3						6.7770			**107.6%**					13.72	36		18.6	74%

* Sanitation District Manhole

** Connects directly to the Sanitation Sewer Trunk Line

***The capacity of the existing Lift Station, PC 88-9, has been included as part of the pipe upsizing calculations.

		Segment			Pipe		Capacity															Ult	New	New (		
	Street Name	M.H.	M.H.	PC #	Size (in)	Slope (ft/ft)	Q 1/2 full (cfs)	Q 3/4 full (cfs)	Area #	Area (Acres)	Zone	Zone Coefficient	Qcalc (cfs)	Qcumulative (cfs)	d (in)	% Full (d/.75*D)	% Full (Q/Qcap)	Area #	Area (Ac)	Zone Coeff	Qcalc (cfs)	Flow (cfs)	Pipe Size	Q 1/2 (cfs)	Q 3/4 full (cfs)	% Full (Q/Qcap)
CITY OF SANTA CLARITA	Lost Cyn Rd.	142	141	PC 9768 R	18	0.002		3.8	21	39	Not Connected to System			8.18			215%	20	2787	0	0.00	16.00	36		24.10	66%
									22	514.3	RE	0.00075	0.39					21	94.2	0.001	0.09					
									23	294.5	RVL	0.001	0.29					22	791	0.0008	0.59					
									24	117.1	Not Connected to System							23	203	0.0010	0.20					
									25	253.9	RVL	0.001	0.25					24	117.1	0.001	0.12					
									26	240.5	A-1	0.001	0.24					25	283	0.001	0.28					
									28	173.8	RVL	0.001	0.17					26	593	0.0005	0.30					
									29	23.2	OS	0.0002	0.00					27	14.8	0.0015	0.02					
									30A	32.0	RL	0.0015	0.05					28	233	0.0010	0.23					
																		29	23.2	0.0002	0.00					
																		30	67.3	0.0015	0.10					
																		Pump	Note	***	0.33					
	Lost Cyn Rd.	141	140	PC 9768 R	18	0.002		3.8	31	3.1	RL	0.0015	0.005	8.21			216%	31	3.1	0.0015	0.00	16.03	36		24.10	67%
									32	15.9	SCHOOL		0.03	---			---	32	15.9	0.0015	0.02					
	Lost Cyn Rd.	140	139	PC 9768 R	18	0.002		3.8		---	---	---	---	8.21			216%					16.03	36		24.10	67%
	Lost Cyn Rd.	139	138	PC 9768 R	18	0.002		3.8		---	---	---	---	8.21			216%					16.03	36		24.10	67%
	Lost Cyn Rd.	138	137	PC 9768 R	15	0.02		8.3		---	---	---	---	8.21			98.9%									
	Lost Cyn Rd.	137	136	PC 9768 R	15	0.02		8.3		---	---	---	---	8.21			98.9%									
	Lost Cyn Rd.	136	135	PC 9768 R	15	0.02		8.3		---	---	---	---	8.21			98.9%									
LA County	Lost Cyn Rd.	135	134	PC 9768 R	15	0.02		8.3	33	4.6	RS	0.005	0.02	8.23	11.16	99%	99.2%									
	Lost Cyn Rd.	134	133	PC 9768 R	18	0.0176		11.2		---	---	---	---	8.23	10.0	74%	73.5%									
	Lost Cyn Rd.	133	132	PC 7532 R	18	0.008		8.5		---	---	---	---	8.23	13.1	97%	96.8%									
NEWHALL WATER DISTRICT	Lost Cyn Rd.	132	NC-24	PC 2-S	21	0.0081		11.6	35	16.3	BP	0.021	0.34	9.49	---	---	81.8%									
									36	8	Note **															
									37	25.5	CC	0.015	0.38													
									38	16.4	Note **			---	---	---	---									
									39	72.6	RS	0.005	0.36	---	---	---	---									
									40	11.2	CO	0.015	0.17	---	---	---	---									
	Lost Cyn Rd.	NC-24	NC-25	PC 2-S	21	0.0078		11.3		---	---	---	---	9.49	---	---	84.0%									
	Lost Cyn Rd.	NC-25	NC-26	PC 2-S	21	0.008		11.5		---	---	---	---	9.49	---	---	82.5%									
	Lost Cyn Rd.	NC-26	NC-27	PC 2-S	21	0.01		12.9		---	---	---	---	9.49	---	---	73.5%									
	Lost Cyn Rd.	NC-27	NC-28	PC 2-S	21	0.009		12.2		---	---	---	---	9.49	---	---	77.8%									
	Lost Cyn Rd.	NC-28	NC-29	PC 2-S	24	0.0042		11.9		---	---	---	---	9.49	---	---	79.7%									
	Lost Cyn Rd.	NC-29	NC-30	PC 2-S	24	0.0042		11.9		---	---	---	---	9.49	---	---	79.7%									
	Lost Cyn Rd.	NC-30	211*	PC 2-S	24	0.0043		12.1		---	---	---	---	9.49	---	---	78.4%									

* Sanitation District Manhole

** Connects directly to the Sanitation Sewer Trunk Line

***The capacity of the existing Lift Station, PC 88-9, has been included as part of the pipe upsizing calculations.

LOS ANGELES COUNTY
DEPARTMENT OF PUBLIC WORKS
LAND DEVELOPMENT DIVISION

AREA STUDY

An area study must be made for all private contract sewer projects. See attached sample. The area study must include the following items:

1. Area being served - In Acres
2. Determined Tributary area to main line being designed (incl. areas of future devel.)- In Acres
3. Existing and Land Use Zoning
4. Anticipated Sewer Discharge in cfs of total area based on zoning, and/or heavy water users
5. Existing or proposed utilities if in conflict
6. Existing and proposed sewers showing pipe size and grade leading up to the trunk line in order for you to evaluate the impact of your proposed development on the existing system
7. Direction of sewer flow
8. Contour lines
9. Scale not to be less than 1"=600'
10. North arrow pointing up or to the left

ZONING COEFFICIENTS

ZONE	COEFFICIENT (cfs/Acre)
Agriculture	0.001
Residential	
R-1	0.004
R-2	0.008
R-3	0.012
R-4	0.016 *
Commerical	
C-1 through C-4	0.015 *
Heavy Industrial	
M-1 through M-4	0.021 *

* Individual building, commercial or industrial plant capacities shall be the determining factor when they exceed the coefficients shown.

The coefficient to be used for any zoned areas not listed will be determined by the County based upon the intended development and use.

The County shall determine which of the coefficients or combination of coefficients shall be used for design as determined by the established or proposed zoning in the study area. Any modifications to these coefficients due to topography, development, or hazard areas, shall be approved by the Department of Public Works.

County Flow Coefficients

RE: Agriculture Flow Coefficient Question

From: **Ma, Allen** (AMA@dpw.lacounty.gov)
Sent: Thu 11/13/08 5:28 PM
To: Leslie Frazier (lesliefrazier@hotmail.com)

Sorry it took so long to get back with you. With a land use zone of A-2-1, a coefficient of 0.001cfs/acre will be ok. With a land use zone of A-1-2, a coefficient of 0.0005cfs/acre will be ok. If you prefer to be conservative and use 0.001cfs/acre for both land uses, it will also be ok.

Allen Ma, P.E.
Land Development Division
Department of Public Works
County of Los Angeles
(626) 458-4921

A-2-1 = 0.001 cfs/ac
A-1-2 = 0.0005 cfs/ac
A-1-10000 = 0.004 cfs/ac

$\frac{43560 \text{ SF}}{10000 \text{ SF}} \times 0.001 \text{ cfs/unit} = 0.004 \text{ cfs/ac}$

Please take a moment to let us know how we are doing by following this link:

http://dpw.lacounty.gov/go/lddsurvey

From: Leslie Frazier [mailto:lesliefrazier@hotmail.com]
Sent: Thursday, November 13, 2008 9:25 AM
To: Ma, Allen
Subject: Agriculture Flow Coefficient Question

Hi Allen!

I'm sorry to email again, but I looked at my zoning designation and then do have a suffix.

I have an A-2-1 and A-1-2. Should I use a flow coefficient of 0.001 cfs/ac for both zoning designations?
Thanks,
Leslie

Subject: RE: Flow Coefficient Question
Date: Thu, 13 Nov 2008 07:18:47 -0800
From: AMA@dpw.lacounty.gov
To: lesliefrazier@hotmail.com

Please use the following values:

R-1-7000:	(43560sqft/1acre)/ (7000sqft/unit) X 0.001cfs/unit = 0.006cfs/acre
R-1-9000:	(43560sqft/1acre)/ (9000sqft/unit) X 0.001cfs/unit = 0.005cfs/acre
R-1-10,000:	(43560sqft/1acre)/ (10000sqft/unit) X 0.001cfs/unit = 0.004cfs/acre
R-1-11,000:	(43560sqft/1acre)/ (11000sqft/unit) X 0.001cfs/unit = 0.004cfs/acre

I rounded some of the values up.

Regarding land use zones A-1 and A-2, if it does not contain a suffix, I agree with your designation of 0.001cfs/acre. However, if it does have a suffix, please follow the above guidelines in determining the appropriate value.

If you have any other questions, please let me know.

Allen Ma, P.E.
Land Development Division
Department of Public Works
County of Los Angeles
(626) 458-4921
Please take a moment to let us know how we are doing by following this link:
http://dpw.lacounty.gov/go/lddsurvey

From: Leslie Frazier [mailto:lesliefrazier@hotmail.com]
Sent: Thursday, November 13, 2008 1:10 AM
To: Ma, Allen
Subject: Flow Coefficient Question

Hi Allen!

One quick question for ya! As I was revising my zones, I wanted to make sure that I had interpreted correctly how to calculate the new zone coefficients. Here's what I was planning on using:

R-1-7000: flow coefficient=0.006
R-1-9000: flow coefficient=0.004
R-1-10,000: flow coefficient=0.004
R-1-11,000: flow coefficient=0.003

Like I mentioned in the meeting, it makes sense to me to round the number down, but I want to make sure my interpretation was correct.

Also, will Zones A-1 and A-2 have the same flow coefficient. In my Zoning Coefficient chart, Agriculture is designated as 0.001, it doesn't distinguish between A-1 and A-2.

Thanks,
Leslie

City of Santa Clarita
Development Services Division

SEWAGE FLOW COEFFICIENTS

ZONING	DESCRIPTION	COEFFICIENT (cfs/gross acreage)	COEFFICIENT (cfs/dwelling unit)
OS	Open Space	0.0002	------
A	Agricultural - 1 single family home/ legal lot	0.0002	------
RE	Residential Estate – large custom single family homes on uniquely configured lots	0.00075	------
RVL	Residential Very Low Density - 1 DU/AC	0.001	0.001
RL	Residential Low Density – 2.2 DU/AC	0.0015	0.00068
RS	Residential Suburban - 5 DU/AC	0.005	0.001
RM	Residential Moderate – 11 DU/AC	0.012	0.00109
RMH	Residential Medium High – 20 DU/AC	0.015	0.00075
RH	Residential High – 28 DU/AC	0.023	0.00082
CTC	Commercial Town Center	0.015	------
CC	Community Commercial	0.015	------
CN	Commercial Neighborhood	0.015	------
CO	Commercial Office	0.015	------
VSR	Visitor Serving/Resort	0.021	------
BP	Business Park	0.021	------
IC	Industrial Commercial	0.021	------
I	Industrial	0.021	------

Notes:
- The coefficient to be used for any zoned area not listed in this table will be determined by the City Engineer based upon the intended development and use.
- Open space coefficient: this coefficient is to account for water infiltration into sewer pipe.
- Coefficients in cfs/gross acreage shall be used for areas that are not yet developed and not yet entitled.
- Coefficients in cfs/dwelling unit shall be used for developed areas and areas that are entitled.

LACSD FLOW GENERATION FACTORS

Average Flow Factor

Land Use	Type	Average Flow gpd/DU
Residential	Single Family Dwelling	260
Residential	Condominium	156

Peak Flow Factors

General Plan	Description	Jurisdiction	Peak Flow cfs/acre
AP	Airport	Regional Planning	0.009
C	Commercial	Regional Planning	0.010
M	Industry	Regional Planning	0.010
N1	Non-Urban 1	Regional Planning	0.001
N2	Non-Urban 2	Regional Planning	0.001
P	Public Services Facilities	Regional Planning	0.009
RR	Resort Recreational	Regional Planning	0.011
HM	Hillside Management	Regional Planning	0.001
U1	Urban 1	Regional Planning	0.004
U2	Urban 2	Regional Planning	0.004
U3	Urban 3	Regional Planning	0.006
U4	Urban 4	Regional Planning	0.008
BP	Business Park	Santa Clarita	0.010
CC	Community Commercial	Santa Clarita	0.009
CN	Commercial Neighborhood	Santa Clarita	0.009
CTC	Commercial Town Center	Santa Clarita	0.011
I	Industrial	Santa Clarita	0.013
IC	Industrial Commercial	Santa Clarita	0.010
PE	Private Education	Santa Clarita	0.011
RE	Residential Estate	Santa Clarita	0.001
RH	Residential High	Santa Clarita	0.008
RL	Residential Low	Santa Clarita	0.004
RM	Residential Moderate	Santa Clarita	0.006
RMH	Residential Medium High	Santa Clarita	0.006
RS	Residential Suburban	Santa Clarita	0.004
RVL	Residential Very Low	Santa Clarita	0.001
VSR	Visitor Center	Santa Clarita	0.009
CO	Commercial Office	Santa Clarita	0.010

APPENDIX B

CITY OF SANTA CLARITA MH#136 FLOW TEST DATA

MH 136 Data

6/11 and 6/12 data were excluded from evaluation

		gph			cfs		
Date	Day	Min	Max	Avg	Min	Max	Avg
6/13/2009	Saturday	537	78,246	32,629	0.020	2.906	1.212
6/14/2009	Sunday	9,500	108,871	49,872	0.353	4.043	1.852
6/15/2009	Monday	5,261	90,323	44,070	0.195	3.354	1.637
6/16/2009	Tuesday	1,198	97,838	47,150	0.044	3.633	1.751
6/17/2009	Wednesday	3,086	100,238	46,026	0.115	3.722	1.709
6/18/2009	Thursday	5,599	95,924	52,973	0.208	3.562	1.967
6/19/2009	Friday	19,973	96,591	50,849	0.742	3.587	1.888
6/20/2009	Saturday	13,637	120,196	55,290	0.506	4.464	2.053
6/21/2009	Sunday	19,467	119,733	59,816	0.723	4.446	2.221
6/22/2009	Monday	5,887	125,230	55,092	0.219	4.651	2.046
6/23/2009	Tuesday	8,112	89,963	43,965	0.301	3.341	1.633
6/24/2009	Wednesday	7,897	87,102	43,956	0.293	3.235	1.632
6/25/2009	Thursday	1,002	82,059	39,886	0.037	3.047	1.481
Average, gph		7,781	99,409	47,813	0.289	3.692	1.776
mgd		0.187	2.386	1.148			
cfs		***0.289***	***3.692***	***1.776***			

Reclaculate average by
1. Removing values less than 15,000
2. Removing values greater than 105,000
3. Utilizing the max 7 day average

Date	Day	Min	Max	Avg
6/13/2009	Saturday	15000	78246	
6/14/2009	Sunday	15000	105000	
6/15/2009	Monday	15000	90323	
6/16/2009	Tuesday	15000	97838	
6/17/2009	Wednesday	15000	100238	
6/18/2009	Thursday	15000	95924	
6/19/2009	Friday	19973	96591	
6/20/2009	Saturday	15000	105000	
6/21/2009	Sunday	19467	105000	
6/22/2009	Monday	15000	105000	
6/23/2009	Tuesday	15000	89963	
6/24/2009	Wednesday	15000	87102	
6/25/2009	Thursday	15000	82059	
Average, gph		15,726	95,253	55489.4
mgd		0.377	2.286	1.332
cfs		*0.584*	*3.537*	*2.061*
	Percent of avg	28.3	171.7	

7-day avg		**Min**	**Max**	
55,295				
57,206				
57,525				
58,574		**15000**	**105000**	
58,011				
57,073				
56,083				
58,574	**gph**	**0.26**	**1.79**	Peaking Factors
1.406	mgd			
2.175 Avg Flow, cfs		**0.557** Min Flow. Cfs	**3.899** Peak Flow, cfs	

APPENDIX C

HDPE DIMENSION RATIO (DR) CALCULATIONS

DEXTER WILSON ENGINEERING, INC.

898-003

Vista Canyon Ranch Sewer Siphon

Preliminary Calculations for HDPE sewer siphon, at Santa Clara River Crossing:

References: 1. Hand book of Polyethylene Pipe, published by Plastics Pipe Institute, (exerpts attache)
2. Handbook of PVC Pipe, published by Uni-Bell PVC Pipe association (excerpts attached).

Project:

Approximately 700 feet of 18" I.D min, HDPE pipe shall extend under the Santa Clara River. Assume 24 HDPE, DIPS.

Maximum depth of cover over the HDPE pipe is 32 feet.

Determine the required DR rating for the pipe so that long term deflection does not exceed the allowable deflection.

*For final design and soils investigations must be performed to make a more definite determination of the load on the pipe.

*Additionally, the calculation will need to check the affects of the internal pressure (level of sewer above the siphon, ft) on the pipe deflection

DEXTER WILSON ENGINEERING, INC.

Use Equation 10 on page 429, Chapter 12 of the Handbook of PE Pipe to calculate the deflection.
(see the attached sections from the Handbook).

Ring Deflection :

$$\frac{Y}{D} = \frac{0.0125\,P_E}{\frac{E}{12(DR-1)^3}}$$

Y = Ring deflection, in.
D = Pipe Diameter, in.
P_E = Earth Pressure, psi.
DR = Pipe Dimension Ratio
E = Modulus of Elasticity, psi.

P_E = Earth Pressure

Calculate earth pressure using Marston Equation for Flexible Pipe Load (Prism load) (see page 138, Equation 18 from the Handbook of PVC pipe)

$W_c = HwB_c$

$W_c = 32(120)(2.15)$

$W_c = 8{,}256$ #/LF

w = unit wt. of fill
= 120 # / ft³
H = Height of fill, ft
= 32 ft
B_c = pipe O.D, ft
= 25.8 in.
= 2.15 ft

Convert to psi.

$$8{,}256 \frac{\#}{LF} \cdot \frac{1\,LF}{12'' \times 25.8''\,O.D} = 26.7\,psi = P_E$$

DEXTER WILSON ENGINEERING, INC.

For DR, try DR = 11

For E, use Table 2 in Handbook for PE Pipe, page 427, for 50 years time frame.

$E = 28,200$ psi

Calculate :

$$\frac{Y}{D} = \frac{0.0125(26.7)}{\frac{28,200}{12(11-1)^3}} = 0.142 = 14.2\%$$

Deflection is 14.8%. From Table 3 in Handbook for PE Pipe, page 429, allowable deflection is 7.5%

Therefore DR11 pipe is not acceptable.

Try DR9 $\frac{Y}{D} = \frac{0.0125(26.7)}{\frac{28,200}{12(9-1)^3}} = 0.727$

$= 7.27\%$

Deflection is 7.27%. From Table 3 allowable is 7.5%. Therefore, DR-9 is acceptable.

* Note: Must chk deflection with internal pressure head on the pipe during final design.

JOB NO.	BY	SUBJECT	DATE	SHEET NO.
898-003	DHJ	VCR Sewer Siphon	6/7/09	3 of 9

For flexible conduits in most installations, the product, $r_{sd}P$, is less than zero (a negative value). Only flexible pipes with very high pipe stiffness can ever have an $r_{sd}P$ product greater than zero. Therefore, use of a $r_{sd}P$ product equal to zero will result in a conservative design approach for most buried flexible pipe installations. As can be seen on the C_c computation graph, when $r_{sd}P$ equals zero, the coefficient C_c is equal to the ratio of H/B_c.

Replacing the C_c in Marston's embankment load formula with the ratio H/B_c yields:

EQUATION 18

$$W_c = HwB_c$$

This is commonly known as the prism load and simply stated it is the weight of the column of soil directly over the pipe for the full height of the backfill. This is the maximum load that will be imposed by the soil on a flexible conduit in nearly all cases and is a conservative design approach.

Comparison of the following earth load determination formulas related to Marston's theory is appropriate:

(EQUATION 13)

Rigid Pipe Load (Trench Condition) $\quad W_c = C_d w B_d^2 \quad$ (lb/Lft)

(EQUATION 14)

Flexible Pipe Load (Trench Condition) $\quad W_c = C_d w B_d B_c \quad$ (lbs/Lft)

(EQUATION 18)

Flexible Pipe Load (Prism Load) $\quad W_c = HwB_c \quad$ (lbs/Lft)

Prism load may also be expressed in terms of soil pressure as follows:

FIGURE 16 – VALUES OF C_c

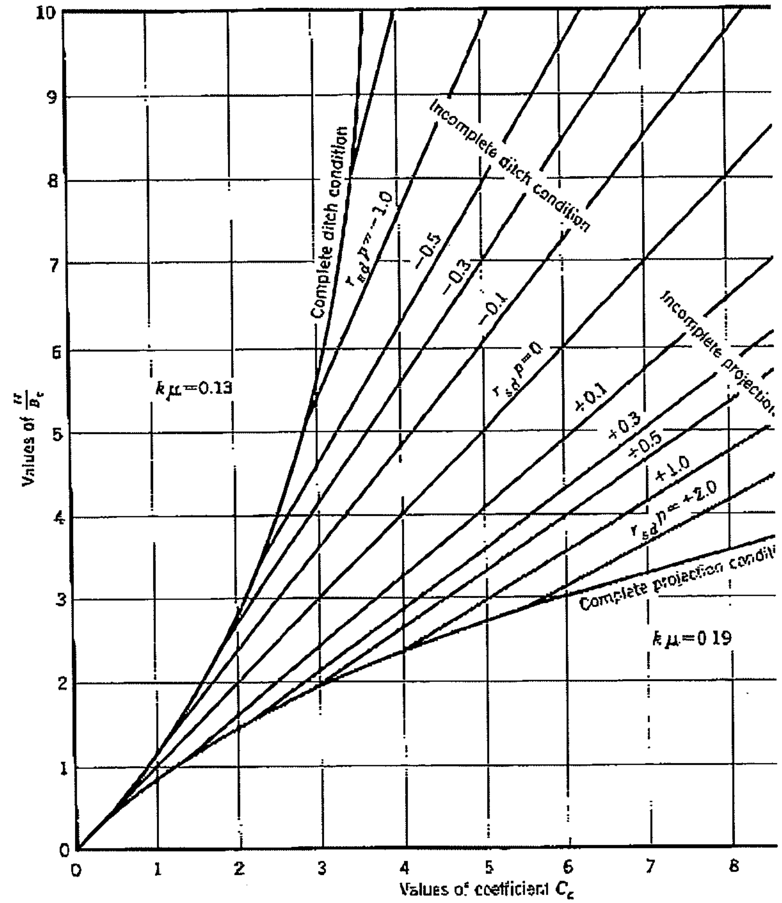

Diagram for coefficient C_C for positive projecting conduits.

SOURCE: DESIGN & CONSTRUCTION OF SANITARY & STORM SEWERS. "MANUALS ENGINEERING PRACTICE NO. 37", AMERICAN SOCIETY OF CIVIL ENGINEERS OF PRACTICE NO. 9", WATER POLLUTION CONTROL FEDERATION. 1969, P. 163

EQUATION 19

(Soil Pressure) $\quad P = wH = \dfrac{W_c}{B_c}$

Where:
- P = pressure due to soil weight a lbs/ft²
- w = unit weight of soil, lbs/ft³
- H = depth at which soil pressure
- W_c = trench load, lbs/Lft
- B_c = pipe outside diameter, ft.

Calculation of soil pressure on both rigid and flexible pipes of the same diameter in the same burial conditions displays the difference between load on flexible conduit in trench and embankment conditions and load on rigid conduit in trench condition.

Example:

Pipe OD	12 in	(nominal OD)
Burial Depth of Cover	12 ft	
Trench Width	3 ft	
Rankine's Ratio (k)	0.33	
Soil Density (w)	120 lb/ft^3	
Coefficient of Soil Friction (μ')	0.5	

Rigid Pipe Load (trench condition)

$$C_d = \frac{1 - e^{-2(0.33)(0.5)(12/3)}}{2(0.33)(0.5)} = 2.221$$

$$W_c = 2.221\ (120)3^2 = 2{,}398 \text{ lb/Lft or } 16.7 \text{ lbs/in}^2$$

(with pipe diameter = 12 in)

Flexible Pipe Load (trench condition)

$$W_c = 2.221(120)(3)(1) = 800 \text{ lb/Lft or } 5.6 \text{ lbs/in}^2$$

Flexible Pipe Load (assume prism condition)

$$W_c = 120(12)(1) = 1440 \text{ lb/Lft or } 10.0 \text{ lb/in}^2$$

*Research and actual long term data confirm that in most conditions the prism load provides a conservative, simplified approach for designing PVC piping systems to accommodate earth load. In a trench, friction

forces can reduce the load on the pipe through arching acti however, frost and water action may dissipate these forces, a term the load may approach the prism load. It is recomme prism load be considered in the conservative design of buri systems.

The following tables have been developed for use i loads on ASTM D3034 PVC sewer pipe. If the condition of known to be a "trench" condition, then Table 21 will prc puted earth load. For unknown conditions or in trenches tion width, the more conservative prism earth loads are Prism earth loads in lbs/lineal foot are listed in Table 22. Pri in lbs/in^2 are listed in Table 23.

TABLE 21 – EARTH LOADS IN TRENCH CONDITIONS (L

$$W_c = C_d w B_d B_c$$

DEPTH OF COVER	TYPE OF SOIL	4" PIPE				6"	
		← Width of Trench (ft.) →					
		0.75	1.00	1.25	1.5	1.0	1.5
3	Granular w/o Cohesion	54	63	68	74	94	110
	Sand and Gravel	65	73	79	84	109	125
	Sat. Top Soil	75	81	86	91	120	135
	Dry Clay	82	86	95	100	132	149
	Sat. Clay	95	100	106	112	150	166
3.5	Granular w/o Cohesion	57	68	75	79	101	118
	Sand and Gravel	70	79	87	93	118	138
	Sat. Top Soil	77	89	96	102	132	152
	Dry Clay	86	97	105	109	144	169
	Sat. Clay	99	110	119	123	163	184
4	Granular w/o Cohesion	60	72	81	81	107	129
	Sand and Gravel	72	86	95	101	129	151
	Sat. Top Soil	81	97	106	112	144	167
	Dry Clay	90	105	116	123	156	184
	Sat. Clay	106	121	131	137	181	204
6	Granular w/o Cohesion	66	82	97	108	123	161
	Sand and Gravel	82	102	116	130	151	193
	Sat. Top Soil	92	114	131	144	170	216
	Dry Clay	109	127	145	158	190	236
	Sat. Clay	130	155	168	182	231	271
8	Granular w/o Cohesion	68	88	105	120	131	178
	Sand and Gravel	85	109	130	145	163	216
	Sat. Top Soil	98	123	146	164	184	244
	Dry Clay	117	145	166	183	217	273
	Sat. Clay	141	173	200	217	258	323
10	Granular w/o Cohesion	68	90	111	126	133	188
	Sand and Soil	87	114	137	157	169	234
	Sat. Top Soil	101	131	156	176	195	262
	Dry Clay	120	154	182	202	229	301
	Sat. Clay	147	183	217	243	273	362

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compressive thrust is ring buckling (collapse). The performance limit of a PE pipe subjected to ring bending (a result of non-uniform external load, i.e. earth load) is ring deflection. See Figure 2.

Time-Dependent Behavior

Both performance limits are proportional to the apparent modulus of elasticity of the PE material. For viscoelastic materials like PE, the modulus of elasticity is a time-dependent property, that is, its value changes with time under load. A newly applied load increment will cause a decrease in apparent stiffness over time. Unloading will result in rebounding or an apparent gain in stiffness. These changes occur because the molecular structure rearranges itself under load. The result is a higher resistance to short term loading than to long-term loading. Careful consideration must be given to the duration and frequency of each load, so that the performance limit associated with that load can be calculated using PE material properties representative of that time period. The same effects occur with the pipe's tensile strength. For instance, during pullback, the pipe's tensile yield strength decreases with pulling time, so the safe (allowable) pulling stress is a function of time.

For viscoelastic materials, the ratio of the applied stress to strain is called the apparent modulus of elasticity, because the ratio varies with load rate. Typical values for the apparent modulus of elasticity at 73°F (23°C) are presented in Table 2. Consult the manufacturer for specific applications.

TABLE 2
Apparent Modulus of Elasticity and Safe Pull Tensile Stress @ 73° F

Typical Apparent Modulus of Elasticity			Typical Safe Pull Stress		
Duration	**HDPE**	**MDPE**	**Duration**	**HDPE**	**MDPE**
Short-term	110,000 psi (800 MPa)	87,000 psi (600 MPa)	30 min	1,300 psi (9.0 MPa)	1,000 psi (6.9 MPa)
10 hours	57,500 psi (400 MPa)	43,500 psi (300 MPa)	60 min	1,200 psi (8.3 MPa)	900 psi (6.02 MPa)
100 hours	51,200 psi (350 MPa)	36,200 psi (250 MPa)	12 hours	1,150 psi (7.9 MPa)	850 psi (5.9 MPa)
50 years	28,200 psi (200 MPa)	21,700 psi (150 MPa)	24 hours	1,100 psi (7.6 MPa)	800 psi (5.5 MPa)

Ring Deflection (Ovalization)

Non-uniform pressure acting on the pipe's circumference such as earth load causes bending deflection of the pipe ring. Normally, the deflected shape is an oval. Ovalization may exist in non-rerounded coiled pipe and to a lesser degree in straight lengths that have been stacked, but the primary sources of bending

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deflection of directionally drilled pipes is earth load. Slight ovalization may also occur during pullback if the pipe is pulled around a curved path in the borehole. Ovalization reduces the pipe's hydrostatic collapse resistance and creates tensile bending stresses in the pipe wall. It is normal and expected for buried PE pipes to undergo ovalization. Proper design and installation will limit ovalization (or as it is often called "ring deflection") to prescribed values so that it has no adverse effect on the pipe.

Ring Deflection Due to Earth Load

As discussed previously, insitu soil characteristics and borehole stability determine to great extent the earth load applied to directionally drilled pipes. Methods for calculating estimated earth loads, when they occur, are given in the previous section on "Earth and Groundwater Pressure."

Since earth load is non-uniform, the pipe will undergo ring deflection, i.e. a decrease in vertical diameter and an increase in horizontal diameter. The designer can check to see if the selected pipe is stiff enough to limit deflection and provide an adequate safety factor against buckling. (Buckling is discussed in a later section of this chapter.)

The soil surrounding the pipe may contribute to resisting the pipe's deflection. Formulas used for entrenched pipe, such as Spangler's Iowa Formula, are likely not applicable as the HDD installation is different from installing pipe in a trench where the embedment can be controlled. In an HDD installation, the annular space surrounding the pipe contains a mixture of drilling mud and cuttings. The mixture's consistency or stiffness determines how much resistance it contributes. Consistency (or stiffness) depends on several factors including soil density, grain size and the presence of groundwater. Researchers have excavated pipe installed by HDD and observed some tendency of the annular space soil to return to the condition of the undisturbed native soil. See Knight (2001) and Ariaratnam (2001). It is important to note that the researched installations were located above groundwater, where excess water in the mud-cuttings slurry can drain. While there may be consolidation and strengthening of the annular space soil particularly above the groundwater level, it may be weeks or even months before significant resistance to pipe deflection develops. Until further research establishes the soil's contribution to resisting deflection, one option is to ignore any soil resistance and to use Equation 10 which is derived from ring deflection equations published by Watkins and Anderson (1995). (Coincidentally, Equation 10 gives the same deflection as the Iowa Formula with an E' of zero.)

$$\text{(10)} \quad \frac{y}{D} = \frac{0.0125P_E}{\dfrac{E}{12\,(DR-1)^3}}$$

4 ————— *

WHERE
y = ring deflection, in
D = pipe diameter, in
P_E = Earth pressure, psi
DR = Pipe Dimension Ratio
E = modulus of elasticity, psi
* To obtain ring deflection in percent, multiply y/D by 100.

Ring Deflection Limits (Ovality Limits)

Ovalization or ring deflection (in percent) is limited by the pipe wall strain, the pipe's hydraulic capacity, and the pipe's geometric stability. Jansen observed that for PE, pressure-rated pipe, subjected to soil pressure only, "no upper limit from a practical design point of view seems to exist for the bending strain." On the other hand, pressurized pipes are subject to strains from both soil induced deflection and internal pressure. The combined strain may produce a high, localized outer-fiber tensile stress. However, as the internal pressure is increased, the pipe tends to re-round and the bending strain is reduced. Due to this potential for combined strain (bending and hoop tensile), it is conservative to limit deflection of pressure pipes to less than non-pressure pipes. In lieu of an exact calculation for allowable deflection limits, the limits in Table 3 can be used.

TABLE 3
Design Deflection Limits of Buried Polyehtylene Pipe, Long Term, %*

DR or SDR	21	17	15.5	13.5	11	9	7.3
Deflection Limit (% y/D) Non-Pressure Applications	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Deflection Limit (%y/D) Pressure Applications	7.5	6.0	6.0	6.0	5.0	4.0	3.0

* Deflection limits for pressure applications are equal to 1.5 times the short-term deflection limits given in Table X2.1 of ASTM F-714.

Design deflections are for use in selecting DR and for field quality control. (Field measured deflections exceeding the design deflection do not necessarily indicate unstable or over-strained pipe. In this case, an engineering analysis of such pipe should be performed before acceptance.)

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