APPENDIX B

MAIN CAMPUS WATER DEMAND PROJECTIONS

To	Alisa Klaus, UCSC	Reference number 130316/GM
cc	Steve Paul, UCSC Bruce Hoffman, UCSC Sally Morgan, UCSC	File reference 1-02
From	Grant McInnes x 594 (Arup SF)	Date September 30, 2005
Subject	UC Santa Cruz: LRDP EIR Water Demand Projections - Calculation Summary	

The following water demand projections were developed using historic metered consumption data supplied by UC Santa Cruz and the City of Santa Cruz, and the program data contained in the Long Range Development Plan (LRDP) for the year 2020. Metered consumption data for the year 2003 was analyzed, and divided into programmatic Water Demand Categories depending on the land-use associated with the meter. The existing building square footage and housing units were allocated to similar categories so that the rate of water consumption could be calculated for each Water Demand Category. The future consumption projections were then extrapolated based on the increase in future program requirements.

The following paragraphs summarize the methodology used in the projection calculations, by providing a brief explanation regarding the purpose of each table.

Table 1A: provides a summary of the Existing and Approved (2004-5) campus program and the Proposed Program for 2020, on a square footage basis. The Existing and Approved (2004-5) data contains program for buildings not yet constructed during 2003 (the year from which the metering data is taken).

Table 1B: provides a summary of the campus housing program by the number of beds for the Existing (2003), Existing and Approved (2004-5) and the Proposed (2020) years.

Table 1C: consolidates the data from Table 1A into the Water Demand Categories to be used in the projection calculations.

Table 1D: summarizes the program data for buildings that are included in the Existing and Approved (2004-05) data, but were not constructed as of 2003.

Table 2: summarizes the metered water consumption for 2003 provided by UCSC. The campus' sub-metering system does not capture all of the water used on campus. Therefore, data from the City's metering system, which provides total campus water consumption, was used to derive the amount of "unmetered water" (i.e. water not captured by the campus' sub-metering system). The unmetered water was distributed to the various Water Demand Categories based on likely use. The assumptions that have been made regarding the likely use of this unmetered water are noted and calculated.

Table 3A: calculates the existing average Water Use Factor (average gpd per GSF or average gpd per bed) for the Existing (2003) program based on the metered water consumption for 2003. This factor is applied to the Proposed 2020 program to generate a proposed baseline demand for 2020, which assumes that future buildings are constructed with similar typical water demands as the existing buildings on campus.

The US Energy Policy Act of 1992 resulted in Californian Plumbing Codes requiring the use of flow low fixtures from 1992 onwards. For the purposes of this study, it is assumed that all buildings constructed during and since 1993 contain fixtures that meet these low flow requirements.

UC Santa Cruz has engaged in a retrofit program for some of these pre-1993 fixtures in recent years. However, fixtures in some of the buildings on the campus that were constructed prior to 1993 have not been retrofitted; these buildings have a water demand greater than those constructed to current code. The actual project demand for 2020 adjusts the baseline demand to account for the fact that new development will comply with current code requirements. Therefore, the Water Use Factors for future buildings will be less than for existing buildings, which have a mix of low-flow and pre-1993 fixtures.

Refer to Table 4 for these adjustment calculations that account for existing low flow fixtures (for the Office/Classroom, Science, Library, Athletic and Housing/Apts water demand categories).

The following demand savings for new development (with respect to buildings fitted with pre-1993 fixtures) that are achievable using low flow fixtures and improved efficiency irrigation systems, have been assumed for the following Water Demand Categories:

- Irrigation = 5%
- Office / Classroom = 50%
- Science Labs = 10%
- Library = 50%
- Athletic (Physical Ed) = 25%
- Housing / Apartments = 20%
- Mechanical / Cooling = 0%
- Other (theatre, retail, etc) = 10%

Table 3B: calculates the proposed baseline irrigation demand for 2020, assuming a linear extrapolation of demand based on the increase in area of general landscaping and athletic fields.

Table 4: calculates the percentage of Existing (2003) buildings that are fitted with code compliant low flow fixtures (completed since 1993, or retrofitted), and the associated program area. The assumed demand savings achievable using low flow fixtures are used to calculate existing Water Use Factors for both low flow fixture fitted and non-low flow fixture fitted Existing (2003) buildings. The existing Water Use Factor for low flow fixture fitted buildings is used to generate the proposed demand for the future buildings, which when added to the Existing (2003) metered demand results in the actual proposed demand for 2020.

TABLE 1A
UCSC Long Range Development Plan (2005-2020) 21,000FTE
Projected Space for Enrollment Scenarios[1]

Draft 18
3/14/2005

Program Element	Code[2]	Existing and Approved (2004-05) ASF	Existing and Approved (2004-05) GSF	Additional Proposed (2020) ASF	Additional Proposed (2020) GSF	Total Proposed (2020) ASF	Total Proposed (2020) GSF
Instruction and Research (non-college)							
Arts	O/C	160,205	256,352	137,900	237,800	298,105	494,152
Humanities	O/C	34,004	55,289	56,200	93,700	90,204	148,989
Physical & Biological Sciences	Sci	311,430	529,303	260,200	464,600	571,630	993,903
Social Sciences	O/C	110,481	188,112	122,700	204,500	233,181	392,612
Engineering	Sci	123,710	208,947	170,100	288,300	293,810	497,247
Classrooms	O/C	53,166	88,666	26,100	43,500	79,266	132,166
Open Computer Labs	O/C	9,962	15,524	5,400	9,000	15,362	24,524
Subtotal: I&R		**802,958**	**1,342,193**	**778,600**	**1,341,400**	**1,581,558**	**2,683,593**
Organized Research Units, ORA's	O/C	86,706	136,542	180,400	311,000	267,106	447,542
Academic Support	O/C	58,589	80,104	46,100	76,800	104,689	156,904
Libraries	Lib	203,883	287,170	65,100	93,000	268,983	380,170
Student Services	O/C	87,767	131,735	137,800	206,500	225,567	338,235
Public Services	O/C	1,434	2,422	57,000	95,000	58,434	97,422
Physical Education and Recreation	PE	56,743	81,954	181,900	245,600	238,643	327,554
Institutional Support (General Services)	O/C	109,498	338,729	86,700	144,500	196,198	483,229
Institutional Support (Administration)	O/C	54,373	89,637	27,700	46,200	82,073	135,837
Other (non-institutional agency)	O/C	1,398	1,848	0	0	1,398	1,848
Total Non-College		**1,463,349**	**2,492,334**	**1,561,300**	**2,560,000**	**3,024,649**	**5,052,334**
Colleges							
(number)			(10)		(12)		
(beds)							
Instruction and Research							
Arts	O/C	12,786	20,073	0	0	12,786	20,073
Humanities	O/C	17,823	28,878	0	0	17,823	28,878
Phys & Bio Sci	Sci	5,329	8,228	0	0	5,329	8,228
Social Sciences	O/C	40,351	67,464	0	0	40,351	67,464
Engineering	Sci	0	0	0	0	0	0
Classrooms	O/C	27,813	45,522	0	0	27,813	45,522
Open computer labs	O/C	6,757	10,249	0	0	6,757	10,249
Subtotal: I&R		**110,859**	**180,414**	**0**	**0**	**110,859**	**180,414**
Academic support	O/C	59,563	91,765	14,400	24,000	73,963	115,765
Undergraduate College Housing	Apt	1,090,745	1,548,759	346,500	498,580	1,437,245	2,047,339
Graduate College Housing	Apt	0	0	125,250	158,544	125,250	158,544
Food Services	Apt	82,881	125,544	0	0	82,881	125,544
Faculty/Staff Housing	Apt	22,652	29,894	4,000	5,300	26,652	35,194
Other (U Ctr, CATS, Cam Fac)	Ot	7,456	10,783	0	0	7,456	10,783
Museum/Exhibit	O/C	5,070	8,117	0	0	5,070	8,117
Student Services	O/C	46,933	68,844	16,900	24,300	63,833	93,144
Total Colleges		**1,426,159**	**2,064,120**	**507,050**	**710,724**	**1,933,209**	**2,774,844**
Additional Undergraduate Apartments	Apt	30,878	41,893	274,200	347,089	305,078	388,982
Additional Graduate Apartments	Apt	23,480	27,269	0	0	23,480	27,269
Family Student Housing	Apt	163,794	192,428	231,200	292,658	394,994	485,086
Faculty/Staff Housing	Apt	303,200	357,325	125,000	158,228	428,200	515,553
Total		**3,410,860**	**5,175,369**	**2,698,750**	**4,068,699**	**6,109,610**	**9,244,068**

Notes:

1) Program data in Table 1 agreed with UCSC on 03/10/2005, Draft 18 (amended).

2) Code designations have been allocated to each Program Element, to facilitate compatibility with the existing metered data (see Table 2) for the purposes of the future demand projection. Program Elements with similar water demand characteristics have been combined to form the following water demand categories: Irr = Irrigation; OC = Office / Classroom; Sci = Science Labs; Lib = Library; PE = Athletic (Phys Ed); Apt = Housing / Apartments; Coo = Mechanical / Cooling; Ot = Other (theatre, retail, etc).

3) See Table 1C for corrected Existing Buildings (2003) ASF/GSF total program areas.

UCSC - Program Assumptions for EIR LRDP (2020), 21,000FTE

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TABLE 1B
Housing Program Summary

Existing On-Campus beds (2003)[1]	
Students	5,630 beds
Employee Housing	557 beds
Total	**6,187 beds**

Existing and Approved On-Campus beds (2004-05)[2]	
Undergraduate	6,140 beds
Graduate	182 beds
Family Student Housing (non-students)	315 beds
Staff	331 beds
Faculty	611 beds
Total	**7,579 beds**

2005 LRDP: Proposed Additional On-Campus beds (2020)[2]	
Undergraduate	2,772 beds
Graduate	418 beds
Family Student Housing Students	200 beds
Family Student Housing Non-Students	320 beds
Staff/Faculty	373 beds
Total	**4,083 beds**

	Total Beds			
Scenario	**Existing (2003)**	**Existing and Approved (2004-05)**	**Additional Proposed (2020)**	**Total Proposed (2020)**
LRDP EIR: Scenario A	6,187	7,579	4,083	11,662

Notes:
1) Existing on-campus beds (2003) data agreed with UCSC by email on 03/11/2005, using the campus-wide vacancy rate data prepared by Geri Wolff (UCSC Colleges and University Housing), September 2004.

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TABLE 1C: Program Summary: Square Footage Area per Water Demand Category - Existing and Proposed

		2003 Buildings[1]		Existing and Approved (2004-05)		Additional Proposed (2020) from (2004-05)		Total Proposed (2020)	
Water Demand Category	**Code**	**ASF**	**GSF**	**ASF**	**GSF**	**ASF**	**GSF**	**ASF**	**GSF**
Irrigation[2]	Irr	na		na		na		na	
Office / Classroom	OC	896,726	1,579,430	984,679	1,725,872	915,300	1,516,800	1,899,979	3,242,672
Science Labs	Sci	269,746	453,096	440,469	746,478	430,300	752,900	870,769	1,499,378
Library	Lib	122,283	170,570	203,883	287,170	65,100	93,000	268,983	380,170
Athletic (Phys Ed)	PE	56,743	81,954	56,743	81,954	181,900	245,600	238,643	327,554
Housing / Apts	Apt	1,553,940	2,101,112	1,717,630	2,323,112	1,106,150	1,460,399	2,823,780	3,783,511
Cooling[3]	Coo	na		na		na		na	
Other	Ot	7,456	10,783	7,456	10,783	0	0	7,456	10,783
		2,906,894	**4,396,945**	**3,410,860**	**5,175,369**	**2,698,750**	**4,068,699**	**6,109,610**	**9,244,068**

Notes:

1) 2003 building areas are calculated using the Existing and Approved (2004-05) program areas, less the areas of the 2004 and 2005 buildings not yet constructed, as listed in Table 1D.
2) Refer to Table 3B for the irrigation demand program assumptions.
3) The Water Demand Category "Mechanical / Cooling" is not based on an assignable program area, therefore is not listed here. Refer to Table 3A for the water demand projection for this category.

TABLE 1D: Approved Buildings not yet constructed (2004 and 2005 buildings)

		Approved Not Yet Constructed (2004-05)	
Building	**Code**	**ASF**	**GSF**
Humanities	OC	51,140	85,000
McHenry Addition	Lib	81,600	116,600
Engineering Building	Sci	90,894	156,937
Physical Sciences	Sci	79,829	136,445
Emergency Response	OC	11,200	17,250
Digital Arts	OC	25,613	44,192
Infill Apartments	Apt	163,690	222,000
		503,966	**778,424**

Notes:

1) Existing and Approved Buildings not constructed data is taken from Appendix A of the Draft LRDP (January 2005).

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TABLE 2: UCSC Measured Water Consumption, Calendar Year 2003

			CONSUMPTION CORRECTED FOR UNMETERED WATER[2]			
	UCSC Land Use Designation[1]	Metered Data (avg gal/day)[1]	% Total measured	Unmetered water (avg gal/day)	Corrected Existing Demand (avg gal/day)[3]	Code[4]
IRRIGATION	LANDSCAPE	34,746	29.2%	29,333	64,080	Irr
	ATHLETIC FIELD	46,996	39.6%	39,675	86,672	Irr
	AGRICULTURE	37,062	31.2%	31,288	68,350	Irr
TOTAL IRRIGATION		**118,804**	**100.0%**	**100,297**	**219,101**	
INDOOR - OMP	TRAILERS	164	0.1%	23	187	Ot
	THEATRE	1,228	0.4%	174	1,402	Ot
	SCIENCE LABS	13,728	4.5%	1,944	15,672	Sci
	RETAIL	977	0.3%	138	1,115	Ot
	OFFICE/CLASSROOM	35,430	11.7%	5,018	40,448	OC
	LIBRARY	12,709	4.2%	1,800	14,509	Lib
	ATHLETIC BLDG	5,402	1.8%	765	6,167	PE
		69,638	**22.9%**	**9,862**	**79,500**	
INDOOR - OTHER	RETAIL FOOD	600	0.2%	85	685	Ot
	OTHER	2,002	0.7%	283	2,285	Ot
	COOLING TOWER	11,775	3.9%	1,668	13,443	Coo
	MECHANICAL	10,731	3.5%	1,520	12,251	Coo
	COMMONS	702	0.2%	99	801	Ot
		25,809	**8.5%**	**3,655**	**29,465**	
INDOOR - RESIDENTIAL	TRAILERS	2,138	0.7%	303	2,441	Apt
	TOWNHOMES	1,660	0.5%	235	1,895	Apt
	LAUNDRY ROOM	832	0.3%	118	950	Apt
	KITCHEN	25,590	8.4%	3,624	29,214	Apt
	HOUSES	17,552	5.8%	2,486	20,038	Apt
	DORMITORIES	91,289	30.1%	12,928	104,217	Apt
	COMMONS	1,412	0.5%	200	1,612	Apt
	APARTMENTS	67,595	22.3%	9,573	77,168	Apt
		208,068	**68.6%**	**29,467**	**237,535**	
TOTAL INDOOR		**303,515**	**100.0%**	**42,984**	**346,500**	
TOTAL		**422,320**		**143,281**	**565,601**	

TOTAL METERED WATER (UCSC sub-metering system)	**422,320 Avg Gal/Day**
METERED IRRIGATION WATER	118,804 Avg Gal/Day
METERED INDOOR WATER	303,515 Avg Gal/Day
TOTAL METERED WATER (from City of Santa Cruz)	**565,601 Avg Gal/Day**
UNMETERED WATER (Imported water usage from City of Santa Cruz)	**143,281 Avg Gal/Day**
Assume 70% unmetered water is used for unmetered irrigation.	100,297 Avg Gal/Day
Assume 20% unmetered water is due to water leaks from the campus and building piping systems.	28,656 Avg Gal/Day
Assume 10% unmetered water is water not measured due to meter turn-down capacity.	14,328 Avg Gal/Day

Notes:

1) UCSC metered water consumption data was obtained from Patrick Testoni of UCSC Physical Plant on April 16, 2004.

2) It is assumed that "unmetered water" can be attributed as follows: 70% = unmetered irrigation systems; 30% = leakage and metering inefficiencies in pipes and meters serving INDOOR uses (from UCSC email received July 26, 2005).

3) Corrected Existing Demand = Metered Data + Unmetered water

4) Code designations have been allocated to each existing Land Use Designation, to facilitate compatibility with the proposed Program Elements (see Table 1A) for the purposes of the future demand projection. Land Use Designations with similar water demand characteristics have been combined to form the following water demand categories: Irr = Irrigation; OC = Office / Classroom; Sci = Science Labs; Lib = Library; PE = Athletic (Phys Ed); Apt = Housing / Apartments; Coo = Mechanical / Cooling; Ot = Other (theatre, retail, etc).

UCSC - Water Demand Calculations for EIR LRDP (2020), 21,000FTE

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TABLE 3A: Proposed (2020) Water Demand Summary - Baseline, assuming Low Flow Fixtures for New Buildings

Water Demand Category	Code[1]	Existing (2003) Demand (avg gpd)[2]	Existing Program - 2003 (GSF/ No of Beds)[3]	Existing Average Water Use Factor (avg gpd)[4]	Existing Average Water Use Factor (cu.ft / year)[4]	Additional Proposed Program (2020) from 2003	Total Proposed Program - 2020[3]	Proposed Baseline Demand - 2020 (avg gpd)[5]	Assumed savings achievable using Low Flow fixtures[6]	Proposed Demand - 2020 (avg gpd)[7]
Irrigation[8]	Irr	219,101	See Table 3B	See Table 3B	See Table 3B	See Table 3B	See Table 3B	**316,110**	**5%**	**311,259**
Office / Classroom	OC	40,448	1,579,430 GSF	0.026 /GSF	1.25 /GSF	1,663,242 GSF	3,242,672 GSF	**83,042**	**50%**	**70,421**
Science Labs	Sci	15,672	453,096 GSF	0.035 /GSF	1.69 /GSF	1,046,282 GSF	1,499,378 GSF	**51,861**	**10%**	**50,244**
Library	Lib	14,509	170,570 GSF	0.085 /GSF	4.15 /GSF	209,600 GSF	380,170 GSF	**32,337**	**50%**	**27,054**
Athletic (Phys Ed)	PE	6,167	81,954 GSF	0.075 /GSF	3.67 /GSF	245,600 GSF	327,554 GSF	**24,649**	**25%**	**22,374**
Housing / Apts	Apt	237,535	6,187 Beds	38 /bed	1,873.23 /bed	5,475 Beds	11,662 Beds	**447,716**	**20%**	**427,698**
Mechanical / Cooling[9]	Coo	25,694	n/a	n/a	n/a	n/a	n/a	**85,025**	**0%**	**85,025**
Other (theatre, retail, etc)	Ot	6,475	10,783 GSF	0.600 /GSF	29.30 /GSF	0 GSF	10,783 GSF	**6,475**	**10%**	**6,475**
	Daily	**565,601**	**gpd total demand**					**1,047,216**		**1,000,551** **gpd total demand**
	Yearly Equivalent	206.4 million gallons / yr						382.2 million gallons / yr		365.2 million gallons / yr
		346,500 gpd - indoor demand only, i.e. discounting irrigation demand						731,106.5 gpd - indoor demand only		689,292.0 gpd - indoor demand only
		126.5 million gallons / yr						266.9 million gallons / yr		251.6 million gallons / yr
		240.62 gpm (average)						507.71 gpm (average)		478.67 gpm (average)

Notes:

1) Code designations have been allocated to each Program Element, to facilitate compatibility with the existing metered data (see Table 2) for the purposes of the future demand projection. Program Elements with similar water demand characteristics have been combined to form the following water demand categories: Irr = Irrigation; OC = Office / Classroom; Sci = Science Labs; Lib = Library; PE = Athletic (Phys Ed); Apt = Housing / Apartments; Coo = Mechanical / Cooling; Ot = Other (theatre, retail, etc).
2) Refer to Table 2 for corrected existing metered demand summary.
3) Refer to Table 1 for LRDP EIR Program data for existing (2003) and 21,000FTE. (2020) program data.
4) Existing Water Use Factor = Existing Demand / Existing Program (area / beds).
5) Baseline Consumption predictions are based on an assumed linear expansion from 15,000FTE to 21,000FTE. Proposed Baseline Consumption = Existing Water Use Factor * Proposed Program - 2020.
6) Assumed savings achievable using Low Flow Fixture technology compliant with existing codes, compared to demands from the existing campus buildings with pre-1993 fixtures.
7) For Irrigation, Proposed Demand-2020 = {[Proposed Baseline Demand (2020) - Existing Demand (2003)] * [1 - assumed savings achievable]} + Existing Demand (2003). Refer to Table 4 in "Factored Low Flow Fixtures" worksheet for the Consumption calculations for the OC, Sci, Lib, PE and Apt uses. This calculation assumes that all new buildings that are constructed under this LRDP EIR will be fitted with conventional fixtures per current minimum standards.
8) Refer to Table 3B for calculation of future irrigation demands.
9) Proposed Mechanical / Cooling water demand is assumed to have a linear relationship with the increase in square footage of the Science Lab buildings (from 453,096GSF to 1,499,378GSF).

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TABLE 3B: Irrigation - Proposed (2020) Water Demand Summary

IRRIGATION USE	Existing (2003) Demand (avg gpd)	Proposed Demand - 2020 (avg gpd)
LANDSCAPE [1]	64,080	89,712
ATHLETIC FIELD [2]	86,672	158,048
AGRICULTURE [3]	68,350	68,350
TOTAL IRRIGATION	**219,101**	**316,110**

Notes:

1) Proposed general landscaping irrigation demand is assumed to have a linear relationship with the increase in student population (from 15,000FTE to 21,000FTE).
2) Proposed Athletic Field irrigation demand is assumed to have a linear relationship with the increase in area of irrigated playing fields (from 17 acres to 31 acres).
3) Future AGRICULTURE demand is assumed to remain as existing.

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TABLE 4A - Water Demand Calculation allowing for existing savings being made due to Low Flow Fixtures
(allowing for retrofits previously performed and due to the implementation of US Energy Policy Act of 1992, for buildings constructed in California after 1993)

% of existing building area completed during and since 1993	33%	calculated from existing program data supplied by UCSC on 4/16/2004
% of existing buildings on-campus retrofitted with Low Flow Fixtures (constructed prior to 1993)	25%	A UCSC fixture audit of pre-1993 OMP buildings determined that 38% of these buildings have been retrofitted. Assume 38% of all pre-1993 buildings have been retrofitted, therefore the % of all existing buildings that have been retrofitted = 38% * (1-33%) = 25%
Total Building Area 2003 (GSF)	4,396,945	refer to Table 1C
Building Area constructed during and since 1993 (GSF)	1,446,252	(% of existing building area completed since 1993 * Total building area 2003)
Building Area constructed prior to 1993, retrofitted with Low Flow Fixtures (GSF)	1,099,236	(% of existing building area built prior to 1993 retrofitted with Low Flow Fixtures * Total building area 2003)
Total Building area with Low Flow Fixtures (GSF)	**2,545,488**	
% of existing buildings with Low Flow Fixtures	**58%**	

	Water Demand Category				
	Office / Classroom	Science	Library	Athletic (Phys Ed)	Housing / Apts[1]
Building program - 2020 (GSF; Beds for Housing / Apts)[1]	3,242,672	1,499,378	380,170	327,554	11,662
Existing Demand - 2003 (gpd)[2]	40,448	15,672	14,509	6,167	237,535
% of existing buildings retrofitted with Low Flow Fixtures	58%	58%	58%	58%	58%
Existing Building Program - 2003 (GSF; Beds for Housing / Apts)[1]	1,579,430	453,096	170,570	81,954	6,187
Existing Building Program - 2003, fitted with low flow fixtures (GSF; Beds for Housing / Apts)[3]	914,367	262,307	98,747	47,445	3,582
Existing Building Program - 2003, not fitted with low flow fixtures (GSF; Beds for Housing / Apts)[4]	665,063	190,789	71,823	34,509	2,605
Assumed X% savings achievable using low flow fixtures[5]	50%	10%	50%	25%	20%
Existing Water Use Factor for low flow fixture fitted buildings - 2003 (gal/GSF or gal/bed)[6]	0.018	0.033	0.060	0.066	34.735
Existing Water Use Factor for non-low flow fixture fitted buildings - 2003 (gal/GSF or gal/bed)[7]	0.036	0.037	0.120	0.088	43.418
Demand from existing low flow fixture fitted buildings - 2003 (gpd)[8]	16,478	8,667	5,911	3,131	124,417
Demand from existing non-low flow fixture fitted buildings - 2003 (gpd)[9]	23,970	7,005	8,598	3,036	113,118
Total Existing Demand - 2003 (gpd)	40,448	15,672	14,509	6,167	237,535
Total Campus Demand 2020 - New Buildings fitted with Low Flow Fixtures (gpd)[10]	**70,421**	**50,244**	**27,054**	**22,374**	**427,698**
Total Campus Demand - All Buildings Retrofitted (gpd)	**58,436**	**49,543**	**22,755**	**21,615**	**405,074**

Notes:

1) Refer to Tables 1B and 1C for Existing (2003) and Proposed (2020) program summaries of Water Demand Categories. The Water Demand Category "Housing / Apts" uses # of beds program information to project future demand.
2) Refer to Table 2 for summary of Existing Demand (2003)
3) 2003 Program fitted with low flow fixtures = Existing Building Program-2003 * % of existing buildings with low flow fixtures
4) 2003 Program not fitted with low flow fixtures = Existing Building Program-2003 * [1 - % of existing buildings with low flow fixtures].
5) This calculation assumes that the existing buildings fitted with low flow fixtures are achieving a water saving of X% for each Water Demand Category. The numbers presented herein have been checked and verified as suitable for use by UCSC.
6) Water Use Factor for low flow buildings-2003 = (7) * [1 - (5)]
7) Water Use Factor for non-low flow buildings-2003 = (2) / { [(3) * [1 - (5)] + (4)}
8) Demand from low flow fitted buildings-2003 = (3) * (6)
9) Demand from non-low flow fitted buildings-2003 = (4) * (7)
10) Total Campus Demand 2020 - New Buildings fitted with Low Flow Fixtures = {[Building Program 2020 - Building Program 2003] * (6)} + (2)

Date: July 5, 2005

To: Shabnam Barati/San Jose Office

From: Ken Eichstaedt, P.E./San Francisco Office

Subject: **Review of Sanitary Sewer Condition and Capacity**
Long-Range Development Plan
University of California, Santa Cruz

This Technical Memorandum addresses the sanitary sewer (SS) system as part of the Long Range Development Plan (LRDP) for the University of California's Santa Cruz campus. The planning forecast for the year 2020 is used to define the SS flow quantities in this document. This document was revised based on comments received from the campus

OBJECTIVES

1. Assess current SS flow rates and distribution of flows within mainlines and estimate future 2020 flow rates.

2. Review as-built drawings of SS infrastructure.

3. Identify areas with insufficient capacity and preliminarily outline improvements to expand the SS system to handle forecast increase in flows.

4. Identify areas with spare capacity at 2020 flow rates.

5. Make recommendations for assessment and system improvements.

BACKGROUND

The SS system serving the UC Santa Cruz Campus is composed of two trunk or mainlines. The westerly line (the West Mainline) is a sewer trunk line that extends down Heller Drive and Empire Grade Road (see Figure 1). The West Mainline includes two sizes: a 12-inch line at the southern end starting from MH SS66-4-3 and a 10-inch line at the northern end commencing near MH SS57-2-1(see Figure 2). The material type of this mainline was not identified in the documents reviewed.

The easterly line (referred to as the Jordon Gulch line or East Mainline), extends down Jordan Gulch to the main entrance area. The East Mainline starts at the bottom of the campus as a 14-inch line and becomes a 12-inch line by Crown College. At manhole SS60-2-2, it reduces in size to 8-inches. The 14-inch section of the line is a vitrified clay pipeline (vcp).

Both the campus' West and East Mainlines connect to a 21-inch line located upstream of the sewer meter. Downstream of the meter, the line reduces to 15 inches before connecting to the City's interceptor line located at Bay Street (Figure 1).

Information on the areas of the Campus West and East Mainlines physical condition is limited. It is understood that the areas where there are trees, primarily the northern and central portions of the campus, blockages have been caused by roots growing into the lines. Review of as-built drawings provided information on the line slopes to be used. For the West Mainline, the range of slopes used are 0.5 to 1.0 percent. For the East Mainline, the range of slopes used are 2 to 2.5 percent.

The LRDP anticipates an increase in campus population from 19,400 in 2003 to 27,700 in 2020. The campus reconfiguration to support a portion of this growth includes constructing additional housing and academic space to the north of the existing campus. On the order of 65 percent of the population increase is expected to occur in existing developed areas. The 84 new units on Ranch View Terrace (in the vicinity of the campus's main entrance) that were approved under the 1988 LDRP have been included in the projected sewer flow rates. They will be connected to the East Mainline near the point of exit from the campus.

CURRENT AND PROJECTED FLOWRATES

Flow data collected from the sewage meter for 2003 identified a total flow of 110,000,000 gallons for the year. The average daily flow during school days is 288 gallons per minute (gpm) based on Diurnal Curves for School Weekday Sewer Flows for the period 1/5 to 1/21/2004 (ARUP, 4/13/05). The average peak dry weather flow (PDWF) is estimated on the order of 600 gpm based on the same Diurnal Curves, utilizing a peaking factor (PF) of 2.1.

The wet weather flow is defined as that flow occurring during a rain event. When it rains, cumulative inflow and infiltration (I&I) enters the SS system. Sources may be direct connections (e.g., cross connections [roof leaders]) or seepage through cracks and/or joints. The increase of flow in the sewage meter attributed to wet weather is on the order of 805 gpm per information reported by ARUP. The use of the 805 gpm for the wet weather flow was taken from 12/19/03 when a significant storm event occurred. The rain was heavy just prior to the measurement and was preceded by half the normal rainfall of the year (reference: http://www.cantrall.net/Rain/0203.txt.). The I & I of 805 gpm appears to be a representative figure for a wet weather condition for 2003. The I & I for 2020 was assumed to increase by 25 percent.

The cumulative peak wet weather flow (PWWF) is defined as:

PWWF = PDWF + Total Inflow/Infiltration; or:

PWWF = 600 gpm + 805 gpm = 1,405 gpm

Because the PDWF and PWWF flows are for the entire campus, to understand the proportion of the SS flow attributed to the West and East Mainlines, water usage by area on the campus was used to apportion wastewater flows between the two mainlines. Table 1 summarizes the 2003 SS flowrates by West and East Mainlines for dry and wet weather average and peak conditions.

The 2020 projected flowrates were taken from the table titled "UCSC – Water Demand and Supply Summary for 21,000 FTE (ARUP)." The SS generation numbers are proportioned similarly to water usage for 2020 (33 percent) and 2003 (39 percent). Thus, they appear appropriate to use. Table 1 provides a summary of the 2020 flowrates.

The distribution of the flow in 2020 was calculated using a weighted average. The percent distribution for 2003 for the West and East Mainlines is 29 and 71 percent, respectively. The additional flowrate associated with the 2020 conditions for the West and East Mainlines is 55 and 45 percent, respectively. Thus, the weighted average for the total flow in 2020 is 41 and 59 percent for the West and East Mainlines.

AVAILABLE CAPACITY

The capacity of the SS West and East Mainlines was evaluated in the areas most critical to servicing the new facilities envisioned under the 2005 LRDP. In the West Mainline area, manhole (MH) SS57-2-1 would likely serve as a connection point for areas developed northwest of the campus. On the East Mainline, MH SS60-2-2 appears to begin the transition to a 12-inch line from an 8-inch line, and thus could be a chokepoint.

As-built drawings indicate that the line slopes for the West and East Mainlines vary from 0.5 to 2.5 percent. The exception is at lower elevations of the system, where the West and East Mainlines connect to the 21-inch line upstream of the City meter. Downstream of the meter, the line is a 15-inch line and is an average of 0.05 percent. For discussion purposes, Table 2 includes this range of slopes to provide understanding of the impact that slope has on flowrates.

The maximum capacity of the mainlines was evaluated under both PDWF and PWWF scenarios. To be deemed adequate to pass the PDWF or PWWF for a specific section, the mainline flow rates would need to be at or less than 80 percent of the full-pipe capacity. It is recommended that 80 percent of capacity be used as the indicator for necessary mitigation to be conservative.

Based on the assumed average Mainline slopes, at the 80 percent capacity, flowrate indicates that both 10-inch segments of both the mainlines may require further evaluation. Note that this is a conservative approach because the 80 percent level is used with all flow entering the 10-inch line., when in fact, the 10-inch line would only see a portion of the flow. For the West mainline, the PWWF is roughly 616 gpm; the line capacity (at a 0.05 percent slope) for the 10- and 12-inch lines is approximately 556 and 905 gpm, respectively. For the East Mainline, the PWWF is estimated to be 1,509 gpm; the capacities (at a 2 percent slope) for the 10-, 12- and 14-inch lines are 1,113, 1,809 and 2,729 gpm, respectively. To understand the effect of the line slope on the capacity, various slopes are shown in Table 2. The line slopes used provide a conservative estimate.

CONCLUSIONS AND RECOMMENDATIONS

1. The average school day flow in 2003 was 288 gpm and is estimated to increase to 533 gpm in 2020. The PDWF and PWWF are expected to be 1,119 and 2,125 in 2020 gpm, respectively;

2. The 10-inch and smaller line sizes on both the West and East sides of the campus may require upgrading, The 12-inch and larger line sizes appear to be able to handle the projected flowrates in 2020 for the line sizes evaluated for the given slopes.

3. The tie-in of new development in the northern part of the campus to the SS system will require a new line to a connection point with sufficient capacity. For the West Mainline, this would likely be MH SS57-2-1. For the East Mainline, it is expected to be MH SS60-2-2;

4. The 15-inch line downstream of the sewer meter may be problematic in the long term under PWWF conditions. It is at 100 pecent capacity in 2020. Consideration should be given for replacement with a larger line (the invert elevations should be confirmed);

5. It is recommended that the main SS campus lines be cleaned and video taped. This would include not only the West and East Mainlines but also other lines that will likely see an increase in SS flows under future development plans. The objective of video taping is to understand the integrity and condition of key lines and their ability to support future development;

6. A sewer flow monitoring program should be initiated to evaluate current flowrates, I/I and which sewers will reach hydraulic design capacity. Monitoring methods vary from high water markers that record maximum depths to gauging with hand held mechanical tools or electronic devices. With a history of flow data, projections can forecast the year the peak flow will reach the design capacity of the sewer.

Attachments: Figure 1 – Mainline Sanitary Sewer - South
Figure 2 – Mainline Sanitary Sewer - North
Table 1 – Sanitary Sewer Flowrates (revised 061605)
Table 2 – Sanitary Sewer Mainline Capacities (revised 061605)

cc: Tom Sweet

Table 1 - Sanitary Sewer Flowrates
Long Range Development Plan - UCSC

	Flowrate (gpm)	West Mainline (gpm)	East Mainline (gpm)	Notes
2003 Percent Distribution	-	29%	71%	
2003				
Avg. Daily Flow	288	84	204	3
PDWF	600	174	426	3
Total I & I	805	233	572	4
PWWF	1,405	407	998	
2020 Additional Flow Percent Distribution		55%	45%	
2020 Weighted Percent Distribution	-	41%	59%	
2020				
Avg. Daily Flow	532.8	219	314	6
PDWF	1,119	459	660	1,5
Total I & I	1,006	413	593	2
PWWF	2,125	872	1,253	

Notes	
1	Peaking factor assumed to be 2.1
2	I & I increased by 25% for 2003
3	From Diurnal Curves by ARUP; PF =2.1 on school day (does not include weekend or vacation days).
4	From flow measurements during wet weather event (12/03)
5	Ranch View Terrace flowrate for 84 units is assumed to be 150gpd/unit and is included.
6	Based on increase of 2003 to 2020 total flowrate (85%) applied to school day (does not include weekend or vacation days).
7	Weighted average is used for the 2020 distribution of flow. Assumption used is that additional flow for 2020 is distributed at 55% to the west side and 45% to the east side. The weighted average for 2020 is 41% to the west side and 45% to the east side.
PDWF	peak dry weather flow
I/I	infiltration/inflow
PWWF	peak wet weather flow

Table 2 - Sanitary Sewer Mainline Capacities
Long Range Development Plan - UCSC

West Mainline					Slope = 0.01 (see Note 2)			Slope = 0.005		
	Mainline Size (in)	n	area (ft2)	R (sf)	slope	Q (cfs)	Q (gpm)	slope	Q (cfs)	Q (gpm)
80% capacity										
	10	0.013	0.5454	0.3514	0.01	1.75	787	0.005	1.24	556
	12	0.013	0.7854	0.3969	0.01	2.85	1,279	0.005	2.02	905
100% capacity										
	10	0.013	0.5454	0.3514	0.01	2.19	983	0.005	1.55	695
	12	0.013	0.7854	0.3969	0.01	3.56	1,599	0.005	2.52	1,131
	West Mainline PDWF 2020						**459**			**459**
	West Mainline PWWF 2020						**872**			**872**

East Mainline					Slope = 0.025 (see Note 4)			Slope = 0.02		
	Mainline Size (in)	n	area (ft2)	R (sf)	slope	Q (cfs)	Q (gpm)	slope	Q (cfs)	Q (gpm)
80% capacity										
	10	0.013	0.5454	0.3514	0.025	2.77	1,244	0.02	2.48	1,113
	12	0.013	0.7854	0.3969	0.025	4.51	2,023	0.02	4.03	1,809
	14	0.013	1.0690	0.4398	0.025	6.80	3,051	0.02	6.08	2,729
100% capacity										
	10	0.013	0.5454	0.3514	0.025	3.46	1,555	0.02	3.10	1,391
	12	0.013	0.7854	0.3969	0.025	5.63	2,528	0.02	5.04	2,261
	14	0.013	1.0690	0.4398	0.025	8.50	3,814	0.02	7.60	3,411
	East Mainline PDWF 2020						**660**			**660**
	East Mainline PWWF 2020						**1,253**			**1,253**

Interceptor Tie-In					Slope = 0.01			Slope = 0.005		
	Mainline Size (in)	n	area (ft2)	R (sf)	slope	Q (cfs)	Q (gpm)	slope	Q (cfs)	Q (gpm)
80% capacity										
	15	0.013	1.2272	0.4605	0.01	6.46	2,899	0.005	3.65	1,640
	21	0.013	2.4053	0.5763	0.01	15.85	7,112	0.005	8.96	4,023
100% capacity										
	15	0.013	1.2272	0.4605	0.01	6.46	2,899	0.005	4.57	2,050
	21	0.013	2.4053	0.5763	0.01	15.85	7,112	0.005	11.20	5,029
	Interceptor Tie-In PDWF 2020						**1,119**			**1,119**
	Interceptor Tie-In PWWF 2020						**2,125**			**2,125**

Definitions	
n	coefficient of pipe roughness (Manning's)
a	cross sectional area of flowing water
R	hydraulic radius
Notes	
1	Q derived using Manning's Equation
2	The West Mainlines have average slopes of 0.05% and 1% based on review of UCSC provided as-built drawings.
3	Flowrates identified use conservative assumption that all flow will occur in that particular Mainline.
4	The East Mainlines have average slopes of 2% and 2.5% based on review of UCSC provided as-built drawings.
PDWF	peak dry weather flow
I/I	infiltration/inflow
PWWF	peak wet weather flow