APPENDIX D: Update of the City of Santa Cruz's Long-Range Water Demand Forecast

POLICY ANALYSIS
FOR THE
PUBLIC AND PRIVATE
SECTORS
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Final Technical Memorandum

Date: September 10, 2021
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Subject: Update of the City of Santa Cruz's Long-Range Water Demand Forecast

Contents

Background

In 2014, the City of Santa Cruz Water Department (hereinafter Water Department) contracted with M.Cubed to prepare a water demand forecast for the Water Department's water service area in connection with other work being done for the Water Supply Advisory Committee. The final product was an econometric analysis of water demand and a forecast of water demand, broken down by customer class, and for total system production through 2035 (M.Cubed, 2015). This forecast was incorporated into the City of Santa Cruz's 2015 Urban Water Management Plan (UWMP). Maddaus Water Management updated the forecast in 2017 with new information on expected water savings from plumbing codes (Maddaus Water Management, 2017). Under normal weather and economic conditions, system water demand was forecast to range between 3.2 and 3.3 billion gallons per year over the 2035 planning horizon. This is the level of water demand the Water Department has been using in its operations modeling and water supply reliability studies.

In 2016, the Water Department completed a Long-Range Financial Plan and implemented several significant changes to its water rates and rate structure outlined in a Comprehensive Cost of Service Water Rate Study (Raftelis 2016). This study conservatively estimated that water sales would be at least 2.5 billion gallons per year.

Water use was rationed by the City of Santa Cruz in 2014 and 2015 due to severe drought conditions. In the years following the end of rationing, water sales have remained low, ranging between 2.3 and 2.4 billion gallons per years, somewhat below the level used in the cost-of-service study and significantly below the long-term projections.

In 2019, M.Cubed completed a comparative analysis of projected and actual water demand (M.Cubed 2019).[1] This study found that the divergence between predicted and actual water sales coincided with changes to the Water Department's water rate structure adopted in 2016. These changes resulted in marginal water cost increases greatly exceeding the rate increases assumed in the demand forecast. Most of the forecast error is explained by these increases. Differences between actual and projected water services also played a role. Together, these two factors explain 85% of the forecast error for 2018, with the increase in marginal water costs accounting for most of the difference. Weather was not found to be a significant explanatory factor, nor were differences in actual and projected water sales to large customers (UCSC and two golf courses).

Adjusting M.Cubed's original forecast for higher marginal water costs and lower service counts eliminated nearly all of the 2018 forecast error and actual water sales fell within the confidence bounds of the forecast. In light of this, it was concluded that the original forecast model's underlying structure

[1] This analysis is included with this memorandum as Attachment A.

appeared to be sound, and it was decided that re-estimation of the weather normalization parameters and price and income demand elasticities developed in 2015 would not be necessary.

In 2020, the Water Department contracted with M.Cubed to update the long-range water demand forecast. The scope of work for this update specifies completion of the following tasks:

1. Update service area population, land use, and housing projections consistent with local planning documents and AMBAG projections.
2. Using customer-level billing data, update the baseline estimates of average water use per service connection by customer class.
3. Apply adjustments to the baseline average use estimates to account for the effects of plumbing codes, on-going conservation, and marginal water service costs on average water use over the course of the forecast.
4. Adjust the projections of future UCSC water demands to be consistent with the university's Long-Range Development Plan (University of California, Santa Cruz 2021).
5. Account for effects of the covid-19 pandemic on current and future water use.
6. Prepare a technical memorandum documenting the data and procedures used to update the demand forecast and provide side-by-side comparisons of the original and updated forecasts. Prepare an Excel workbook containing the datasets and calculations used to update the water demand forecast.

This Technical Memorandum constitutes the completion of the demand forecast update. The updated demand forecast will be incorporated into the City of Santa Cruz's 2020 UWMP. The remainder of this memorandum is organized as follows. In the next section, the population, housing, and service growth projections are presented and compared to the 2015 forecast. Next, the baseline average water use estimates and adjustments are presented. The updated average use forecast is then compared to the 2015 forecast. Lastly, the housing and service growth forecasts are combined with the average use forecasts and the UCSC water use forecast to produce the water demand forecast, which is then compared to the 2015 forecast.

Population and Housing Projections

The projections of service area population and housing units are primarily based on the Association of Monterey Bay Area Governments (AMBAG) 2022 Regional Growth Forecast (hereinafter AMBAG 2022 RGF; AMBAG 2020). The following key assumptions and procedures are used to construct these projections:

- 2015 and 2020 population and housing estimates are drawn from the Water Department's 2015 and 2020 Urban Water Management Plans (UWMP).

- After 2020, growth in residential and group quarters population and housing for the Inside-City portion of the service area are taken directly from the AMBAG 2022 RGF. This includes population living within the City of Santa Cruz as well as population housed on the UCSC campus.
- After 2020, growth in residential and group quarters population and housing for the Outside-City portion of the service area are based on the AMBAG 2022 RGF projections for the unincorporated portions of Santa Cruz County and on planned redevelopment of the Capitola Mall in Capitola.
    - Housing units in the Outside-City portion of the service area are projected as follows:
        - Future housing growth in Capitola is expected to be driven by the Capitola Mall Redevelopment, which will be served by the Water Department.[2] The project is expected to add 637 new housing units.[3] The forecast assumes this new housing will be online by 2030.
        - Future housing growth for the remainder of the Outside-City service area is based on the projected housing growth rate for unincorporated portions of Santa Cruz County in the AMBAG 2022 RGF.
    - Residential and group quarters population in the Outside-City portion of the service area is projected as follows:
        - Residential population in 2015 and 2020 are equal to the Water Department's UWMP estimates (City of Santa Cruz 2016, City of Santa Cruz 2021). After 2020, residential population is equal to the product of the projected number of occupied housing units and the average persons per household estimated in 2020, which is approximately 2.37.[4]
        - Group quarters population for Capitola and the unincorporated county areas projected in the AMBAG 2022 RGF is apportioned to the Outside-City portion of the service area based on the residential population shares for these areas.

It should be noted that the method used to project population and housing units for the Outside-City portion of the service area differs from how these estimates have been developed for previous forecasts. In previous forecasts, Outside-City population and housing units were based on an allocation of Traffic Analysis Zone (TAZ) population and housing units falling within the Outside-City service boundaries. However, the AMBAG 2022 RGF TAZ projections were not available at the time this forecast was prepared and therefore an alternative approach was needed.

[2] Personal communication with Katie Herlihy, City of Capitola, January 13, 2021.
[3] Ibid.
[4] This is similar to the average persons per household of 2.36 for the Inside-City portion of the services, per the AMBAG 2022 RGF.

Tables 1 and 2 summarize the population and housing unit projections used in the demand forecast. Tables 3 and 4 compare these projections to the 2015 UWMP projections. Note that the 2015 UWMP projections extend only to 2035. The following is noted:

- The updated service area population and occupied housing unit projections for 2035 are, respectively, 2.8% and 7.9% lower than the projections in the 2015 UWMP.
- The lower occupied housing unit projection is due to (1) lower overall projected population, per the AMBAG 2022 RFG, and (2) significantly more UCSC student body housed on campus, per the proposed 2020 UC Santa Cruz LRDP, than was assumed in the 2015 UWMP.

Table 1. Water Department Service Area Population Projection

Inside-City Service Area Population

	Population			
Year	Household	UCSC	Group Quarters	Total
2015	54,755	9,034	*	63,789
2020	53,299	9,750	1,375	64,424
2025	55,335	11,650	1,860	68,845
2030	56,552	13,750	1,916	72,218
2035	57,374	15,950	1,933	75,257
2040	58,192	18,650	1,986	78,828
2045	58,877	18,650	2,007	79,534

*Household and group quarters population were not reported separately in 2015

Outside-City Service Area Population

	Population			
Year	Household	UCSC	Group Quarters	Total
2015	31,462	0	*	31,462
2020	31,744	0	*	31,744
2025	32,669	0	449	33,119
2030	33,397	0	458	33,854
2035	33,478	0	458	33,936
2040	33,568	0	457	34,025
2045	33,658	0	457	34,116

*Household and group quarters population were not reported separately in 2015 and 2020

Total Service Area Population

	Population			
Year	Household	UCSC	Group Quarters	Total
2015	86,217	9,034	*	95,251
2020	85,043	9,750	1,375 *	96,168
2025	88,004	11,650	2,309	101,964
2030	89,949	13,750	2,374	106,072
2035	90,852	15,950	2,391	109,193
2040	91,760	18,650	2,443	112,853
2045	92,535	18,650	2,464	113,650

*Household and group quarters populations were not reported separately in 2015 for the inside- and outside-city service areas and were not reported separately in 2020 for the outside-city service area.

Table 2. Water Department Service Area Housing Unit Projection

Inside-City Service Area Housing Units

	Housing Units			
Year	Occupied	Vacant	Total	Avg PPH
2015	22,039	1,496	23,535	2.48
2020	22,608	1,346	23,954	2.36
2025	23,552	1,436	24,988	2.35
2030	24,084	1,494	25,578	2.35
2035	24,422	1,552	25,974	2.35
2040	24,706	1,589	26,295	2.36
2045	24,923	1,602	26,525	2.36

Outside-City Service Area Housing Units

	Housing Units			
Year	Occupied	Vacant	Total	Avg PPH
2015	13,136	1,560	14,696	2.40
2020	13,372	1,425	14,797	2.37
2025	13,762	1,642	15,404	2.37
2030	14,068	1,748	15,816	2.37
2035	14,103	1,799	15,902	2.37
2040	14,140	1,807	15,947	2.37
2045	14,179	1,796	15,975	2.37

Total Service Area Housing Units

	Housing Units			
Year	Occupied	Vacant	Total	Avg PPH
2015	35,175	3,056	38,231	2.45
2020	35,980	2,771	38,751	2.36
2025	37,314	3,078	40,392	2.36
2030	38,152	3,242	41,394	2.36
2035	38,525	3,351	41,876	2.36
2040	38,846	3,396	42,242	2.36
2045	39,102	3,398	42,500	2.37

PPH = Persons Per Household

Table 3. Water Department Service Area Population Projection Comparison

Inside-City Service Area Population

Year	Current	2015 UWMP	% Diff
2015	63,789	63,789	0%
2020	64,424	66,860	-3.6%
2025	68,845	70,058	-1.7%
2030	72,218	73,375	-1.6%
2035	75,257	76,692	-1.9%
2040	78,828		
2045	79,534		

Outside-City Service Area Population

Year	Current	2015 UWMP	% Diff
2015	31,462	31,462	0%
2020	31,744	32,543	-2.5%
2025	33,119	33,562	-1.3%
2030	33,854	34,614	-2.2%
2035	33,936	35,698	-4.9%
2040	34,025		
2045	34,116		

Total Service Area Population

Year	Current	2015 UWMP	% Diff
2015	95,251	95,251	0.0%
2020	96,168	99,403	-3.3%
2025	101,964	103,620	-1.6%
2030	106,072	107,989	-1.8%
2035	109,193	112,390	-2.8%
2040	112,853		
2045	113,650		

Table 4. Water Department Service Area Occupied Housing Unit Projection Comparison

Inside-City Occupied Housing Units

Year	Current	2015 UWMP	% Diff
2015	22,039	21,829	1.0%
2020	22,608	23,492	-3.8%
2025	23,552	24,177	-2.6%
2030	24,084	25,136	-4.2%
2035	24,422	25,925	-5.8%
2040	24,706		
2045	24,923		

Outside-City Occupied Housing Units

Year	Current	2015 UWMP	% Diff
2015	13,136	14,644	-10.3%
2020	13,372	14,832	-9.8%
2025	13,762	15,107	-8.9%
2030	14,068	15,540	-9.5%
2035	14,103	15,884	-11.2%
2040	14,140		
2045	14,179		

Total Service Area Occupied Housing Units

Year	Current	2015 UWMP	% Diff
2015	35,175	36,473	-3.6%
2020	35,980	38,324	-6.1%
2025	37,314	39,284	-5.0%
2030	38,152	40,676	-6.2%
2035	38,525	41,809	-7.9%
2040	38,846		
2045	39,102		

Non-Residential Services Projections

The projections of non-residential services are based on historical rates of service growth and projected increases in service area population and employment.

The following key assumptions are used to construct these projections:

- Business services are assumed to increase at the same rate as service area population (excluding UCSC population housed on campus).
- No growth is assumed for Municipal services. This assumption was also used in the 2015 UWMP.
- Irrigation services are assumed to increase at the average rate of increase for the previous 15 years.
- No growth is assumed for Industrial services. Historically, industrial service growth has been slightly negative. The AMBAG 2022 RGF projects negligible growth in City of Santa Cruz manufacturing employment.
- No growth is assumed for Golf Course services. Water service to the Delaveaga golf course is assumed to continue unchanged. The Pasatiempo golf course shifted golf course irrigation to use of treated wastewater from the City of Scotts Valley in 2017. The club signed a 30-year agreement with Scotts Valley allowing it to divert the Scott Valley's secondary treated wastewater for irrigation of the golf course.[5]

Table 5 summarizes the non-residential service projections and compares them to the 2015 UWMP projections. The following is noted:

- The 2015 UWMP did not include Industrial or Golf Course service projections. Only aggregate industrial water use was projected and the Golf Course projection was based on irrigated acreage. The current projection includes a forecast of both services and irrigated acreage for Golf Courses. Relative to the 2015 UWMP, the current projection assumes less irrigated acreage for Golf Courses. This is driven by Pasatiempo's shift to using treated wastewater. This shift has proven to be faster and larger than projected in the 2015 UWMP.
- The updated projection assumes significantly fewer irrigation services than did the 2015 UWMP. The previous forecast was based on the historical relationship between the growth in the number of multi-family and business services and the number of irrigated services. This relationship began to break down during the drought and following the water rate increases. Consequently, by 2020 the previous forecast of irrigation services had diverged from actual services.

[5] The club constructed a multi-million dollar tertiary treatment, storage, and irrigation system, which began operating in 2017, to utilize Scotts Valley's wastewater.

Table 5. Santa Cruz Water Department Non-Residential Services Projection

Current Projection		**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**
		Actual	Actual	Forecast	Forecast	Forecast	Forecast	Forecast
Service Units	**Units**							
BUS	Services	1,897	1,874	1,959	2,002	2,023	2,045	2,062
IND	Services	40	38	38	38	38	38	38
MUN	Services	217	219	219	219	219	219	219
IRR	Services	460	440	448	455	463	471	479
GOLF	Services	6	3	3	3	3	3	3
	Acres	146	93	93	93	93	93	93

2015 UWMP		**2015**	**2020**	**2025**	**2030**	**2035**
		Actual	Forecast	Forecast	Forecast	Forecast
Service Units	**Units**					
BUS	Services	1,897	1,948	1,971	2,008	2,055
IND	Services	40	NA	NA	NA	NA
MUN	Services	217	218	218	218	218
IRR	Services	460	651	723	845	951
GOLF	Services	6	NA	NA	NA	NA
	Acres	146	119	109	99	99

% Difference		**2015**	**2020**	**2025**	**2030**	**2035**
		Actual	Forecast	Forecast	Forecast	Forecast
Service Units	**Units**					
BUS	Services	0%	-3.8%	-0.6%	-0.3%	-1.6%
IND	Services	0%	NA	NA	NA	NA
MUN	Services	0%	0%	0%	0%	0%
IRR	Services	0%	-32%	-38%	-46%	-51%
GOLF	Services	0%	NA	NA	NA	NA
	Acres	0%	-22%	-15%	-6%	-6%

Average Water Use Per Service

The baseline average water use per service is based on observed 2017 to 2020 water use in each customer category. Baseline average use is adjusted over the forecast period for the effects of plumbing codes, conservation programs, and changes in marginal water service costs.

The following key assumptions are used to construct these projections:

- Residential water use increased slightly in 2020. This almost surely was in part due to Covid-19 shelter-in-place orders. However, residential water use in 2020 was not significantly greater than in 2017-19 and therefore is used to establish baseline residential water use for the forecast.
- Separate residential baseline water use estimates are made for the Inside- and Outside-City service areas reflecting historical differences in consumption between these two parts of the system.
- Indoor residential water use is adjusted for plumbing code effects. A floor of 36 gallons per capita day (GPCD) is set for inside water use, which is in line with highly efficient WaterSense retrofitted households, as measured by the 2016 Residential End Uses of Water Study (Water Research Foundation 2016).
- Residential water use is adjusted for increases in marginal water cost. These adjustments are assumed to capture the effects of the City's residential conservation programs.[6]
- Business water use decreased significantly in 2020. This almost surely was the result of shelter-in-place orders in response to the Covid-19 pandemic. Changes in business water use associated with the pandemic response have been observed throughout California (Pacific Institute 2020). Because 2020 Business water use was significantly below use in 2017-19, it has been excluded from the calculation of baseline water use for the long-range forecast. Baseline business water use is based on the three-year 2017-19 average use per service.
- Baseline water use for industrial, municipal, irrigation, and golf course services is based on the four-year 2017-2020 average use per service.
- Non-residential baseline water use per service is adjusted for plumbing codes and changes in marginal water costs.
- Plumbing code effects are derived from estimates prepared by M.Cubed for the California Department of Water Resources (M.Cubed 2016).

[6] When marginal water cost increases, customers demand less water by forgoing consumption and by substituting other factors of production for it. For example, households may install more efficient water using appliances or change their landscaping and irrigation practices. Utility conservation programs facilitate these transitions and thus are not strictly exogenous to the price change. Rather, the price change motivates program participation. The empirical estimates of price elasticity used to adjust the demand forecast capture these dynamics.

- Increases in marginal water costs between 2020 and 2031 are based on Water Department projections of water service costs and rates through 2031. After 2031, marginal water costs are assumed to keep pace with general price inflation.
- Price elasticities used to adjust average water use for increases in marginal water cost are taken from M.Cubed's 2015 demand study (M.Cubed 2015).

Table 6 summarizes the average water use projections and compares them to the projections contained in the 2015 UWMP.

Table 6. Santa Cruz Water Department Average Water Use Projections

Current Projection		**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**
		Actual	Actual	Forecast	Forecast	Forecast	Forecast	Forecast
Avg Use	**Units**							
SFR	CCF/HH	59	67	66	66	66	66	66
MFR	CCF/HH	45	47	45	43	42	42	42
BUS	CCF/SVC	342	276	344	326	307	299	299
IND	CCF/SVC	1,435	1,362	1,302	1,302	1,302	1,302	1,302
MUN	CCF/SVC	214	404	329	312	289	284	284
IRR	CCF/SVC	133	233	229	203	169	164	164
GOLF	CCF/ACRE	795	558	627	580	515	503	503

2015 UWMP		**2015**	**2020**	**2025**	**2030**	**2035**
		Actual	Forecast	Forecast	Forecast	Forecast
Avg Use	**Units**					
SFR	CCF/HH	59	86	83	80	77
MFR	CCF/HH	45	56	52	50	49
BUS	CCF/SVC	341	400	389	383	377
IND	CCF/SVC	1,435	NA	NA	NA	NA
MUN	CCF/SVC	214	294	290	283	277
IRR	CCF/SVC	133	285	271	257	244
GOLF	CCF/ACRE	795	671	641	606	593

% Difference		**2015**	**2020**	**2025**	**2030**	**2035**
		Actual	Forecast	Forecast	Forecast	Forecast
Avg Use	**Units**					
SFR	CCF/HH	0%	-23%	-20%	-18%	-15%
MFR	CCF/HH	0%	-17%	-14%	-14%	-14%
BUS	CCF/SVC	0%	-31%	-12%	-15%	-19%
IND	CCF/SVC	0%	NA	NA	NA	NA
MUN	CCF/SVC	0%	37%	13%	10%	4%
IRR	CCF/SVC	0%	-18%	-16%	-21%	-31%
GOLF	CCF/SVC	0%	-17%	-2%	-4%	-13%

UCSC Water Use

Separate forecasts are provided for the main and marine science campuses.

Main Campus: The water use projection for the main campus is taken from the UCSC Draft 2021 Long Range Development Plan (LRDP). This forecast is 292 MG by 2040, the LRDP's assumed build-out year. Main campus water use in 2017-19 averaged 168 MG. The LRDP notes that some of the projected increase in demand may be offset through conservation and use of local groundwater. However, it does not quantify this potential offset and therefore the updated demand projection assumes all of the increase would be supplied by the Water Department. The projection of UCSC demand in the 2015 UWMP was based on the water demands in the 2005 LRDP, which were adjusted by UCSC in 2014. That plan estimated build-out demand of 349 MG. Thus, UCSC has reduced its projected water demand at build-out by 16%. The projection assumes a linear increase in demand between 2020 and 2040.

Marine Science Campus: The water use projection for the marine science campus is taken from UCSC Marine Science Campus CLRDP Environmental Impact Report (University of California, Santa Cruz, 2004).[7] This forecast is 26 MG by 2040, the assumed build-out year for the marine campus. Marine campus water use in recent years has averaged about 4 MG. The projection assumes a linear increase in demand between 2020 and 2040.

Coastal Irrigation, Miscellaneous Use, and System Water Losses

The Water Department currently provides untreated water to coastal agricultural irrigators on the western side of its service area. Water use by coastal irrigators has been in steady decline. It annually averaged 33 MG between 2006 and 2010, 25 MG between 2011 and 2015, and 12 MG between 2016 and 2020. An annual demand of 12 MG is assumed for purposes of the long-range forecast.

Miscellaneous water uses and system water losses are assumed to comprise 7.5% of total production (excluding coastal irrigation). This is the same assumption that was used in the 2015 UWMP forecast.

COVID-19 Impacts on Business and Residential Water Use

As noted above, residential water use was slightly higher, and business water use was significantly lower in 2020. The change in business water use is almost certainly a consequence of the shelter-in-place and business restrictions put in place in response to the COVID-19 pandemic. Changes in business water use associated with the pandemic response have been observed in other parts of California as well (Pacific Institute 2020). Because 2020 Business water use is significantly below use in 2017-19, it has been excluded from the calculation of baseline water use for the long-range forecast.

[7] Table 4.16-3 of the EIR.

Pandemic-related changes in residential water use on the order of 3-5 GPCD in other parts of California have been measured (California Department of Water Resources, 2021). Observed increases in Santa Cruz residential water use between 2017-19 and 2020 have been on the order of 2 GPCD. Some of this increase can be attributed to weather differences. Because 2020 Residential water use is not significantly different from residential use in 2017-19, it has not been excluded from the calculation of baseline water use for the long-range forecast.

Projected Water Sales and Production

Projected water sales and total production are summarized in Table 7. Projected water sales are equal to the product of projected services and average water use per service. Projected production is equal to projected water sales plus miscellaneous and coastal irrigation water uses and distribution system water losses. In 2020, total production was 2,600 MG (rounded to nearest 100 MG). This is projected to increase to 2,800 MG by 2045 (rounded to nearest 100 MG).

The updated projection for 2035 is 22 percent lower than the 2015 UWMP forecast – 2,681 MG versus 3,442 MG. The primary causes for the difference are:

- Large increases in marginal water cost occurring between 2015 and 2020 and the projected continuation of these increases from 2020 to 2031.
- Slower projected growth in service area population and occupied housing units.
- Slower projected growth in irrigation services.
- Lower projected UCSC build-out water demand.

Table 7. Santa Cruz Water Department Sales and Production Projection

YEAR		**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**
		Actual	Actual	Forecast	Forecast	Forecast	Forecast	Forecast
Service Units	**Units**							
SFR	Households	19,029	19,119	19,249	19,380	19,511	19,644	19,777
MFR	Households	16,146	16,861	18,065	18,773	19,014	19,203	19,325
BUS	Services	1,897	1,874	1,959	2,002	2,023	2,045	2,062
IND	Services	40	38	38	38	38	38	38
MUN	Services	217	219	219	219	219	219	219
IRR	Services	460	440	448	455	463	471	479
GOLF	Services	6	3	3	3	3	3	3
UC Coastal	Services	2	2	2	2	2	2	2
UC Main	Services	9	9	9	9	9	9	9
Avg Use	**Units**							
SFR	CCF/HH	59	67	66	66	66	66	66
MFR	CCF/HH	45	47	45	43	42	42	42
BUS	CCF/SVC	342	276	344	326	307	299	299
IND	CCF/SVC	1,435	1,362	1,302	1,302	1,302	1,302	1,302
MUN	CCF/SVC	214	404	329	312	289	284	284
IRR	CCF/SVC	133	233	229	203	169	164	164
GOLF	CCF/SVC	19,339	17,309	19,441	17,988	15,964	15,608	15,608
UC Coastal	CCF/SVC	2,931	2,933	6,604	10,276	13,947	17,618	17,618
UC Main	CCF/SVC	23,154	15,688	22,610	29,532	36,453	43,375	43,375
Sales	**Units**							
SFR	MG	835	952	954	952	958	966	974
MFR	MG	538	588	604	608	602	607	611
BUS	MG	485	388	504	488	464	458	462
IND	MG	43	39	37	37	37	37	37
MUN	MG	35	66	54	51	47	47	47
IRR	MG	46	77	77	69	59	58	59
GOLF	MG	87	39	44	40	36	35	35
UC Coastal	MG	4	4	10	15	21	26	26
UC Main	MG	156	106	152	199	245	292	292
Total	**MG**	**2,228**	**2,257**	**2,435**	**2,459**	**2,469**	**2,526**	**2,543**
MISC/LOSS	MG	223	348	197	199	200	205	206
Coastal Irr.	MG	34	6	12	12	12	12	12
Production	**MG**	**2,486**	**2,612**	**2,645**	**2,671**	**2,681**	**2,742**	**2,761**
Rounded	**MG**	**2,500**	**2,600**	**2,600**	**2,700**	**2,700**	**2,700**	**2,800**
2015 UWMP								
Production	**MG**		**3,385**	**3,350**	**3,389**	**3,442**		
Rounded	**MG**		**3,400**	**3,400**	**3,400**	**3,400**		

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Attachment A - Comparative Analysis of Projected and Actual Water Demand in 2018

POLICY ANALYSIS FOR THE PUBLIC AND PRIVATE SECTORS
M.CUBED

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DATE: February 22, 2019
TO: Toby Goddard
City of Santa Cruz Water Department
FR: David Mitchell
RE: Comparative Analysis of Projected and Actual Water Demand in 2018

Introduction and Summary of Findings

In 2014, the Water Department contracted with M.Cubed to prepare a water demand forecast for the City's water service area in connection with the work being done for the Water Supply Advisory Committee. The final product was an econometric analysis of water demand and a forecast of water demand, broken down by customer class, and for total system production through 2035 (M.Cubed, August 2015). Two near-term sales forecasts spanning 2014-2020 were also prepared for the Water Department, one by M.Cubed and the other by Raftelis Financial Consultants.[8] M.Cubed summarized and compared the two near-term forecasts in a memorandum to the Water Department dated August 12, 2015 (Attachment 1). The two near-term forecasts are compared to actual sales in Figure 1.[9] Both forecasts assumed a period of sales rebuilding (or rebound) following the lifting of drought water use restrictions. The M.Cubed forecast predicted quicker rebound than the Raftelis forecast. So far the Raftelis forecast has performed well with a mean absolute forecast error of less than 5% between 2015 and 2018. The M.Cubed forecast has not performed as well. While it closely tracked actual sales in 2014 and 2015, it began to diverge from actual sales in 2016. After normalizing for weather, the M.Cubed forecast is approximately 19% greater than actual sales in 2018 (see Table 2).

The divergence of the M.Cubed forecast from actual sales coincided with changes to the City's water rate structure adopted in 2016 that resulted in significant increases in the marginal cost of water service.[10] As demonstrated later, most of the forecast error is explained by the increase in the marginal cost of water service. Differences between actual and projected service units also played a role. Together, these two factors explain roughly 85% of the 2018 forecast error, with the increase in the

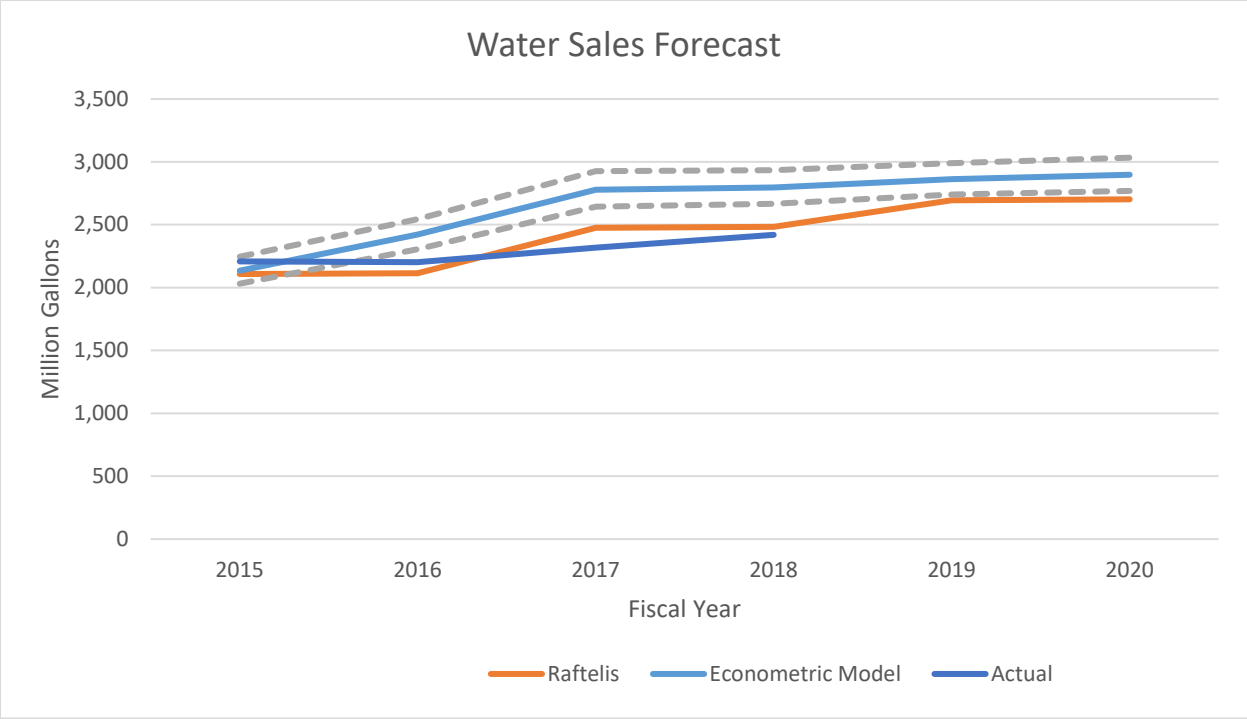
[8] The M.Cubed forecast spanned 2014-2020 while the Raftelis forecast spanned 2015-2020.
[9] The forecasts did not include sales to Coast Irrigation or Miscellaneous/Other. System losses also were not included as part of the forecast.
[10] These changes are described in the Water Department's Comprehensive Cost of Service Water Rate Study (2016).

marginal cost of water service accounting for most of the explanation. Weather was not found to be a significant explanatory factor, nor were differences in actual and projected sales to large customers (UCSC and the two golf courses).

Recalibrating the M.Cubed forecast to actual service units and marginal water service cost eliminates most of the forecast error. Calibrating the forecast to actual service units reduces the forecast error from 19% to 14% (see Tables 2 and 4). Adjusting the forecast for the increase in the marginal cost of water service further reduces the forecast error from 14% to 3% (see Tables 4 and 7). After making these adjustments, actual sales in 2018 are bracketed by the lower- and upper-bounds of the recalibrated forecast (see Table 7).

The analysis suggests that the increase in the marginal cost of water service was the primary cause for the divergence between actual and forecast sales in 2018. This has implications for the long-term forecast as well, assuming the higher marginal costs will carry forward into the future. If this is the case, then the long-range forecast should be adjusted to reflect the effect of these higher marginal costs on the future demand for water.

Figure 1. Forecast and Actual Sales, FY 2015-2020



Forecast and Actual 2018 Sales

Table 1 shows the original M.Cubed forecast compared to actual 2018 sales. The largest relative forecast errors are associated with industrial (44%) and irrigation (49%) water uses. The smallest

relative forecast errors are associated with business (9%) and municipal (3%) water uses. Most of the absolute error, however, is associated with single-family and multiple residential water use. Note that the comparison between actual and forecast sales in Table 1 has not been normalized for weather.

Table 8. Actual and Forecast Water Sales in CY2018 in Million Gallons, Not Normalized for Weather

	Actual	Forecast	Diff	% Diff
Single Family Residential	925	1,124	199	21%
Multiple Residential	564	652	88	16%
Business	501	546	45	9%
Industrial	39	56	17	44%
Municipal	45	46	1	3%
Irrigation	76	113	37	49%
Golf Course Irrigation	57	66	9	15%
UCSC	174	192	18	10%
Total	2,381	2,796	415	17%
Lower-Bound Forecast		2,656	275	12%
Upper-Bound Forecast		2,936	554	23%

Weather Normalization

Normalizing for actual weather conditions in 2018 results in the forecast shown in Table 2. Weather normalization causes predicted sales to increase by approximately 1% which in turn increases the forecast error by approximately 2%, from 17% to 19%.

Projected Versus Actual Service Units

The sales forecast depends on projections of service units. Actual and projected service units for 2018 are shown in Table 3.[11] The difference between projected and actual service units is less than 5% except in the case of irrigation, where the difference is nearly 40%. Between 1999 and 2013 there was a strong positive correlation between the total number of multi-family and business accounts and the number of irrigation accounts. This relationship provided the basis for the forecast of irrigation services. However, the relationship appears to have broken down more recently and the number of irrigation accounts has

[11] Actual service units for multi-family residential are calculated by multiplying the number of multi-family accounts by 6.38, the average number of multi-family dwelling units per account. This is the same dwelling unit factor used in the original forecast.

actually declined slightly since 2013. This may partly be a consequence of drought water use restrictions and higher marginal water cost.

Table 9. Actual and Weather-Normalized Forecast Water Sales in CY2018 in Million Gallons

	Actual	Weather-Adjusted Forecast	Diff	% Diff
Single Family Residential	925	1,125	200	22%
Multiple Residential	564	652	88	16%
Business	501	553	52	10%
Industrial	39	56	17	44%
Municipal	45	49	5	10%
Irrigation	76	117	41	53%
Golf Course Irrigation	57	79	21	37%
UCSC	174	192	18	10%
Total	2,381	2,823	442	19%
Lower-Bound Forecast		2,682	301	13%
Upper-Bound Forecast		2,965	583	24%

Table 10. Actual and Projected Service Units

	Service Units	Actual	Projected	Diff	% Diff
Single Family Residential	Housing Units	19,074	19,312	238	1%
Multiple Residential	Housing Units	17,673	18,450	778	4%
Business	Accounts	1,879	1,931	52	3%
Municipal	Accounts	219	218	-1	0%
Irrigation	Accounts	435	594	159	37%
Golf Course Irrigation	Acres	Unknown	127		

The 2018 sales forecast calibrated to the actual number of service units is shown in Table 4. The forecast error drops from 19% to 14%. Thus, errors in the projected number of service units explain a bit more than one-fourth of the forecast error.

Table 11. Actual and Service Unit Calibrated Forecast Water Sales in CY2018 in Million Gallons

	Actual	Service Unit Calibrated Forecast	Diff	% Diff

Single Family Residential	925	1,111	186	20%
Multiple Residential	564	623	60	11%
Business	501	538	37	7%
Industrial	39	56	17	44%
Municipal	45	49	5	11%
Irrigation	76	74	-2	-3%
Golf Course Irrigation	57	79	21	37%
UCSC	174	192	18	10%
Total	2,381	2,723	341	14%
Lower-Bound Forecast		2,587	205	9%
Upper-Bound Forecast		2,859	478	20%

Water Rates

Table 5 summarizes the differences between actual and forecast marginal cost of water service. The calculation of these percentages is provided in Attachment 2. By 2018 actual marginal cost was between 55% and 79% greater than forecast marginal cost.

Table 12. Exceedence of Actual to Forecast Marginal Cost of Water Service

Year	Inside City	Outside City	UCSC
2014	0%	0%	0%
2015	1%	1%	1%
2016	18%	13%	18%
2017	73%	55%	76%
2018	74%	55%	79%

The parameters in Table 6 were used to adjust the sales forecast for the higher marginal cost of water service. For example, the single-family residential sales adjustment factor in Table 6 is calculated as:

SFR Adjustment Factor = 1 + -.114*[.74*.623+.55*.377] = 0.924

This is the weighted-average price adjustment for inside- and outside-city single-family residential customers. Thus, on average, the higher marginal cost of water service would be expected to reduce single-family water sales by 7.6%, given the sales shares and elasticity estimates in Table 6.

Because price elasticities were not estimated for UCSC and industrial customers in the original econometric analysis, the elasticity for inside-city business customers is used as a proxy for these two classes.

Table 13. Parameters Used to Re-Calibrate Sales Forecast to Actual 2018 Marginal Cost of Water Service

	Marginal Water Cost % Increase		Sales Share		Price Elasticity		Sales Adjustment Factor 1/
	Inside	Outside	Inside	Outside	Inside	Outside	
Single Family Residential 2/	74%	55%	0.623	0.377	-0.114	-0.114	0.924
Multiple Residential	74%	55%	0.560	0.440	-0.124	-0.124	0.919
Business	74%	55%	0.630	0.370	-0.099	-0.262	0.901
Industrial 3/	74%	55%	1.000	0.000	-0.099		0.927
Municipal	74%	NA	1.000	0.000	-0.237		0.825
Irrigation	74%	55%	0.644	0.356	-0.545	-0.545	0.634
Golf Course Irrigation	74%	55%	0.446	0.554	-0.358	-0.358	0.773
UCSC 3/	79%	NA	1.000	0.000	-0.099		0.922

Notes:
1/ Sales Adjustment Factor is equal to one plus the sales weighted average adjustment for inside and outside city customers.
2/ The single family residential elasticity is the sales weighted average of the peak and off-peak elasticities estimated with the econometric model.
3/ Inside-city business price elasticity used as proxy for industrial and UCSC price response.

Table 7 shows the adjusted sales forecast, calibrated to actual marginal water service cost. Re-calibrating the forecast to actual marginal cost reduces the forecast error from 14% to 3%. There are still significant class-level errors following recalibration, but these mostly cancel out. Note that predicted UCSC and golf course sales are now close to their actuals, indicating that their forecast errors in previous tables are largely resolved by the marginal cost adjustment.

Re-calibrating the sales forecast to the actual service units and marginal water service cost eliminates approximately 85% of the 2018 forecast error. Actual sales now fall between the lower- and upper-bounds of the forecast.

Table 14. Actual and Marginal Water Cost Calibrated Forecast Water Sales in CY2018 in Million Gallons

	Actual	Marginal Water Cost Calibrated Forecast	Diff	% Diff

Single Family Residential	925	1,026	101	11%
Multiple Residential	564	572	9	2%
Business	501	484	-17	-3%
Industrial	39	52	13	33%
Municipal	45	41	-4	-9%
Irrigation	76	47	-29	-38%
Golf Course Irrigation	57	61	4	6%
UCSC	174	177	3	2%
Total	2,381	2,461	79	3%
Lower-Bound Forecast		2,338	-44	-2%
Upper-Bound Forecast		2,584	202	9%

Drought Recovery

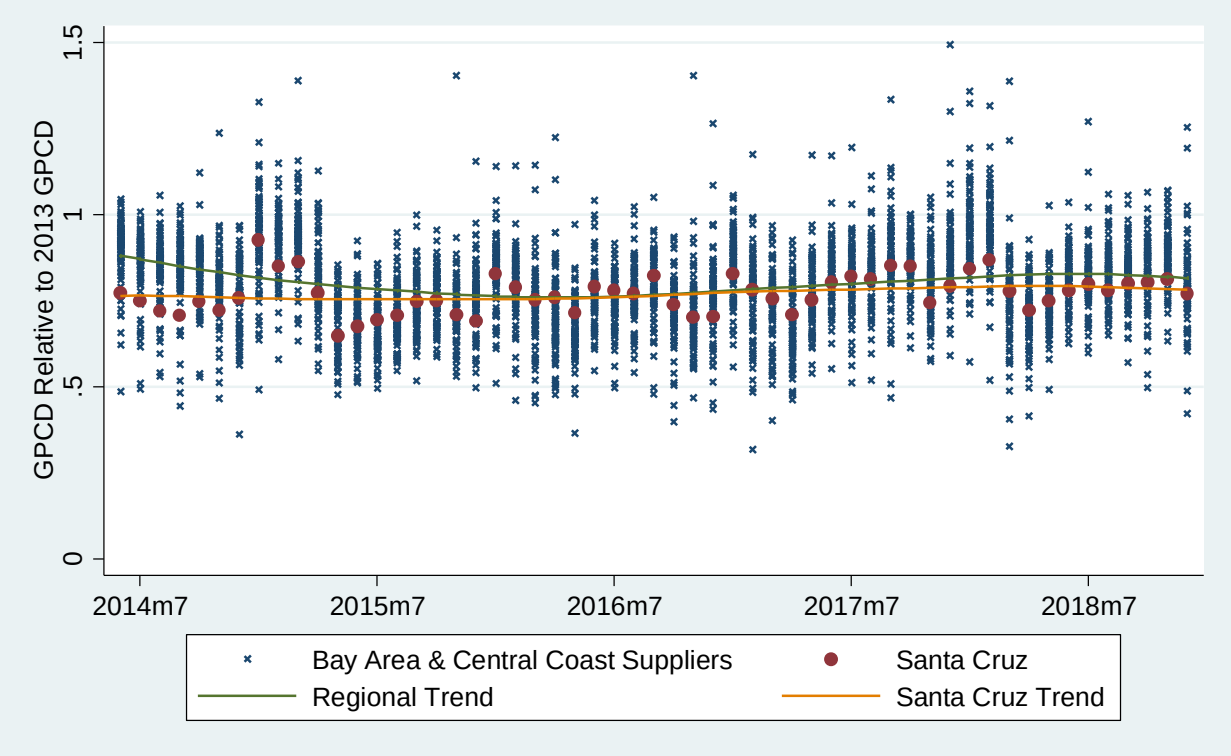
Santa Cruz's drought recovery has lagged the average rate of recovery for all water suppliers in the Bay Area and Central Coast hydrologic regions. Figure 2 shows actual and trend monthly GPCD relative 2013. Starting in 2017, Santa Cruz's recovery began to lag the regional trend. This is also illustrated in Table 8, which compares Santa Cruz's year-over-year percentage change in GPCD to the mean and median rates for Bay Area and Central Coast water suppliers.

The divergence in drought recovery rate coincides with Santa Cruz's increase in the marginal cost of water service. Of course there may be other causes of the divergence and Santa Cruz's recovery has been faster than many other suppliers (see Figure 2), but the escalation in the marginal cost of water service is at the very least consistent with a slower rate of drought recovery.

Table 15. Year-Over-Year Change in GPCD

		Bay Area and Central Coast Water Suppliers	
Year	Santa Cruz	Mean	Median
2017	3.3%	8.7%	6.3%
2018	-1.0%	3.0%	0.3%
Source: State Water Resource Control Board			

Figure 2. Monthly GPCD Relative to 2013 Monthly GPCD



Summary of Findings

To summarize the results of this analysis:

- The Raftelis near-term forecast has performed well with a mean absolute forecast error of less than 5% between 2015 and 2018. The M.Cubed forecast has not performed as well. While it closely tracked actual sales in 2014 and 2015, it began to diverge from actual sales in 2016. After normalizing for weather, the M.Cubed forecast was approximately 19% greater than actual sales in 2018 (see Table 2).

- Recalibrating the M.Cubed forecast to actual service units and marginal water service cost eliminates most of the forecast error. Calibrating the forecast to actual service units reduces the forecast error from 19% to 14% (see Tables 2 and 4). Adjusting the forecast for the increase in the marginal cost of water service further reduces the forecast error from 14% to 3% (see Tables 4 and 7). After making these adjustments, actual sales in 2018 are bracketed by the lower- and upper-bounds of the forecast (see Table 7).

- Santa Cruz's drought recovery has lagged the average rate of recovery for the Bay Area and Central Coast hydrologic regions. The divergence in drought recovery rate coincides with Santa Cruz's increase in the marginal cost of water service. Of course there may be other causes of the divergence and Santa Cruz's recovery has been faster than many other suppliers (see Figure 2), but the escalation in the marginal cost of water service is at the very least consistent with a slower rate of drought recovery.

- The analysis suggests that the increase in the marginal cost of water service was the primary cause for the divergence between actual and forecast sales in 2018. This has implications for the long-term forecast as well, assuming the higher marginal costs will carry forward into the future. If this is the case, then the long-range forecast should be adjusted to reflect the effect of these higher marginal costs on the future demand for water.

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Attachment 1:

M.Cubed August 12, 2015 Memorandum to Toby Goddard, Santa Cruz Water Department

POLICY ANALYSIS
FOR THE
PUBLIC AND PRIVATE
SECTORS
M.CUBED

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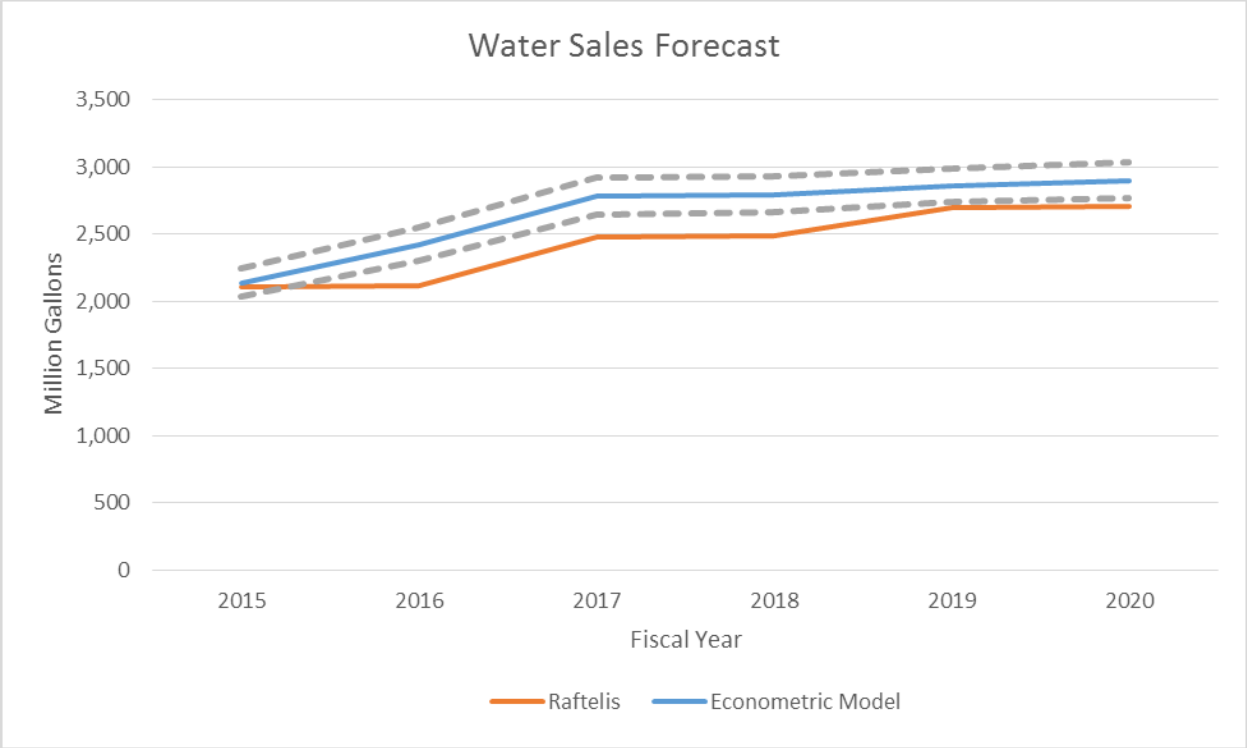
DATE: August 12, 2015
TO: Toby Goddard, City of Santa Cruz
FR: David Mitchell
RE: FY2015-2020 Water Sales Forecast

A comparison of the Raftelis and M.Cubed water sales forecasts for FY2015-2020 is provided in the following figure. The data used to generate the figure are provided at the end of this memo.



The following is noted:

- The Raftelis forecast is about eight percent less, on average, than the M.Cubed primary forecast; and about three and a half percent less, on average, than the M.Cubed lower-bound forecast.

- The main difference is in the middle period of the forecast. The two forecasts are almost the same at the beginning and end of the forecast period, but they diverge in the middle. The Raftelis forecast assumes a slower rate of sales recovery from the drought than the M.Cubed forecast.

- The Raftelis forecast, though more conservative, is not at odds with the M.Cubed forecast. Both indicate a period of sales rebuilding between FY2016 and FY2019, and then a leveling off of sales in the range of 2,700 to 2,900 million gallons.

- The rate of drought recovery is a big uncertainty, so the two forecasts together may provide a useful range for revenue analysis and fiscal planning.

We made the following assumptions to generate the M.Cubed sales forecast for FY2015-2020:

- Weather variables in the model were set to their long-term normal values.

- Drought stage restrictions were used as a proxy in the model for a gradual rebound in sales even if the drought were to end this year. Stage 3 drought restrictions were assumed to stay in place for the remainder of 2015. Stage 2 drought restrictions were assumed to be in effect in 2016 and 2017. Stage 1 drought restrictions were assumed to be in effect in 2018. No restrictions were assumed in effect in 2019 and 2020. The rate of this rebound, of course, is highly uncertain. For example, if we had used a linear extrapolation from 2015 (Stage 3) to 2020 (no restriction), the sales forecast would show a more gradual rise and lay somewhat closer to the Raftelis forecast. Our approach assumes that golf, irrigation, and municipal demands will snap back more quickly once the stage 3 restrictions are lifted.

- Housing vacancy and unemployment rates were projected along a linear trend from their current levels to their long-term normal levels by 2020.

- Household income and water rates were projected along a linear trend from their current levels to their 2020 forecasted levels.

A backcast of 2014 total production was made with the model. The model predicted total (calendar year) 2014 production of 2,612 million gallons, essentially the same as actual production of just about 2,600 million gallons. For (calendar year) 2015, the model predicts sales of 2,126 million gallons and total production of 2,298 million gallons, which is right in line with current Water Department expectations.

Santa Cruz Water Department Water Sales Forecast: FY2015-2020, Million Gallons

Primary Forecast									TOTAL	MISC/	TOTAL	Raftelis	%
Fiscal Year	SFR	MFR	BUS	IND	MUN	IRR	GOLF	UC	SALES	LOSS	PROD	Sales	Difference
2015	757	535	468	56	27	50	55	186	2,135	173	2,308	2,108	-1.3%
2016	921	588	506	56	34	70	58	188	2,421	196	2,618	2,114	-12.7%
2017	1,121	648	547	56	44	104	69	190	2,780	225	3,005	2,476	-10.9%
2018	1,124	652	546	56	46	113	66	192	2,796	227	3,023	2,484	-11.2%
2019	1,160	660	546	56	49	132	63	194	2,861	232	3,093	2,694	-5.9%
2020	1,188	661	545	57	48	141	60	196	2,898	235	3,132	2,702	-6.7%
Lower Bound Forecast									TOTAL	MISC/	TOTAL	Raftelis	%
Fiscal Year	SFR	MFR	BUS	IND	MUN	IRR	GOLF	UC	SALES	LOSS	PROD	Sales	Difference
2015	714	517	448	56	24	44	44	183	2,031	165	2,196	2,108	3.8%
2016	869	569	489	56	30	61	48	184	2,306	187	2,493	2,114	-8.3%
2017	1,058	625	533	56	39	90	58	184	2,643	214	2,858	2,476	-6.3%
2018	1,067	629	531	56	41	101	55	185	2,666	216	2,882	2,484	-6.8%
2019	1,113	637	530	56	45	120	53	185	2,739	222	2,962	2,694	-1.7%
2020	1,140	635	529	56	44	129	50	186	2,769	225	2,994	2,702	-2.4%
Upper Bound Forecast									TOTAL	MISC/	TOTAL	Raftelis	%
Fiscal Year	SFR	MFR	BUS	IND	MUN	IRR	GOLF	UC	SALES	LOSS	PROD	Sales	Difference
2015	803	553	489	56	30	58	68	189	2,246	182	2,428	2,108	-6.1%
2016	975	609	523	56	38	80	71	193	2,545	206	2,751	2,114	-16.9%
2017	1,188	671	562	56	50	119	82	196	2,925	237	3,162	2,476	-15.4%
2018	1,183	676	562	57	51	128	79	200	2,935	238	3,173	2,484	-15.4%
2019	1,209	685	562	57	53	145	76	203	2,990	242	3,233	2,694	-9.9%
2020	1,238	688	562	57	53	155	72	207	3,033	246	3,279	2,702	-10.9%

Attachment 2:
Marginal Cost Indices Used in Original and Recalibrated M.Cubed Forecasts

The marginal cost index used in the original M.Cubed forecast is provided in the following table, which is from Attachment 7 of M.Cubed 2015 Sales Forecast Report. The original forecast assumed a 32.1% increase in the marginal cost of water from 2014 to 2018.

Year	Caltrans Inflation Rate Forecast	% Change in Water Rate	% Change Net of Inflation	Real Water Rate Index	% Change from 2014
2014	2.8%			100.0	
2015	3.3%	10.0%	6.7%	106.7	6.7%
2016	3.2%	10.0%	6.8%	114.0	14.0%
2017	2.4%	10.0%	7.6%	122.6	22.6%
2018	2.3%	10.0%	7.7%	132.1	32.1%
2019	2.4%	10.0%	7.6%	142.1	42.1%
2020	2.3%	4.4%	2.1%	145.1	45.1%

The average annual commodity charges based on actual rates and charges are provided in the next table. The actual increase in the marginal cost of water between 2014 and 2018 ranged from 104% to 137%.

	Average Commodity Charge ($/CCF, 2013 $)				Real Water Rate Index		
Year	Inside City	Outside City	UCSC		Inside City	Outside City	UCSC
2014	$4.03	$5.13	$4.03		100.0	100.0	100.0
2015	$4.32	$5.51	$4.32		107.3	107.4	107.3
2016	$5.39	$6.62	$5.39		134.0	129.1	134.0
2017	$8.56	$9.74	$8.68		212.5	189.7	215.7
2018	$9.27	$10.50	$9.52		230.2	204.5	236.5
2019	$9.56	$10.84	$9.83		237.6	211.1	244.1
2020	$9.92	$11.24	$10.20		246.4	219.0	253.2

Actual marginal costs are 55% to 79% larger in 2018 than assumed in the original M.Cubed forecast, as shown in the next table.

Rate Category	Real Water Rate Index in 2018		% Difference
	Original Forecast	Actual Rates	
Inside City	132.1	230.2	74.3%

Outside City	132.1	204.5	55.8%
UCSC	132.1	236.5	79.0%