



Soquel Creek Water District
Groundwater Replenishment Feasibility Study

ADDENDUM TO TECHNICAL MEMORANDUM 2 (CEC REMOVAL THROUGH ADVANCED TREATMENT) SECONDARY EFFLUENT SAMPLING RESULTS

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SECONDARY EFFLUENT SAMPLING RESULTS

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PROJECT PURPOSE AND DEFINITION

This Addendum summarizes the concentrations of various chemical constituents in the Santa Cruz Wastewater Treatment Facility's (SCWWTF) secondary effluent, including unregulated Constituents of Emerging Concern (CECs) and regulated drinking water chemicals. The SCWWTF is the potential source water for advanced water purification and potable water reuse for the proposed Pure Water Soquel project. This Addendum is a supplement to Technical Memorandum No. 2 CEC Removal Through Advanced Treatment (CEC TM), provided to the Soquel Creek Water District (SqCWD) in March 2016. The CEC TM provided a comprehensive literature review detailing the reported occurrence of a wide range of CECs in secondary effluent and their removal across advanced water purification facilities (AWPFs), including microfiltration (MF), reverse osmosis (RO), and Ultra Violet advanced oxidation (UV AOP).

To provide context, this addendum compares the CEC concentrations in the SCWWTF secondary effluent with occurrence data from other sites. Removal of detected CECs in the SCWWTF secondary effluent by purification processes is also estimated, based upon results from other sites using the same treatment processes planned for the Pure Water Soquel AWPF. Lastly, anticipated purified water CEC concentrations are compared with CEC monitoring data from the San Lorenzo River (SLR), published in August 2016 by the City of Santa Cruz as well as reported sampling data from USGS for Soquel Creek Water District groundwater.

MATERIALS, METHODS, AND COLLABORATING PARTIES

SCWWTF staff conducted four grab sampling events over a one month period of time. Grab samples of secondary effluent from SCWWTF were sent to Eurofins Eaton Analytical Laboratories (Eurofins) to perform all analytical analyses for this study. Data from the sampling events were provided to Carollo Engineers for analysis and reported in this Addendum.

All analyzed constituents, including regulated chemicals (i.e. those with maximum contaminant levels (MCLs), secondary MCLs or notification levels (NLs)) and CECs were measured during sampling event #1. The subsequent three sampling events measured only the CEC list constituents. Table 1 details the four sampling events.

A detailed description of all methods, quality assurance/quality control (QA/QC) procedures, and laboratory responsibilities are included in the source water sampling plan.

Table 1 Sampling Event Details at the SCWWTF Treatment Facility

Sampling Event	Sample Date	Sampling Method	Santa Cruz WWTF Secondary Effluent ⁽¹⁾						
			CECs ⁽²⁾	Inorganics (Table 64431-A, 64432-A) ⁽³⁾	Organic Chemicals (Table 64444-A) ⁽³⁾	Disinfection Byproducts (Table 64533-A) ⁽³⁾	Secondary MCLs (Table 64449-A) ⁽³⁾	Contaminants with Notification Levels ⁽³⁾	Radionuclides (Tables 64442 and 64443) ⁽³⁾
1	5/30/2017	Grab Sampling	1	1	1	1	1	1	1
2	6/6/2017	Grab Sampling	1						
3	6/13/2017	Grab Sampling	1						
4	6/20/2017	Grab Sampling	1						

Notes:

- (1) Values in this table represent the number of samples that will be collected in that sampling period and analyzed for the corresponding constituents.
- (2) A complete list of the CECs tested are included in Table 6 of the Sampling Plan and Table 3 of this document.
- (3) Each class of chemicals is detailed in Table 5 of sampling plan.

SECONDARY EFFLUENT (SOURCE WATER) ANALYSIS

Summary of Constituent Detections

Key findings are listed below, with a detailed breakdown of all regulated chemical concentrations, associated MCLs, and method reporting limits (MRLs) shown in Table 2. Results from all four CEC sampling events, health screening levels, and MRLs are detailed in Table 3.

- Of the 174 chemicals analyzed per California requirements for potable water reuse, 129 chemicals were not present in the SCWWTF secondary effluent, and 45 were detected; of those 45:
 - 16 were chemicals regulated as Primary MCLs.
 - 8 were chemicals regulated as Secondary MCLs.
 - 4 were chemicals listed as NLs.
 - 17 were unregulated chemicals.
- All four (4) detected chemicals that have regulatory NLs were found below the associated regulatory notification level.
- Of the 16 chemicals with primary drinking water MCLs, all were below their respective MCLs, with the exception of nitrite which was detected at 1.4 mg/L - above the MCL of 1 mg/L.
- Eight secondary MCL chemicals were detected and all were below the associated secondary MCL, with the exception of color and odor, which is not unusual for secondary wastewater effluent.
- For the unregulated CECs, 17 CECs were detected in the SCWWTF secondary effluent, and all were found to be below their associated health screening levels.

Table 2. Detected Regulated Chemical Concentrations and MCLs, Secondary MCLs, and Notification Levels (NLs).

Chemical Class	Analyte	Concentration	Units	MRL	MCL ⁽¹⁾
Chemicals with NLs	Boron Total ICAP	280	µg/L	50	1000
	Chlorate by IC	51	µg/L	10	800
	Formaldehyde	9.6	µg/L	5	100
	N-Nitrosodiethylamine (NDEA)	2.8	ng/L	2	10
Chemicals with Secondary MCLs	Apparent Color	70	ACU	6	15
	Chloride	160	mg/L	5	250
	Manganese Total ICAP/MS	200	µg/L	2	500
	Odor at 60 C (TON)	67	TON	1	3
	Sulfate	78	mg/L	2.5	250
	Surfactants	0.12	mg/L	0.1	0.5
	Turbidity	1	NTU	0.1	5
	Zinc Total ICAP/MS	32	µg/L	5000	5000
Chemicals with MCLs	2,4-D	250	ng/L	5	7000
	Aluminum Total ICAP/MS	22	µg/L	20	1000
	Antimony Total ICAP/MS	1	µg/L	1	200
	Arsenic Total ICAP/MS	4	µg/L	1	6
	Asbestos	<MRL	MFL	0.2	7
	Barium Total ICAP/MS	16	µg/L	2	1000
	Beta, Gross	18	pCi/L	3	50
	Copper Total ICAP/MS	7.1	µg/L	2	1300
	D/DBP Haloacetic Acids (HAA5)	3.4	µg/L	2	60
	Fluoride	180	µg/L	0.1	2000
	Nitrate as Nitrogen by IC	6.6	mg/L	0.5	10
	Nitrate as NO3 (calc)	29	mg/L	2.2	45
	Nitrite Nitrogen by IC	1.4	mg/L	0.3	1
	Strontium 90 (sub)	<MRL	pCi/L	1.1	8
	Total Nitrate, Nitrite-N, CALC	8	mg/L	0.1	10
	Tritium	<MRL	pCi/L	292	20000

ICAP = Inductively Coupled Argon Plasma - a detection method for trace metals

MS = Mass Spectrometry - a detection method for trace organics or metals.

NL = Notification Level

MCL = Maximum Contaminant Level

MRL = Method Reporting Limit

<MRL = Detected below Method Reporting Limit

TON = Threshold Odor Number

Note:

(1) Based on CA DDW Title 22 Table 64431-A, Table 6449-A, Table 6449-B, Table 64442, Table 64443, Table 6444-A, and Table 64533-A.

Table 3 CEC Monitoring Results in SCWWTF Secondary Effluent and Associated Health Screening Levels

Analyte	Common Use	Units	SCWWTF Secondary Effluent Sampling Events					Health Screening Level ^(1,2,3)	MRL
			5/30/2017	6/6/2017	6/13/2017	6/20/2017	Average		
4-nonylphenol	Manufacturing	ng/L	680	1100	1700	1300	1195	500,000	100
Acetaminophen	Analgesic	ng/L	56	21	28	19	31	350,000	5
Atenolol	Beta Blocker	ng/L	ND	810	1400	740	983	70,000	5
Caffeine	Stimulant/additive	ng/L	36	ND	ND	8	22	350	5
Carbamazepine	Anti-convulsant	ng/L	440	410	910	420	545	1,000	5
DEET	Insect Repellent	ng/L	130	50	46	74	75	2,500	10
Estradiol - 17Beta	Natural Steroid Hormone	ng/L	ND	ND	ND	ND	ND	1	0.4
Estrone	Natural Steroid Hormone	ng/L	<MRL	<MRL	<MRL	<MRL	<MRL	350	1
Ethinylestradiol - 17Alpha	Synthetic Hormone	ng/L	ND	ND	ND	ND	ND	280	5
Fluoxetine	Anti-depressant	ng/L	ND	ND	ND	ND	ND	10,000	10
Gemfibrozil	Anti-cholesterol	ng/L	ND	530	840	990	787	45,000	5
Ibuprofen	Anti-inflammatory	ng/L	1800	2600	37	2100	1634	40,000	10
Meprobamate	Anti-anxiety	ng/L	230	230	250	190	225	260,000	5
Naproxen	Anti-inflammatory	ng/L	520	420	170	540	413	220,000	10
PFOA	Manufacturing	ng/L	<MRL	<MRL	<MRL	<MRL	<MRL	400	2.5
PFOS	Manufacturing	ng/L	<MRL	<MRL	<MRL	<MRL	<MRL	200	2.5
Primidone	Anti-convulsant	ng/L	ND	61	94	75	77	840	5
Progesterone	Natural Steroid Hormone	ng/L	ND	ND	ND	ND	ND	110,000	5
Sucralose	Artificial sweetener	µg/L	240	47	38	71	99	150 ⁽⁴⁾	1
Sulfamethoxazole	Antibiotic	ng/L	4000	2200	2400	2700	2825	35,000	5
TCEP	Flame retardant	ng/L	340	290	350	690	418	2,500	10
Testosterone	Natural Steroid Hormone	ng/L	ND	ND	ND	ND	ND	7,000	5
Triclocarban	Anti-microbial	ng/L	8	45	ND	25	26		10
Triclosan	Anti-microbial	ng/L	120	99	60	140	105	350	2
Trimethoprim	Pharmaceutical, antibiotic	ng/L	440	400	460	520	455	70,000	5

MRL = Method Reporting Limit
 ND = Non Detect
 Blank = Not Defined
 <MRL = Detected below the Method Reporting Limit

Notes:

- (1) 2013 Amended Recycled Water Policy for both surface spreading and groundwater injection projects.
- (2) Additional health-based screening levels from 2010 SWRCB Recycled Water CEC Science Advisory Panel Final Report.
- (3) 2008 Australian Water Recycling Guidelines.
- (4) FDA threshold identified as a health screening level in WE&RF project 11-02.

Source Water CEC Comparison

CEC monitoring results from SCWWTF secondary effluent were compared to CEC results from other secondary effluent water sources that feed operating advanced water purification facilities (AWPFs). The comparative data set is limited, as most AWPFs do not sample secondary effluent for CECs. For this comparison, three sites were used, as listed below with associated data (Figure 1):

- Santa Clara Valley Water District (SCVWD): The SCVWD receives secondary effluent from the City of San Jose CA.
- City of Oxnard, CA: Oxnard's AWPF receives secondary effluent from their adjacent wastewater treatment plant.
- Colorado River Municipal Water District, TX: The Colorado River Municipal Water District's AWPF receives secondary effluent from the town of Big Spring TX.

Predicted Chemical Removal Through AWPF

For each of the three facilities used for comparison, CEC removal with an MF, RO, UV AOP treatment train was measured as part of research efforts. Sampling for CECs in secondary effluent is not regulated in California for potable water reuse projects. The CEC removal rates determined in those studies were averaged and applied to each individual CEC measured at SCWWTF to predict chemical removal through an AWPF treating SCWWTF secondary effluent as shown in Figure 2.

The predicted removal through AWPF was done as follows:

- Secondary effluent and finished water CEC concentrations from the 3 reference AWPFs were used to calculate the percent removal through each facility.
- Where a CEC was non-detect in the finished water, 10 percent of the MRL was used to predict a finished water concentration ($ND = 0.1 \times MRL$).
- The predicted removal across AWPF for each CEC was calculated by averaging the CEC removal through any or all of the three reference facilities.
- Predicted removal values were then used to estimate a finished water CEC concentration beginning with SCWWTF secondary effluent.
- In some cases, the predictive removals were limited by the existing data sets, resulting in "<" predictions for several CECs. In those cases, finished water concentrations were below detectable levels, thus making the estimates of predicted removal conservative. One example is ibuprofen. For the three referenced data sets, 2 of the three facility data sets measured ibuprofen and only 1 of the three facilities detected ibuprofen in the secondary effluent source. The predicted removal of ibuprofen used for the SCWWTF source was the same as the removal from this one facility. The starting concentration of ibuprofen in the secondary effluent reference source water was 6 ng/L, below the MRL of 10 ng/L, and the finished water concentration was ND. Using the predictive CEC removal calculation described above, a finished water concentration was calculated to be 1 ng/L ($0.1 \times MRL = ND$ concentration). Therefore, a removal rate of 83 percent was calculated based on the AWPF removal of ibuprofen from 6 ng/L to 1 ng/L. This removal rate is conservative, considering the initial detection was below the MRL, and a removal rate of >83 percent is expected. This removal rate was then used to predict the finished water ibuprofen concentration at the SCWWTF, with an influent ibuprofen level of 1634 ng/L, and with a predicted >83 percent removal, a finished water concentration of <272 ng/L. The health screening level for ibuprofen in drinking water is set at 40,000 ng/L, provided for perspective.

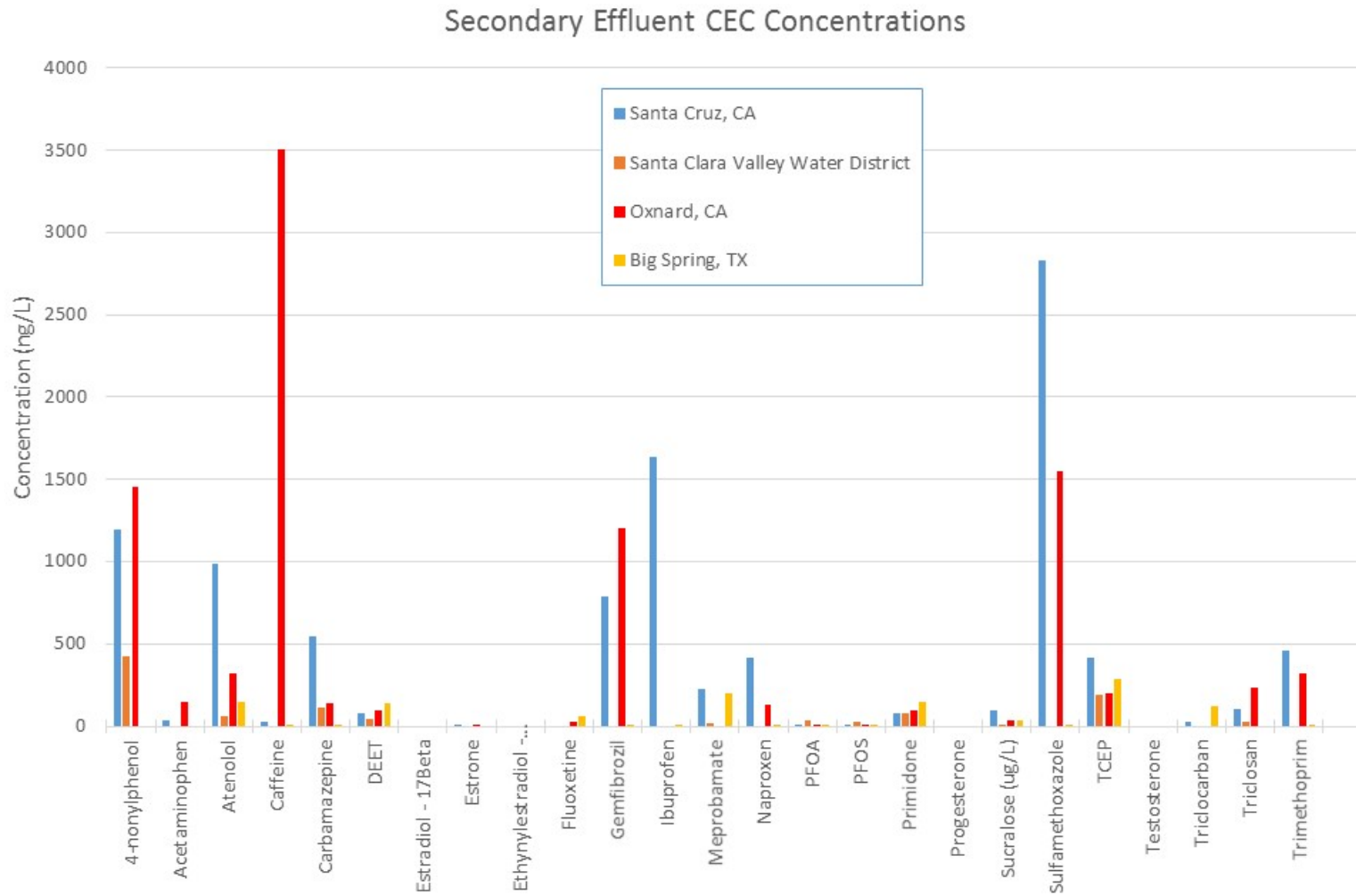


Figure 1 Comparison of Secondary Treated Effluent from SCWWTF CEC Concentrations with the Secondary Treated Effluent (Source Water) to Three AWPFF Facilities.

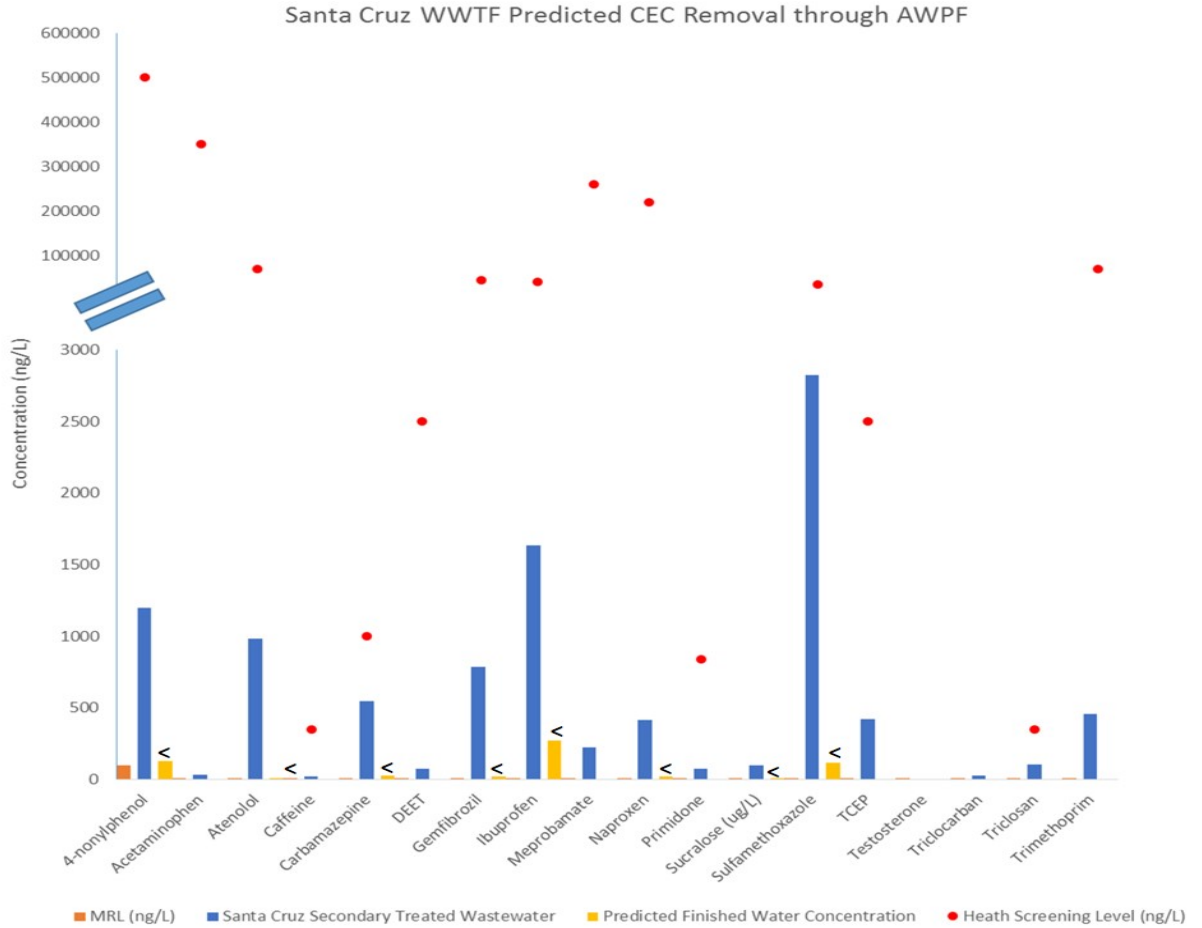


Figure 2 Predicted CEC Removal by AWPf Treatment (MF, RO, UV AOP) from SCWWF Secondary Treated Effluent

Overall, the CECs found in the SCWWTF secondary effluent were all projected to be removed to orders of magnitude below their associated health screening levels, and are all predicted to be removed by between >83 percent and 99.9 percent with additional purification treatment using AWPf processes. The predicted concentrations of CECs in purified water from a SCWWTF source are predominantly expected to be below detection/below their associated MRL. Predicted removal rates and predicted purified water concentrations are shown in Table 4.

Table 4 Predicted CEC Removal Rates and Concentrations Through MF, RO, UV AOP from SCWWTF Secondary Effluent

Analyte	Predicted Removal (%) ⁽¹⁾	Units	Predicted Finished Water Concentration	Health Screening Level ^(2,3,4)	MRL
4-nonylphenol	89.1%	ng/L	130.7	500,000	100
Acetaminophen	99.7%	ng/L	ND	350,000	5
Atenolol	99.6%	ng/L	4.1	70,000	5
Caffeine	96.1%	ng/L	ND	350	5
Carbamazepine	95.6%	ng/L	24.2	1,000	5
DEET	98.6%	ng/L	ND	2,500	10
Estradiol - 17Beta	NA ⁽⁶⁾	ng/L	ND	1	0.4
Estrone	98.8%	ng/L	ND	350	1
Ethinylestradiol -17Alpha	NA ⁽⁶⁾	ng/L	ND	280	5
Fluoxetine	97.3%	ng/L	ND	10,000	10
Gemfibrozil	97.2%	ng/L	22.0	45,000	5
Ibuprofen	83.3%	ng/L	272.4	40,000	10
Meprobamate	98.3%	ng/L	ND	260,000	5
Naproxen	94.6%	ng/L	22.2	220,000	10
PFOA	97.2%	ng/L	ND	400	2.5
PFOS	94.9%	ng/L	ND	200	2.5
Primidone	99.5%	ng/L	ND	840	5
Progesterone	NA ⁽⁶⁾	ng/L	ND	110,000	5
Sucralose	99.6%	ug/L	0.4	150,000 ⁽⁵⁾	1000
Sulfamethoxazole	95.8%	ng/L	118.2	35,000	5
TCEP	99.5%	ng/L	ND	2,500	10
Testosterone	NA ⁽⁶⁾	ng/L	ND	7,000	5
Triclocarban	99.7%	ng/L	ND		10
Triclosan	99.6%	ng/L	ND	350	2
Trimethoprim	99.8%	ng/L	ND	70,000	5

MRL = Method Reporting Limit; ND = Non Detect; Blank = Not Defined; <MRL = Lower than the Method Reporting Limit

NA = CEC was ND in All Studies

Notes:

- (1) Removal rates calculated by averaging the removal across all three treatment facilities where contaminant was detected above MRL.
- (2) 2013 Amended Recycled Water Policy for both surface spreading and groundwater injection projects.
- (3) Additional health-based screening levels from 2010 SWRCB Recycled Water CEC Science Advisory Panel Final Report.
- (4) 2008 Australian Water Recycling Guidelines.
- (5) FDA threshold identified as a health screening level in WE&RF project 11-02.
- (6) For the three reference facilities, there was no data for this particular chemical, thus no ability to predict removal.

Constituent Data Comparison to San Lorenzo River and Existing Groundwater Sources

Estimated concentrations of regulated and unregulated constituents for the proposed Pure Water Soquel AWP were compared to constituent data from monitoring in the San Lorenzo River (SLR) and two of SqCWD's production wells - Sells Well and Altivo Well, with results shown in Table 5. SLR monitoring data published in the City of Santa Cruz Water Department's Constituents of Emerging Concern, August 2016 Report (<http://www.cityofsantacruz.com/home/showdocument?id=54006>) was

used for this analysis. Production well CEC information was provided by SqCWD from 2012 monitoring. This monitoring effort was conducted using grab samples, which reflect a single point in time at a particular place in the drinking water system. The results do not reflect the removal efficiency across treatment processes.

Of the 39 CECs reported in each study, 21 were not detected across any water source - estimated purified water, SLR, or groundwater. Of the 18 detected CECs in the different supplies, none represent a health concern based upon reported Health Screening Levels (established by the 2013 Amended Recycled Water Policy, 2010 SWRCB Recycled Water CEC Science Advisory Panel Final Report, and 2008 Australian Recycled Water Guidelines) or existing MCLs. Where detected, the CECs in the secondary effluent source water are well below health screening levels before AWPf treatment.

CONCLUSIONS

The analysis summarized here documents regulated and unregulated chemicals in the SCWWTF secondary effluent. Conclusions are:

- These results suggest similar CEC concentrations to other secondary wastewater effluents that are used as AWPf source waters.
- The reduction/removal of these chemicals by purification (MF/RO/UV AOP) was estimated based upon full-scale results from other purification facilities in California and Texas. Those predicted results suggest a high quality new water supply that is of comparable or superior quality to other regional supplies and meets all MCLs and health-based screening levels from the 2010 State's Recycled Water CEC Science Advisory Panel Final Report.

It is important to note the limits of this study and important continuing steps as the proposed Pure Water Soquel project is further developed.

- The CEC data set for this project is small, based upon four grab samples over a narrow window of time. Repeating this analysis on a 1/4 basis is recommended to gain a broader understanding of chemical concentrations.
- Utilize the existing data and the recommended future data for two purposes:
 - Integrate with the County of Santa Cruz's wastewater source control program, providing a keener focus on chemicals and chemical dischargers into the collection system; and
 - Adjust the AWPf design and operational parameters, where necessary, to account for chemical concentrations in SCWWTF effluent.

Table 5 Predicted SCWWTF Purified Water And Measured Untreated San Lorenzo River (SLR) and Graham Hill (GHWTP) Treated and SqCWD Groundwater (GW) CEC Concentrations.

Analyte	Units	Predicted SCWWTF Treated, Purified Water	GHWTP (treated water) ⁽¹⁾	Untreated SLR at Felton ⁽¹⁾	Untreated SLR at Trait ⁽¹⁾	GW at Sells ⁽²⁾	GW at Altivo ⁽²⁾	Heath Screening Level ^(3,4,5) or MCL ⁽⁶⁾	MRL
2,4-D	ng/L	ND	ND	ND	ND			70,000	5
4-nonylphenol	ng/L	131	ND	ND	ND	ND	ND	500,000	100
Acesulfame-K	ng/L	ND	58	97	93				20
Acetaminophen	ng/L	ND	ND	ND	ND	ND	ND	350,000	5
Atenolol	ng/L	4	12	6	10			70,000	5
Atrazine	ng/L	ND	ND	6	ND		ND	1,000	5
Bisphenol A (BPA)	ng/L	ND	ND	ND	ND	ND	ND	35,000	10
Bromoform	ng/L	ND				545	ND	7,000	1
Caffeine	ng/L	ND	ND	ND	ND	ND	ND	350	5
Carbamazepine	ng/L	24	ND	ND	ND	269	9.1	1,000	5
Cyanazine	ng/L	ND	ND	96	16				5
DEET	ng/L	ND	20	23	33		ND	2,500	10
Diethanolamine (DEA)	ng/L	ND	ND	ND	ND				5
Estradiol - 17Beta	ng/L	ND	ND	ND	ND			1	0.4
Estrone	ng/L	ND	ND	ND	ND		ND	350	1
Ethinylestradiol -17Alpha	ng/L	ND	ND	ND	ND		ND	280	5
Fluoxetine	ng/L	ND	ND	ND	ND	0.5	ND	10,000	10
Gemfibrozil	ng/L	22	ND	ND	ND		ND	45,000	5
Ibuprofen	ng/L	272	ND	ND	ND			40,000	10
Iohexal	ng/L	ND	13	27	ND				10
Iopromide	ng/L	ND	ND	ND	ND				5
Isobutylparaben	ng/L	ND	ND	ND	ND				5
Meprobamate	ng/L	ND	ND	ND	ND			260,000	5
Methylparaben	ng/L	ND	ND	ND	ND				20
Naproxen	ng/L	22	ND	ND	ND			220,000	10
PFOA	ng/L	ND	ND	ND	ND			400	2.5
PFOS	ng/L	ND	ND	ND	ND			200	2.5

Table 5 Predicted SCWWTF Purified Water And Measured Untreated San Lorenzo River (SLR) and Graham Hill (GHWTP) Treated and SqCWD Groundwater (GW) CEC Concentrations (Continued)

Analyte	Units	Predicted SCWWTF Treated, Purified Water	GHWTP (treated water) ⁽¹⁾	Untreated SLR at Felton ⁽¹⁾	Untreated SLR at Trait ⁽¹⁾	GW at Sells ⁽²⁾	GW at Altivo ⁽²⁾	Health Screening Level ^(3,4,5) or MCL ⁽⁶⁾	MRL
Primidone	ng/L	ND	ND	ND	ND		ND	840	5
Progesterone	ng/L	ND	ND	ND	ND		ND	110,000	5
Quinoline	ng/L	ND	ND	12	ND				5
Sucralose ⁽⁷⁾	ug/L	0	0.2	0.2	0.2			150,000	1
Sulfamethoxazole	ng/L	118	ND	ND	ND	ND	8	35,000	5
TCEP	ng/L	ND	ND	ND	ND	ND	ND	2,500	10
Tetrachloroethylene	ng/L	ND				17		5,000	500
Testosterone	ng/L	ND	ND	ND	ND		ND	7,000	5
Theophylline	ng/L	ND	ND	ND	41				20
Triclocarban	ng/L	ND	ND	ND	ND				10
Triclosan	ng/L	ND	ND	ND	ND		ND	350	2
Trimethoprim	ng/L	ND	ND	ND	ND		ND	70,000	5

MRL = Method Reporting Limit

ND = Non Detect

Blank = Not Defined

<MRL = Detected below the Method Reporting Limit

Notes:

(1) Data published in City of Santa Cruz Water Department Constituents of Emerging Concern August 2016 Report.

(2) Data received from Soquel Creek Water District

(3) 2013 Amended Recycled Water Policy for both surface spreading and groundwater injection projects.

(4) Additional health-based screening levels from 2010 SWRCB Recycled Water CEC Science Advisory Panel Final Report.

(5) 2008 Australian Water Recycling Guidelines.

(6) Based on CA DDW Title 22 Table 64431-A, Table 6449-A, Table 6449-B, Table 64442, Table 64443, Table 6444-A, and Table 64533-A.

(7) FDA threshold identified as a health screening level in WE&RF project 11-02.

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