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Technical Memorandum No. 9

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Subject: Desalination Facility Clean-in-Place Waste Characterization
MMWD Seawater Desalination Pilot Plant Program
0468029

This Technical Memorandum describes the general characteristics and expected frequency and volumes of the periodic chemical clean-in-place (CIP) waste from the microfiltration (MF), ultrafiltration (UF) and reverse osmosis (RO) membrane systems for a full-scale 15 million gallon per day (MGD) capacity desalination facility. These wastes are anticipated to be disposed of by discharge to the San Rafael Sanitation District's (SRSD) sanitary sewer and to the Central Marin Sanitation Agency's (CMSA) plant for treatment. As part of a full-scale desalination facility, another possibility would be to recycle some of the CIP wastes through the plants washwater recovery system.

The desalination process would also produce other waste streams including:

- Pretreatment Waste (Conventional or MF/UF)
- Reverse Osmosis Brine Waste
- Biological Growth Control Cleaning Waste
- RO Lay-up Solution Waste (from membrane storage during prolonged shutdowns)

A separate memorandum describes the waste characteristics, treatment and potential reuse of these additional waste streams. These additional waste streams are not expected to be disposed of by discharge to the sanitary sewer.

CHEMICAL CLEAN-IN-PLACE

Chemical cleaning is necessary to minimize biogrowth and control fouling on the MF/UF pretreatment filters and to minimize scaling and fouling on the first pass seawater reverse osmosis (SWRO) and second-pass RO membranes. The chemical CIP cleaning of the MF/UF filters and of the SWRO and RO membrane systems consists of periodic semi-automatic clean-in-place (CIP) operations. The cleaning solution is circulated through the off-line membrane unit. The spent cleaning solution is then neutralized to a pH of approximately 6.5 to 8.5 to be non-corrosive before discharge to the sanitary sewer.

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Table 1 below summarizes typical cleaning chemical solutions that could be used for periodic MF/UF, first pass SWRO and second pass RO CIP events. The Material Safety Data Sheets (MSDS) for these chemicals are included as an appendix to this memorandum.

Table 1: Typical MF, UF, SWRO and RO Cleaning Chemical Solutions

Cleaning Solution	Chemical Ingredients	Percent Solution
1	Citric Acid	2%
2	STPP (sodium tripolyphosphate) Na-EDTA (sodium salt of ethylenediaminetetraacetic acid)	2% 0.8%
3	STPP (sodium tripolyphosphate) Na-DDBS (sodium salt of dodecylbenzene sulfonate)	2% 0.25%
4	HCL Acid (hydrochloric acid)	0.5%
5	Sodium hydrosulfite	1%
6	NaOH (sodium hydroxide) SDS (sodium dodecylsulfate)	0.1% 0.03%
7	NaOH (sodium hydroxide)	0.1%
8 (MF and UF Only)	NaOCl (Sodium Hypochlorite)	2%

SPENT CIP WASTE CHARACTERISTICS

Table 2 below presents an analysis of the spent CIP waste solution from a CIP cleaning of the MF/UF pretreatment filters and from a CIP cleaning of the SWRO units at the MMWD Seawater Desalination Pilot Plant.

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For the MF/UF units, a low pH cleaning (with solution #1) was performed first to remove inorganic scale followed by a high pH cleaning (with solution #8) to remove organic foulants.

For the SWRO units, a low pH cleaning (with solution #1) was performed first to remove inorganic scale followed by a high pH cleaning (with solution #3) to remove organic foulants.

The results indicate that the wastewater meets the concentration requirements in the Central Marin Sanitation Agency (CMSA) Sewer Use Ordinance for the listed constituents of concern (Local Limits).

Table 2: Analysis Results of MF/UF and SWRO CIP Cleaning Waste Solutions for Discharge to the Sanitary Sewer

Analyte	Unit	CMSA local discharge limits	MF/UF Acid (low pH) CIP Waste	MF/UF Base (high pH) CIP Waste	SWRO Acid (low pH) CIP Waste	SWRO Base (high pH) CIP Waste
antimony	mg/L	NA	ND	NA ¹	ND	0.012
arsenic	mg/L	0.59	0.011	NA ¹	0.0052	0.013
beryllium	mg/L	NA	ND	NA ¹	ND	ND
cadmium	mg/L	0.13	ND	NA ¹	ND	0.0016
chromium	mg/L	2	0.27	NA ¹	0.1	0.64
copper	mg/L	1.5	0.11	NA ¹	0.068	0.067
lead	mg/L	1.5	0.0018	NA ¹	0.0014	0.002
mercury	mg/L	0.011	ND	NA ¹	ND	ND
selenium	mg/L	NA	ND	NA ¹	ND	0.004
silver	mg/L	1	ND	NA ¹	ND	ND
thallium	mg/L	NA	ND	NA ¹	ND	ND
zinc	mg/L	1	0.051	NA ¹	0.056	0.026
cyanide	mg/L	1.2	ND	NA ¹	ND	ND

1. Data not available due to laboratory error. Based on SWRO Base CIP waste, the MF/UF Base CIP waste is not expected to exceed CMSA limits.

Table 3 below provides additional analytes from the analysis of CIP cleaning waste solution for a CIP cleaning of a MMWD Seawater Desalination Pilot plant SWRO Unit. A low pH cleaning (with solution #1) was performed first to remove inorganic scale followed by a high pH cleaning (with solution #3) to remove organic foulants.

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Table 3: Additional Analysis Results of SWRO CIP Cleaning Waste Solutions

Analyte	Unit	MRL	SWRO Acid (low pH) CIP Waste	SWRO Base (high pH) CIP Waste
Conductivity	umho/cm	0.5	2500	17000
Total Dissolved Solids (TDS)	mg/L	10	1000	11000
Neutralized pH	pH units	–	6.5	8
Alkalinity, Total	mg/L as CaCO ₃	1	<MRL	2700
Hardness, Calcium	mg/L as CaCO ₃	0.25	27	11
Bromide	mg/L	0.01	1.7	0.76
Chloride	mg/L	2	500	140
Sulfate	mg/L	5	64	22
Nitrogen, Ammonia	mg/L	0.1	0.13	<MRL
Nitrate	mg/L	0.1	<MRL	<MRL
Fluoride	mg/L	0.1	<MRL	<MRL
Total Organic Carbon (TOC)	mg/L	0.5	23.4	40.7
UV absorbance at 254 nm	cm-1	0.009	0.991	1.7
Calcium	mg/L	0.1	11	4.5
Iron	mg/L	0.02	9.2	6.7
Magnesium	mg/L	0.1	30	7.8
Potassium	mg/L	0.2	12	60
Silica, Dissolved	mg/L	0.1	0.79	1.1
Silica, Total	mg/L	0.1	1.6	1.7
Sodium	mg/L	0.1	290	3300
Aluminum	mg/L	0.002	0.096	1.2
Barium	mg/L	0.002	<0.010	<0.010
Boron	mg/L	0.005	0.94	1.2
Manganese	mg/L	0.002	0.19	0.058
Strontium	mg/L	0.002	0.23	0.054

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For a full scale facility, the CIP cleaning wastes from the MF/UF system and from the RO systems would be neutralized to a pH of approximately 6.5 to 8.5 to be non-corrosive and then discharged to the sanitary sewer.

SPENT CIP WASTE VOLUMES AND FREQUENCY

Table 4 summarizes the expected CIP waste stream volume and frequency for a full scale 15-MGD desalination facility. For purposes of conservatively estimating the volumes of waste CIP water for this memorandum, the pretreatment system is assumed to comprise six 5-MGD MF/UF units with one redundant unit for an operational capacity of 30 MGD. The first pass SWRO system is assumed to comprise six 2.5 MGD SWRO units with one redundant unit for an operational capacity of 15 MGD. The second pass RO system is assumed to comprise four 2.5-MGD RO units for an operational capacity of 10 MGD.

Table 4: Expected CIP Waste Volume for a Full Scale Desalination Facility

Process Cleaning	Number of Process Units	Approx. Frequency of Unit Cleaning	Approx. Units Cleaned per Month	Approx. Waste Volume per CIP (gal/CIP)	Approx. Waste Volume per month (gal/month)	Treatment/ Disposal
MF/UF CIP	7	Every 2 months	4 units per month	10,000	40,000	- Neutralized and sent to sewer
First Pass SWRO CIP	7	Every 4 to 6 months	2 units per month	5,000	10,000	-Neutralized and sent to sewer
Second Pass RO CIP	4	Every 12 months	1 unit every 3 months	5,000	2,000	-Neutralized and sent to sewer

Note: Waste volume assumes low pH and high pH cleanings on each CIP event. Rinse water following a CIP would be sent to the washwater recovery basin to minimize volume sent to the sanitary sewer.

Based on the assumptions above, the estimated volume of waste CIP water discharged to the sanitary sewer from a full scale 15 MGD desalination facility would be approximately 50,000 to 55,000 gallons per month. With individual MF/UF and/or SWRO cleanings occurring each week to spread out the cleaning effort, the weekly waste volume would be approximately 12,000 to 15,000 gallons. The waste would be captured and neutralized with sodium hydroxide or a mineral acid to a pH of approximately 6.5 to 8.5 to be non-corrosive and then discharged at a controlled rate to the sanitary sewer over a period of days. Assuming a two to three day

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discharge period, the discharge rate to the sanitary sewer could be approximately 4,000 to 7,500 gallons per day or approximately 3 to 6 gallons per minute.

Another scenario would be to clean all the MF/UF trains, one after another, over a one week period. This would generate approximately 70,000 gallons of spent wastewater over the week. Assuming a constant discharge of neutralized wastes during that period, the discharge rate to the sanitary sewer could be approximately 10,000 gallons per day or approximately 9 gallons per minute.

For the above full-scale scenarios the discharge rate of the CIP waste water to the sanitary sewer would be in the range of 6 to 9 gallons per minute, which is similar to the rate of discharge to the sewer from the spent washwater holding tank for the pilot plant operation. The discharge rates are similar since the washwater holding tank for the pilot plant collects washwater from the MF/UF and conventional pretreatment processes as well as CIP cleaning waste. In a full-scale facility the washwater from the selected pretreatment process would be treated through a washwater recovery system and not discharged to the sewer.

MMWD would work with the SRSD and CMSA to determine the maximum permitted discharge rate to provide the SWRO Facility flexibility in cleaning of the MF/UF and SWRO units and discharging the waste CIP solutions to the sewer.

SUMMARY

Based on the cleaning chemicals used by the desalination process as presented in Table 1 above, and the quality of the spent CIP solution wastewater as presented in Tables 2 and 3 above, discharge of neutralized CIP wastes to the SRSD sanitary sewer and to the CMSA plant for treatment should be acceptable.

The volume of wastes generated over a given period will depend on the cleaning approach but in any case should be in a range that would be acceptable to SRSD and to CMSA.

cc: Project File