Appendix A

Testing and Monitoring Plan

Final Testing and Monitoring Plan

August 31, 2011

CITY OF SAN DIEGO

Indirect Potable Reuse/Reservoir Augmentation Demonstration Project
Advanced Water Purification Facility

THE CITY OF SAN DIEGO

City of San Diego
PUBLIC UTILITIES
Water & Wastewater

CDM

in association with:
MWH

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Contents

Appendices

Appendix A PFD & Site Layout
Appendix B Technical Memorandum: *Survey of North City Water Reclamation Plant Industrial Dischargers*, prepared by RMC for the City of San Diego, June 21, 2010
Appendix C Technical Memorandum: *Initial Planning for the UV/AOP Component of the City of San Diego AWT Demonstration Plant*, prepared by CDM/MWH for the City of San Diego, May 21, 2010
Appendix D Technical Specifications for the 3D TRASAR® Automation System
Appendix E Membrane Cleaning Protocols
Appendix F AWPF Data Collection Sheets
Appendix G Treated Water Quality Regulatory Requirements and Guidance
Appendix H Comparison of NCWRP CEC Data to Compounds Identified for Monitoring by the State Water Resources Control Board
Appendix I Analytical Testing Methods, MDLs, Lab Assignments, TATs, etc.
Appendix J Sampling Procedures for Microbial Parameters

Appendices (Cont.)

Tables

Figures

List of Acronyms & Abbreviations

°C	Degrees Celsius
°F	Degrees Fahrenheit
AQWATEC	Advanced Water Technology Center, Colorado School of Mines
AOP	Advanced Oxidation Process
ASTM	American Standard Technical Method
AWP	Advanced Water Purification
Basin Plan	San Diego Basin Plan
BAT	Best Available Technology
BOD	Biological oxygen demand
CCP	Critical control point
CDPH	California Department of Public Health
CDWR	California Department of Water Resources
CEC	Chemicals of Emerging Concern
CFD	Computational fluid dynamics
CFU/mL	Colony forming units per milliliter
CIP	Clean-in-place
City	City of San Diego
City Council	San Diego City Council
CLP	Contract Lab Program
CWA	Clean Water Act
/day	Per day
DBP	Disinfection By-product
DO	Dissolved oxygen
DMA	Dimethylamine
DP	Differential pressure
EBEP	Enclosed Bay and Estuaries Plan
EEO	Electrical Energy per Order
ELAP	Environmental Laboratory Accredited Program
gpm	Gallons per minute
g/mol	Grams per mol
gfd	gallons per square-foot day
gpm	gallons per minute
GWRS	Ground Water Replenishment System
H_2O_2	Hydrogen peroxide
HACCP	Hazard Analysis and Critical Control Point
HRT	Hydraulic residence time
IAF	Integrated averaging factor
IAP	Independent Advisory Panel
in	Inch
IMP	Integrity Monitoring Plan
IPR	Indirect Potable Reuse
ISWP	Inland Surface Waters Plan
kW	Kilowatt
L/m^2	Liters per square meter

lb	Pound
LDC	Laboratory Data Consultants, Inc.
LPHO	Low pressure high output
LT2ESWTR	Long Term 2 Enhanced Surface Water Treatment Rule
MCL	Maximum contaminant limit
MF	Microfiltration
MGD	Million gallons per day
mg/L	Milligrams per Liter
MPN/100 mL	Most probable number per 100 milliliters
MRL	Method reporting level
MTBE	Methyl tert-butyl ether
MTL	Monitoring Trigger Level
MW	Molecular weight
µg/L	Micrograms per Liter
N	Nitrogen
NA	Not applicable
NaOCl	Sodium hypochlorite
NC	North City
NCWRP	North City Water Reclamation Plant
ND	Non Detect
NDMA	N-nitrosodimethylamine
NDBA	N-nitrosodi-n-butylamine
NDEA	N-nitrosodiethylamine
NDPA	N-nitrosodi-n-propylamine
NH2Cl	Monochloramine
NMEA	N-nitrosomethylethylamine
NPIP	N-nitrosopiperidine
NTR	National Toxics Rule
NYPR	N-nitrosopyrrolidine
ng/L	nanograms per liter
NTU	Nephelometric Turbidity Units
O&M	Operations and maintenance
OCWD	Orange County Water District
OH	Hydroxyl radical
P	Phosphorus
PAT	Project Advisory Team
PCPP	Pharmaceutical and Personnel Care Products
POM	Point of monitoring
ppm	parts per million
ppb	parts per billion
ppt	parts per trillion
psi	Pounds per square inch
PVC	Polyvinyl chloride
QA	Quality assurance
QC	Quality control
QCP	Quality control point

RA	Reservoir Augmentation
RO	Reverse osmosis
RWC	Recycled Water Contribution
RWQCB	Regional Water Quality Control Board
SAP	Science Advisory Panel
SCADA	Supervisory control and data acquisition
SVI	Sludge volume index
SWRCB	State Water Resources Control Board
T&M	Testing and Monitoring
TDS	Total dissolved solids
TLD	Trace leak detection
TMP	Transmembrane pressure
TN	Total nitrogen
TOC	Total organic carbon
UF	Ultrafiltration
USEPA	United States Environmental Protection Agency
UV	Ultraviolet
UVT	Ultraviolet transmittance

Section 1
Background

1.1 City of San Diego Indirect Potable Reuse / Reservoir Augmentation Demonstration Project

In January 2004, the San Diego City Council (City Council) directed the City Manager to conduct a study to evaluate options to increase the use of recycled water produced at the City of San Diego's (City) two water reclamation plants. The City Council mandated the study to also include research on the health effects of reuse options and to facilitate active involvement of the public.

The Water Reuse Study (City of San Diego, Draft Final Report, March 2006) resulted in the identification of six potential options to maximize the use of the City's existing recycled water. The various project stakeholders identified the North City-3 (NC-3) strategy to be the most beneficial reuse strategy. The NC-3 option includes reservoir augmentation of the City's San Vicente Reservoir using highly purified tertiary water from the City's North City Water Reclamation Plant (NCWRP).

The Water Reuse Study represented Phase I of a three phase program that may lead to the implementation of full scale indirect potable reuse reservoir augmentation (IPR/RA) project. Phase II is the current demonstration project and Phase III will be the full scale IPR/RA project. In October 2007, the City Council voted to proceed with the demonstration project consisting of the following components:

- Design, construct, operate and test a demonstration scale Advanced Water Purification Facility (AWP Facility) at the NCWRP.
- Conduct a Limnology and Reservoir Detention study for the San Vicente Reservoir to establish residence time and short circuiting conditions of advanced treated water in the reservoir.
- Conduct a public outreach and education program.
- Convene an Independent Advisory Panel (IAP) to provide expert review of the technical, scientific, and regulatory aspects of the project.
- Define regulatory requirements for a full scale IPR/RA project (Phase III of the program).

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Section 2
Objectives, Development and Organization

A key component to the operation and testing of the AWP Facility is the development and implementation of a comprehensive Testing and Monitoring (T&M) Plan. This section provides specific objectives of the testing and monitoring component of the AWP Facility, information on how the T&M Plan was developed, and a roadmap as to where key components of the plan are located in the document.

2.1 Testing and Monitoring Objectives

The ultimate goal of testing and monitoring the AWP Facility is to generate the necessary data to support the regulatory approval and permitting of the proposed full-scale IPR/RA project. Specific objectives of the testing and monitoring component are provided in the following paragraphs.

- **Demonstrate that the proposed AWP technology, operation and performance meets the criteria outlined by the California Department of Public Health (CDPH) and California Department of Water Resources (CDWR) 1996 proposed framework for Regulating IPR by Surface Water Augmentation.** The selection of the treatment technologies, operational strategy and water quality sampling plan associated with the AWP Facility will target meeting the following criteria:

    - Enable CDPH to find that the proposed technology will ensure that the recycled water meets or exceeds all applicable primary and secondary drinking water standards and poses no significant threat to public health

    - Compliance with the draft 2008 CDPH groundwater recharge criteria for injection.

    - Maintenance of reservoir quality.

    Other criteria established by the proposed IPR/RA project framework, which are also being evaluated as part of the overall demonstration project, and supported by the operation of the AWP Facility, include:

    - Maintenance of appropriate San Vicente Reservoir residence time based on reservoir dynamics.

    - Provision of an effective source control program for discharges into the wastewater collection system.

- **Evaluate nutrient removal performance of the baseline AWP Facility treatment train.** A key objective of the demonstration testing will be to collect nutrient removal data and associated product water quality of the AWP Facility. The performance goals for product water nutrient levels of the proposed full-scale facility are driven by the Regional Water Quality Control Board (RWQCB) as outlined in the San Diego Basin Plan (Basin Plan). The Basin Plan sets a threshold limit for total phosphorus concentration for any streams at the point of entering inland standing body surface waters, such as San Vicente Reservoir, of 0.05 milligrams phosphorus per liter (mg-P/L). Though the RWQCB has not established nitrogen thresholds, the Plan references the use of natural nitrogen to phosphorus (N:P) ratios of 10:1, which would establish a total nitrogen threshold at 0.5 milligrams of nitrogen per liter (mg-N/L). However, the Basin Plan notes certain exceptions to these levels can be made on a case-by-case basis for discharges of reclaimed water to surface waters. A goal of the overall demonstration project is to work with the RWQCB to establish specific nutrient goals for the full scale IPR/RA project. The established regulatory requirements and nutrient removal performance of the baseline AWP Facility treatment train will dictate if any additional treatment would be needed beyond the baseline treatment train.

- **Implement a monitoring plan for Chemicals of Emerging Concern (CECs) tailored to the NCWRP tertiary water characteristics and current recommendations of the State Water Resources Control Board (SWRCB).** The proposed T&M Plan includes a specific CEC monitoring program to be implemented over the demonstration period. The basis of the plan is the prioritization framework and recommendations presented in the Final Report "Monitoring Strategies for Chemicals of Emerging Concern in Recycled Water," published by the SWRCB on June 25, 2010. The compounds selected for monitoring can be classified into two general categories including compounds that have toxicological relevance and compounds that serve as suitable performance indicators. The specific compounds incorporated into the T&M Plan are based on previous CEC data captured during the City's Advanced Water Treatment Research Studies (2005) and the on-going NCWRP sewer shed investigation, as well as occurrence data for secondary/tertiary treated effluents summarized in the SWRCB report. The proposed plan is multi-tiered with the intention of being carried over to the monitoring requirements of the full-scale IPR/RA project.

- **Demonstrate integrity monitoring techniques and performance reliability measures for the AWP Facility treatment train, which can be implemented at the full-scale facility.** The overall T&M Plan includes a comprehensive plan to monitor the integrity and reliability of each unit process throughout the demonstration period to achieve water quality objectives. The foundation of this T&M Plan is the use of a surrogate/indicator approach for continuous performance monitoring of each unit process. A correlation is made between removals of indicator compounds (i.e., an individual compound that is present in the source water with characteristics of a larger family of compounds) and surrogate compounds (i.e., quantifiable change of bulk parameter corresponding to performance of individual unit process). The T&M Plan also includes direct and indirect measures of the microfiltration/ultrafiltration (MF/UF) and reverse osmosis (RO) membrane integrity, as well as the ultraviolet (UV) system of the advanced oxidation process

(AOP). With regards to RO integrity monitoring, a tiered approach is proposed with the use of different direct and indirect monitoring methods corresponding to different stages of RO commissioning and operation.

- **Validate the performance of AWP Facility unit processes using full-scale treatment equipment.** The AWP Facility baseline treatment train will use a multiple barrier approach consisting of MF/UF, RO, and UV/AOP with a total production capacity of approximately 1 million gallons per day (MGD). The design of the system incorporates the use of MF, UF, and RO membranes which are the same size, specification, and configuration as those that could be utilized for the full-scale IPR/RA facility. UV/AOP system selection was based on review of the system used at the Orange County Water District's (OCWD's) Groundwater Replenishment (GWR) System and consultation with representatives of Trojan, Inc., the UV System manufacturer. The proposed UV/AOP demonstration system is the UV Phox Model 72AL75, which is a single chamber version of the reactors used at OCWD. During the initial phase of testing, the ability of the unit to achieve 1.2-log (93.7%) removal of N-Nitrosodimethylamine (NDMA) at a flow of 1 MGD will be verified. Results obtained during initial testing will establish the power setting at which to operate the system for the remainder of the operations period.

- **Define vendor pre-qualification criteria for the full-scale AWP Facility.** As part of the testing program, vendor pre-qualification criteria will be developed for the full-scale AWP Facility. Testing will include two different low pressure (MF/UF) membranes and two different RO membranes. The performance of the Trojan UV Phox system will be monitored to access and gain further insight on AOP performance. Both water quality and operational performance observed during the demonstration plant study will be utilized to develop pre-qualification criteria for consideration during procurement of equipment for the full-scale facility. Though operation and testing of the AWP Facility will provide useful information to develop vendor pre-qualification criteria it is not intended to pre- qualify vendors for the potential full-scale AWP. Pre-qualification of vendors for the full scale AWP would require further evaluation outside the current scope of work.

- **Monitor and collect operational performance and maintenance requirements of the AWP Facility equipment -** During the testing period, key operational parameters and maintenance requirements of each unit process (MF/UF, RO and UV/AOP) will be monitored on a routine basis. This information will be evaluated to assess ways to improve operational efficiencies and provide a basis for estimating operations and maintenance (O&M) costs for the full-scale AWP Facility.

- **Evaluate the degradation and by-product formation of nitrosamines and 1, 4-dioxane by UV/AOP and compare alternative chloramines application conditions to mitigate NDMA formation.** Nitrosamines and 1,4-dioxane will be monitored in the AWP Facility product water by performing an initial spiking experiment and performing quarterly sampling to demonstrate log removal requirements established by the CDPH and assess the ability of the treatment train to meet current notification limits, respectfully. In addition, possible by–products, that may form as a result of the oxidation of nitrosamines (*e.g. NDMA, NDBA, NDEA, NDPA, NMEA, NPIP, NYPR*) and 1, 4-dioxane will be evaluated during the testing period. Based on monitoring data from the AWP Facility and an initial literature review performed by the project team, bench-scale testing may be performed to simulate worse conditions to identify potential UV/AOP by-products and at what level and conditions they occur. Should bench testing be conducted, results may be used to adjust operating conditions for the UV/AOP component of the AWP Facility and tailor the monitoring program for the product water. As part of the overall T&M Plan, the use of pre-formed chloramines and sequential chloramines formed in-situ will be evaluated to reduce the formation potential of nitrosamine compounds due to chloramination upstream of the RO system, which is required to prevent biological fouling.

2.2 T&M Plan Development

Several sources of information serve as the basis of this T&M Plan, which include:

- Final Report of the *May 11-12, 2009 Meeting of the Independent Advisory Panel (IAP) for the City of San Diego IPR/RA Demonstration Project* (IAP Final Report), NWRI, September 2009.
- CDPH comments to the IAP Final Report, December 2009, and the City's response to comments, May 2010.
- City of San Diego, *Advanced Water Treatment Research Studies* conducted at the NCWRP, 2005.
- Final Report *Monitoring Strategies for CECs in Recycled Water, Recommendations of Science Advisory Panel*, SWRCB, June 25, 2010.
- CDPH Groundwater Recharge Reuse Draft Regulations, August 2008.
- IAP Subcommittee Findings and Recommendations of the Advanced Water Purification Facility Subcommittee Meeting, November 15, 2010, NWRI.
- Input received from the project team's Project Advisory Committee (PAC):
    - Professor Dr. Jörg Drewes, Advanced Water Technology Center (AQWATEC), Colorado School of Mines.
    - Professor Dr. Shane Snyder, University of Arizona, Arizona Laboratory for Emerging Contaminates.

  - Professor Dr. Bill Cooper, University of California, Irvine, Urban Water Research Center.
  - Professor Dr. Greg Leslie, UNSW Global, University of New South Wales.
  - Ms. Margie Nellor, Nellor Environmental.
- Comments received from the IAP/CDPH/RWQCB on the *City of San Diego IPR/RA Demonstration Project Advanced Water Purification November 30, 2010 Final Draft Testing and Monitoring Plan.*

2.3 T&M Plan Organization

This T&M Plan conforms to the recommendations outlined in the IAP Final Report (September 2009), CDPH comments to the IAP Final Report (December 2009), and the City's response to CDPH comments (May 2010). The T&M Plan is organized as follows:

Section 1 - Background

Section 2 – Objectives, Development and Organization

Section 3 – Materials and Methods

Section 4 – Process Operation, Activities, and Schedule

Section 5 – Demonstration Facility Process Evaluation

Section 6 – Specialty Testing

Section 7 – Quality Assurance / Quality Control

Section 8 – Additional Scope of Services

Section 9 – References

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Section 3
Materials and Methods

3.1 Demonstration Testing Site

3.1.1 North City Water Reclamation Plant

The AWP Facility is located at the City of San Diego's North City Water Reclamation Plant (NCWRP) located at 4949 Eastgate Mall, San Diego, California 92121.

The NCWRP currently produces 22.5 MGD of recycled water of which approximately 7.3 MGD is used for the non-potable beneficial use in the surrounding area. NCWRP has a total design capacity of 30 MGD. The recycled water distribution system consists of approximately 83 miles of recycled water pipeline, two reservoirs and three pump stations.

A general schematic of the NCWRP treatment process is provided in **Figure 3-1.** As shown the AWP Facility will receive feed water from the tertiary filters, product water will be returned to the NCWRP recycled water upstream of the chlorine contact chamber.

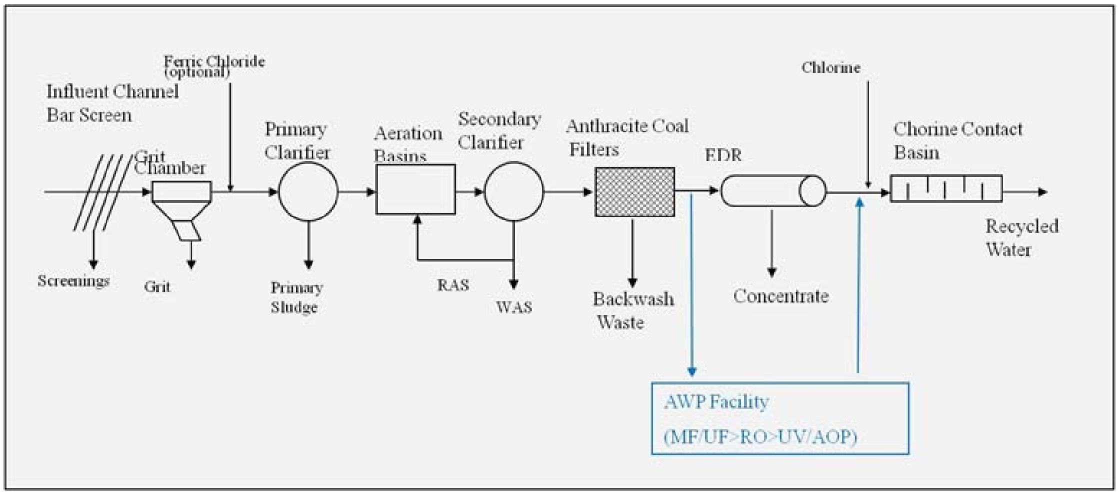

Figure 3-1
NCWRP Treatment Process

The NCWRP is a tertiary treatment plant and consists of the following major treatment processes:

- Influent headworks – consists of bar screen and grit chamber to remove large debris and coarse sediments.
- Primary Treatment – consists of primary sedimentation basins to remove settable solids not removed in the grit chamber.

- Secondary Treatment – consists of aeration basins (anoxic and aerobic) that promote biological treatment of wastewater through microbial decomposition and secondary clarifiers, which remove the settled activated sludge.

- Tertiary Treatment – consists of anthracite coal filters to remove particulate matter.

- Demineralization - utilizes electrodialysis reversal (EDR) for partial demineralization.

- Disinfection - consists of chlorine contact chambers where chlorine is applied to the water to kill bacteria and other microbes prior to distribution to recycled water customers through the recycled water distribution system.

The AWP Facility is located on a concrete pad adjacent to the existing EDRs #4 and #5. The new pad area is 3,800 square feet (50 feet x 76 feet). The western edge of the new pad houses the EDR unit #6 and is not part of this project. The operations trailer is located on the existing Research Pad, which has an area of 2,000 square feet (40 feet x 50 feet). An aerial photograph of the NCWRP showing the demonstration facility site in proximity to NCWRP unit processes is provided in **Figure 3-2**.

3.1.2 AWP Facility Layout

A layout of the AWP Facility showing the location of main components including equipment skids, chemical storage tanks, and the trench drain is provided in **Figure A-1 (Appendix A)**. The AWP Facility is laid out to facilitate public tours through the facility in order of treatment process: MF/UF, RO, and UV/AOP.

Both pads have steel frame roofs with 18 feet of vertical clearance. The Research Pad is equipped with lights, outlets, raceways, and electrical panels.

The AWP Facility is connected to the NCWRP product water by an 8-inch Schedule 80 polyvinyl chloride (PVC) pipe anticipated to deliver water to the demonstration plant at 980 gallons per minute (gpm) and a pressure between 50 to 70 pounds per square inch (psi). The water is delivered by the same pumps that feed EDRs #4, 5 and 6. Two drains are provided for liquid process and cleaning waste. The drains are routed overhead in the AWP Facility and EDR #6 areas and then routed below grade to discharge to an existing manhole. Water produced by the AWP Facility is discharged into the tertiary effluent piping upstream of the chlorine contact tanks. As with the drain piping, the product water piping is routed overhead in the AWP Facility and EDR #6 areas and then routed below grade to discharge into the existing product water pipeline.

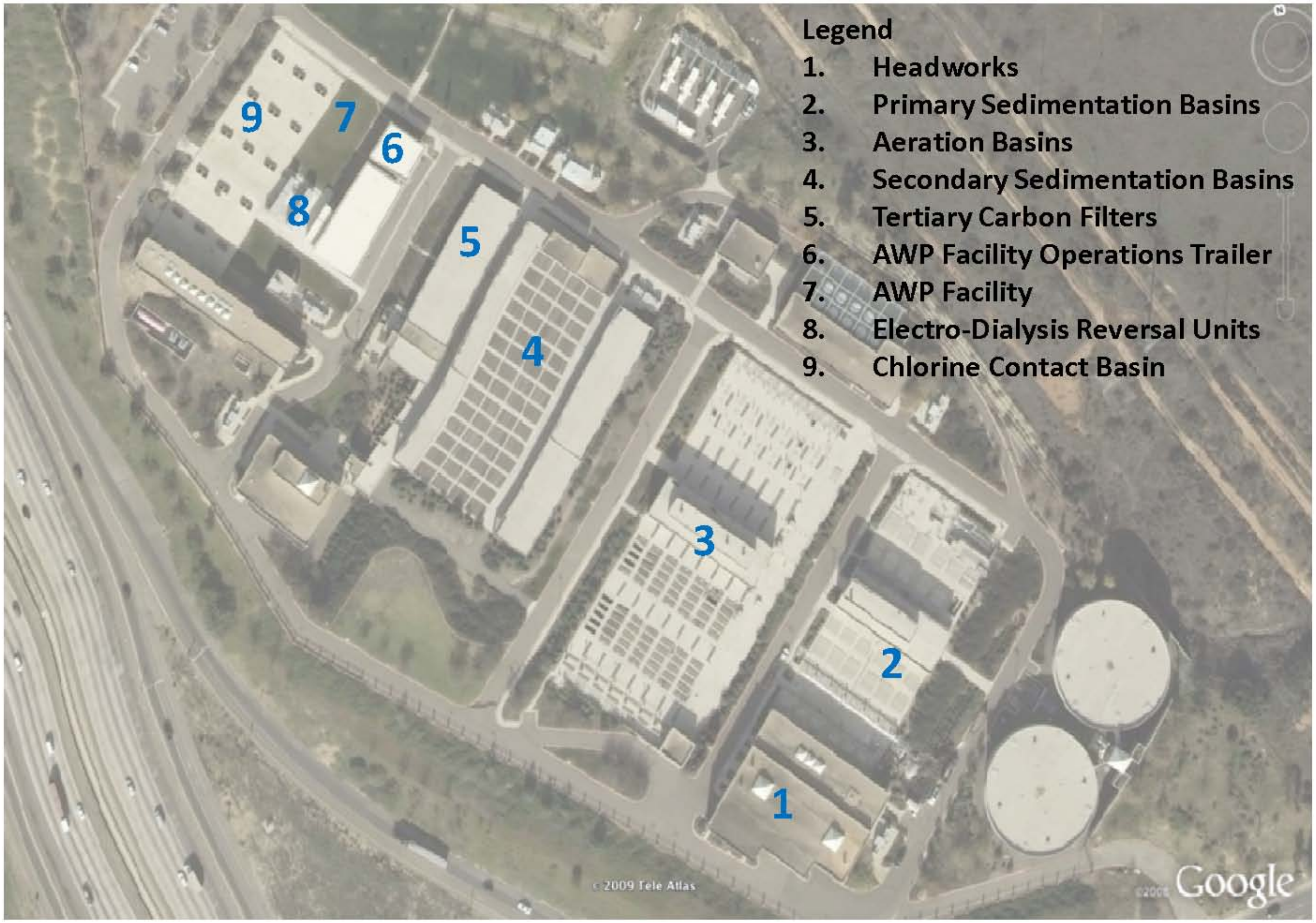

Figure 3-2
Aerial Photograph of the NCWRP

3.1.3 Feed Water Characteristics

The AWP Facility testing will be conducted using tertiary treated water (prior to chlorination and demineralization) from the NCWRP. **Table 3-1** presents water quality of disinfected tertiary filtered effluent based on data collected at NCWRP during the 2009 annual monitoring report. While the water quality shown in **Table 3-1** is based on measurements made post chlorination it should be representative (with the exception of microbial parameters: heterotrophic plate count, total coliform and total coliphage) of the filtered effluent which will be used during the testing.

Table 3-1
NCWRP Disinfected Effluent Water Quality Data

Parameter	Unit	Value
pH	--	7.13 [1]
TSS	mg/L	ND [1]
VSS	mg/L	ND [1]
Turbidity	NTU	0.63 [1]
Ammonia-N	mg/L	ND [2]
TKN	mg/L	ND [2]
Aluminum	µg/L	86 [1]
Arsenic	µg/L	0.58 [1]
Boron	µg/L	325 [1]
Chloride	mg/L	240 [1]
Sulfate	mg/L	217 [1]
Silica	mg/L	14 [4]
Iron (total)	µg/L	113 [1]
Calcium	mg/L	62.3 [1]
Magnesium	mg/L	26.7 [1]
Conductivity	micromhos/cm	1,530 [2]
TDS	mg/L	893 [1]
Hardness	mg/L	265 [1]
Alkalinity (bicarbonate)	mg/L	103 [1]
BOD	mg/L	ND [1]
HPC	cfu/mL	ND [3]
Total Coliphage	MPN/ 100mL	ND [3]
Total Coliforms	MPN/ 100mL	ND [1]

[1] Average value measured in December 2009, NCWRP Annual Monitoring Report
[2] Based on measurement October 6, 2009
[3] Based on data presented in Long Term Testing Experimental Plan (MWH, 2005)
[4] Based on average values collected July 14 - 19, 2005 (MWH, 2007)

3.1.3.1 NCWRP Operational Changes to Reduce Effluent Total Nitrogen

In January 2008 the City began a 12-month study to assess improving the NCWRP recycled water quality by enhancing the plant's denitrification process (Trussell et al., 2010). The purpose of this project was to document the plant's nitrogen removal performance over that time period and to provide recommendations to improve water quality and nitrogen removal. Results of the study produced five possible immediate action recommendations and two potential future capital improvements to further reduce total nitrogen. The five possible immediate actions include:

- Increase aeration solids retention time from 5.8 days to 10 days to ensure complete nitrification (< 1 mg/L of ammonia) and to encourage the filamentous bacteria growth which will increase sludge volume index (SVI).

- Take a primary sedimentation tank offline and cease the addition of coagulant to the primary treatment process, in order to increase primary effluent Biochemical Oxygen Demand (BOD).

- Bring down the dissolved oxygen (DO) set point to 1 mg/L to improve denitrification efficiency at the anoxic zones by carrying less oxygen in the internal recycling streams. Before changing the DO set point, preventive maintenance for the air control system should be performed to ensure accurate airflow control and avoid DO deficits at the aerobic zones. It is also recommended to first set the DO set point to 2 mg/L to make sure the DO controller is reliable before bringing the DO set point down to 1 mg/L.

- Lab use the Environmental Laboratory Accredited Program (ELAP) approved methods for nitrate analyses and elimination of weekly ammonia effluent sampling.

- Take two additional secondary sedimentation tanks offline, one tank at a time, to reduce energy and reduce maintenance costs.

The two potential future capital improvements to further reduce total nitrogen include:

- Increase anoxic volume from 20% to 40% of the total aeration volume to allow additional anoxic contact time for denitrification. With anoxic volume at 40%, a DO set point of 2 mg/L will be required to avoid air deficits at the aerobic zones.

Increase internal recycle rate from 1.6 times the average primary effluent flow to 3 times the average primary effluent flow to introduce more nitrates to the anoxic zone for oxidation of influent biodegradable organic matter. With the optimization of the NCWRP's operations per Trussell Technologies' recommendations, the nitrification process will be more stable and the total nitrogen should be reduced by approximately 10 to 15%. If all of Trussell Technologies recommendations, including some capital improvement projects (CIP), were to be implemented then the total nitrogen in the NCWRP tertiary water could be reduced by more than 50%.

Figure 3-3 provides average monthly values of nitrate measured in the NCWRP between January 2010 and September 2010. As shown, the values have shown an overall decreasing trend with an average nitrate value of 11.5 mg-N/L based on samples measured between May 1 2010 to August 31 2010. This improvement is credited to on-going changes to the plant process per findings of the study described above. The changes are being made gradually with final adjustments to be completed in December 2010 prior to start up of the AWP Facility scheduled for February 2011. The ongoing enhancements may result in ultimate lower nitrogen values in the AWP Facility product water which is an important aspect over the overall IPR/RA project with respect to reservoir quality.

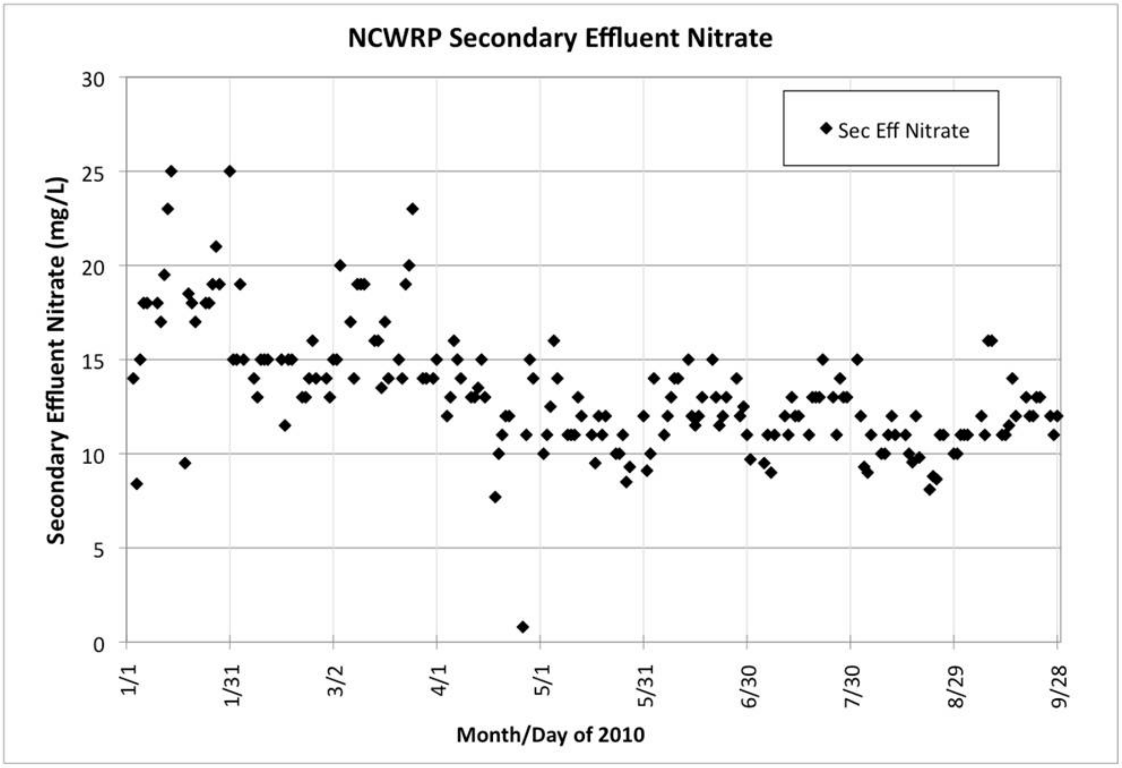

Figure 3-3
NCWRP Effluent Nitrate Data

3.1.3.2 CECs

A key component in characterizing the NCWRP tertiary water for the AWP Facility is analyzing the water for new classes of chemicals potentially impacting recycled water quality, or CECs. CECs include currently used pesticides, industrial chemicals, endocrine disrupting compounds (EDCs), and pharmaceuticals and personal care products (PPCPs). The majority of CECs are not part of the Citys NCWRP annual water quality monitoring; however, analysis for CECs in NCWRP tertiary water was conducted as part of the City's AWT Research Studies conducted in 2005. **Table 3-2** presents concentration for 29 CEC compounds measured in the NCWRP tertiary water. As described later in **Section 5**, this data was considered during the development of the specific CEC monitoring plan for the AWP Facility.

Table 3-2
[1]NCWRP Tertiary Effluent Water CEC Data

Parameter	Unit	Value (3/23/05)	Value (4/13/05)
Hydrocodone	ng/L[2]	80	87
Trimethoprim	ng/L	383	346
Acetaminophen	ng/L	1	ND
Caffeine	ng/L	ND	ND
Erythromycin-H_2O	ng/L	335	311
Sulfamethoxazole	ng/L	758	817
Fluoxetine	ng/L	46	36
Pentoxifylline	ng/L	ND	ND
Meprobamate	ng/L	252	271
Dilantin	ng/L	133	117
TCEP	ng/L	353	225
Carbamazepine	ng/L	223	327
DEET	ng/L	146	393
Atrazine	ng/L	1	1
Diazepam	ng/L	4.5	1.2
Oxybenzone	ng/L	ND	1.4
Estriol	ng/L	ND	ND
Ethynylestradiol	ng/L	ND	ND
Estrone	ng/L	18	6.3
Estradiol	ng/L	ND	ND
Testosterone	ng/L	ND	ND
Progesterone	ng/L	ND	ND
Androstenedione	ng/L	4.4	4.9
Iopromide	ng/L	633	453
Naproxen	ng/L	48	23
Ibuprofen	ng/L	24	28
Diclofenac	ng/L	52	71
Triclosan	ng/L	94	171
Gemfibrozil	ng/L	146	222
NDMA	ng/L	14	23
1,4-Dioxane	µg/L[3]	43	ND

[1] Data Collected for the 2005 AWP Pilot Study (MWH, 2007)
[2] ng/L – nanograms per liter
[3] µg/L – micrograms per liter

3.1.3.3 NCWRP Collection System Catchment Area Investigation

Under a separate contract, the City recently completed a desktop study to identify specific contaminants of concern in the NCWRP collection system based on a survey of industrial dischargers. The final technical memorandum prepared by RMC (**provided in Appendix B**) provides results of data review conducted on 30 industries within the NCWRP collection system area categorized in the TM as follows:

- Two Class 1, federally regulated, pharmaceutical manufacturers;
- Twenty Class 2 industries with the greatest industrial wastewater flow; and
- Nine industries (mainly R&D) geographically clustered on Nancy Ridge Drive, including one Class 2 industry.

The major findings of the study include a comprehensive listing of chemicals used or stored by each facility. This list was reviewed by the project team in the development the T&M Plan for the AWP Facility provide in Section 5. Based on this review, it is recommend that the City follow up with two discharges (02-0730 and 02-0972) for further screening based on the number of reported compounds present. A first step would be to assemble flow data for each discharger, which could be either concentration or mass load estimates. Based on this information it may be possible for the City to identify specific contaminants to add to the monitoring program.

Under a separate contract, the City recently completed a desktop study to identify specific contaminants of concern in the NCWRP collection system based on a survey of industrial dischargers. The final technical memorandum prepared by RMC (provided in Appendix B) provides results of data review conducted on 30 industries within the NCWRP collection system area categorized in the TM as follows:

- All (total of 2) Class 1, federally regulated, pharmaceutical manufacturers;
- Twenty Class 2 industries with the greatest industrial wastewater flow; and
- Nine industries (mainly research and development) geographically clustered on Nancy Ridge Drive, including one Class 2 industry.

3.2 AWP Facility Configuration

This section includes information about the AWP Facility equipment and configuration, including the process flow diagram, information about the selected equipment, discussion of the dual-train configuration, and scale-up rationale and suitability for the equipment.

3.2.1 Process Flow Diagram

The AWP Facility with sample locations is shown on the process flow diagram provided in **Figure A-2** located in **Appendix A**.

3.2.1.1 Selected Equipment and Dual-Train Configuration

The AWP Facility is configured to test MF and UF side-by-side to allow comparison of their effectiveness for RO pretreatment. Operational performance parameters, such as flux, fouling, cleaning intervals, and chemical consumption, as well as filtrate water quality will be directly compared for the MF and UF.

Pall MF membranes were selected because Pall MF system has a strong record of reliability and membrane integrity at numerous reuse and drinking water facilities.

Toray UF membranes were selected for the UF system because these membranes are CDPH-certified, use PVDF material, similar to the Pall MF membranes, but have approximately a 5 times smaller pore size. Toray membranes can be used in a standardized skid configuration, which could accommodate UF membranes from Norit, Dow, or Toray. This provides flexibility with the AWP Facility if the City decides to test another UF manufacturer, and could also provide advantages for membrane replacement in the full-scale plant.

Chlorine and ammonia are injected in the common header pipe upstream of the MF and UF trains, for chloramination or break-point chlorination, to ensure that the feed water for MF and UF have the same water quality.

In addition, the AWP Facility is configured to test two 0.5 mgd capacity RO trains side-by-side to allow the following evaluation:

- Comparison of two different RO membranes to quantify the trade-offs between greater rejection and lower feedwater pressure; and
- Comparison of 2-stage and 3-stage configuration to quantify the impacts on energy recovery and fouling rate.

The two types of RO membranes selected for testing include the lower pressure, Hydranautics ESPA 2 membranes, and the higher pressure and higher rejection, Toray TML20-400 membranes. The Hydranautics ESPA 2 membranes are used in other advanced treatment facilities, such as OCWD’s GWR System. The Toray membranes were selected as they are anticipated to have higher nitrate rejection than the Hydranautics membranes.

The MF and UF filtrate are combined in the MF/UF Filtrate Tanks, upstream of the RO, and antiscalant is injected in the common RO feed water pipe upstream of the RO feed pumps, to provide the same feed water quality to both RO trains. Providing each RO train the same quality feed water is critical to the above-listed evaluation to confirm that the differences in RO performance in the two trains are not attributable to the differences in feed water quality.

The RO permeate from the two RO trains are combined and treated through an AOP, comprised of ultraviolet light (UV) coupled with hydrogen peroxide (H_2O_2). Trojan

UVPhox™, a low pressure and high output (LPHO) UV system is used to demonstrate UV/H_2O_2 AOP. The advantages of LPHO UV include electrical efficiency, longer lamp life, narrower UV wavelength targeted for microbial destruction. Trojan LPHO UV systems have a proven history with advanced water treatment in California with systems installed at the OCWD GWR System, the West Basin Edward C. Little Water Recycling Facility, and the Water Replenishment District Leo J. Vander Lans Advanced Water Treatment Facility.

The sampling locations are also shown on **Figure A-2**. In addition to the 12 sampling points shown on **Figure A-2**, the sampling ports for the permeate from each RO membrane vessel of each train and the concentrate from each RO stage of each train will be provided on the RO skid.

3.2.2 Scale-Up Rationale and Suitability

The MF, UF, and RO systems are directly scalable to the full-scale plant. The systems can be scaled up or down based on the flux (i.e., by using the same flux tested in the AWP Facility for the full-scale plant). For a given flow, the desired flux could be achieved by adjusting the number of membrane elements provided (total membrane area).

Because of reactor hydraulics, the UV system is the most difficult process to scale-up from the AWP Facility to the full-scale plant. The larger the UV system, the more electrically efficient the system will be. If the AWP Facility UV system were scaled-up for the full-scale plant, then the full-scale system would be much more electrically inefficient than a system designed specifically for the full-scale plant. It is typical for the UV vendors to use bench scale testing, UV transmittance (UVT), contaminant removal goals, and computational fluid dynamics (CFD) modeling to size the UV systems. Therefore, the UV system for the AWP Facility is sized for the 1 MGD plant capacity and to achieve the NDMA and 1,4-dioxane reduction requirements in the 2008 draft CDPH regulations. The primary goal of the AWP Facility AOP system is to focus on demonstrating AOP effectiveness at the 1 MGD capacity to prove the required removal efficiencies to gain public acceptance.

It should be noted, it is not the goal of the UV/AOP demonstration testing to validate reactor performance for the potential the future full-scale AWP Facility. Validation testing of the exact reactor configuration designed for the full-scale AWP Facility would be required during plant commissioning. This would include verification the UV/AOP system can achieve log removal requirements for NDMA and 1, 4 dioxane as specified in the August 4, 2008 CDPH Draft Groundwater Recharge Regulations. **Appendix C** contains a TM provided by the project team to the City on May 21, 2010 which describes the selection process of the specific UV / AOP system unit to be tested as part of the demonstration testing. The City provided this memorandum to CDPH in June 2010 for review and comment.

3.3 Description of Certified Laboratories

For thorough water quality analysis, several different laboratories were selected to conduct analysis of samples collected during the demonstration period, which include MWH Laboratories, Weck Laboratories, Biovir Laboratories, and the AQWATEC Laboratory at the Colorado School of Mines. In addition, Laboratory Data Consultants, Inc. (LDC) was selected to perform data validation of the laboratory analyses. Selecting multiple laboratories allows for specific analysis to be performed by labs that specialize in that area, increasing accuracy and lowering detection levels. Additionally, multiple laboratories allows for labs with overlapping capabilities to perform redundant analysis for increased quality assurance (QA)/quality control (QC), via split sampling.

The commercial and specialty laboratories that will be used over the course of the testing period to perform water quality analysis per the T&M Plan are presented in **Section 5**. **Table 3-3** identifies the laboratories to be used, and provides specific information on their credentials and types of analysis they will perform as part of the test plan. The laboratories performing analysis of regulated compounds will utilize EPA-approved methods. Laboratories performing analysis on non-regulated compounds (e.g., CECs) were carefully selected based on use of peer-reviewed methods utilizing state of the art analytical equipment. Laboratory analysis data validation will be performed by LDC, Inc. as described in **Section 7.5**.

Table 3-3
Water Quality Analysis Laboratories and Data Validation

Laboratory Name and Address	Certifications / Credentials	Area of Specialty	Analysis to be Performed
MWH Laboratories 750 Royal Oaks Dr, Ste 100 Monrovia, CA 91016	CDPH NELAP USEPA UCMR2 WaterRF project 4176 – Principal Investigator	Potable and recycled water analysis, CECs	CECs UCMR3 QC Weck Lab Analysis
Weck Laboratories, Inc. 1489 E. Clark Ave City of Industry, CA 91745	CDPH NELAP USEPA UCMR2 California MBE	Water, soil, and hazardous waste analysis	General Parameters Federal and CA MCLs Priority Pollutants CDPH Notification Limits AOP Byproducts
Biovir Laboratories, Inc. 685 Stone Rd, Unit 6 Benicia, CA 94510	NELAC CDPH NELAP	Water microbiology	Coliphage
Colorado School of the Mines, Environmental Science and Engineering Dept / AQWATEC 1500 Illinois St Golden, CO 80401		Water quality issues and engineering solutions in indirect potable reuse	QC MWH CEC analysis
LDC, Inc. 7750 El Camino Real, Ste 2L Carlsbad, CA 92009	State of CA Certified Small Business	Data quality, data validation, and environmental chemistry	Laboratory sampling data validation
On-Site Laboratory Components	NA	Continuous process performance monitoring	Routine analysis of general water quality and process performance parameters

3.4 On-site Lab Description

The AWP Facility will include an operations trailer which will be used to house desks, lap top computers, filing cabinets and phones for on-site operations staff as well as an on-site laboratory. The on–site lab will be used to perform routine water quality analysis as identified in **Section 5**.

3.5 Description of AWP Facility Process Equipment

The following section describes the major AWP Facility process equipment including the MF/UF systems, RO systems and the UV/AOP system. Information is also provided for ancillary equipment including strainers, chemical dosing systems, and on-line water quality monitoring instrumentation.

3.5.1 Pre-Filtration System

A pre-filter system will be used upstream of the MF/UF systems to remove particles present in the NCWRP tertiary water. Specifications for the filtration system are provided in **Table 3-4.**

Table 3-4
Technical Specification Pre-filtration System

Parameter	**Unit**	**Toray**	**Pall**
Manufacturer		Amiad	Amiad
Model	---	SAF 3000	Filtomat 014C
Maximum Flow Rate	USgpm	660	350
Minimum working pressure	psi	30	30
Maximum working pressure	psi	150	150
Filter Area	in2	465	232.5
Screen size	micron	150	300
Inlet / Outlet diameter	in	(3”, 4”, 6”)	(3”, 4”)
Maximum Temperature	°C	50	55
Weight (empty)	lb	232 (3”)	66 (3”)

3.5.2 MF/UF Systems

The MF system utilizes the Aria Water Treatment System manufactured by Pall Corporation (Port Washington, NY). The UF system is designed around a standardized skid(s) configuration which can accommodate several manufacturers’ membranes. Initially, UF membranes manufactured by Toray will be used and tested. The skid system has been designed and supplied by H2O Innovation (Poway, CA).

The major components of the MF/UF system are:

- MF/UF Skids;
- Reverse Flow system comprised of a reverse flow pump, reverse flow storage tank, pressure sensors and pressure switches;
- Compressed Air system comprised of rotary screw compressor, air receiver tanks, coalescing filters, pressure gauges, flow meters;
- Chemical, Hot Water and Neutralization System comprised of recirculation tank, heater, hot water transfer pumps, chemical transfer pump, flow switches, temperature gauges and transmitters and control panel;
- Chlorine injection system comprised of chlorine dosing pump, dilution tank, containment tank and calibration column;

- Sodium Metabisulfate feed system comprised of dosing pump, dilution tank, containment tank and calibration column; and
- Coagulant feed system comprised of dosing pump, dilution tank and containment tank.

The skids will be painted steel frames. **Table 3-5** provides general specifications for the MF/UF membranes.

Table 3-5
MF and UF Membrane Specifications

Manufacturer	Pall	Toray
Mode of Operation	Pressured/ Outside-in	Pressured/ Outside-in
Type	Aria packaged model AP-6	Toray membranes in standard skid
No. of Fibers per Module	6,350	
Membrane area per module	538 sq ft	775 sq ft
No. of modules per unit	48	32
Dimensions of modules	6” diameter x 80” long	
Removal Rating/Nominal pore size	0.1 um	0.02 um
Membrane material	PVDF	PVDF
Min/Max inlet Pressure	15/45 psi	15/45 psi
Maximum Operating Temperature	40 ° C	40 ° C

3.5.3 RO System

The major components of the RO system are:

- RO Skid;
- High Pressure Feed Pumps;
- Chemical pre-treatment anti-scalant system comprised of anti-scalant chemical pumps, chemical tank;
- Cleaning system comprised of RO cleaning storage tank, cleaning pump, immersion heater, bag filter unit, flow meters, pressure gauges and indicators, temperature gauges and indicators;
- Permeate flushing system comprised of a storage tank, flow meter and flushing pump;
- Sampling Panel; and
- Control Panel.

Skid Configuration

The RO system will consist of two independent trains housed on one skid designed and supplied by Enaqua (Poway, CA). The skids are composed of structural steel with baked epoxy and powdered coated for corrosion resistance. **Table 3-6** provides specifications of the RO skid.

Table 3-6
Technical Specification RO Membrane Skid

Parameter	**Unit**	**Value**
Approximate Dimension (LXWXH)	Feet	25X9X9
Number of Passes	----	1
Number of Trains	----	2
Train 1 array	----	11x6
Train 2 array	----	11x6x3
Train 1 Membranes per vessel	----	7
Train 2 Membranes per vessel	----	6

RO Membranes

Specifications for the RO membranes to be tested during the demonstration period are provided in **Table 3-7.**

Table 3-7
Technical Specification RO Membranes

Parameter	**Unit**	**Hydranautics**	**Toray**
Commercial designation	‘------	ESPA2	TML
Membrane Material		Polyamide (thin film composite)	Polyamide (thin film composite)
Nominal membrane area per element	ft2	400	400
Operating pH Range		2-10.6	2-11
Cleaning pH Range		1-12	1-12
Maximum feedwater turbidity	Nephelometric Turbidity Units (NTU)	1	
Maximum feedwater SDI (15 min.with 0.45 micron)		5	5
Maximum Feed Water Chlorine Concentration		<0.1 parts per million (ppm)	ND
Maximum Operating Temperature	°F	113	113
Maximum Operating Pressure	psig	600	600
Spiral Wound Configuration			
Element length	Inches	40	40
Element diameter	Inches	7.89	7.9
Permeate channel diameter (O.D.)	Inches	1.125	1.125

3.5.4 UV-AOP System

The demonstration facility will utilize a UVPhox UV-oxidation treatment system by Trojan Technologies for UV treatment. The UV unit is a LPHO amalgam lamp system. The lamp power can be adjusted between 100% and 60% in 2% increments. General design criteria for the UV/AOP system are provided in **Table 3-8.**

Table 3-8
UV-AOP Design Criteria

Flow Rate	1 MGD
UVT @ 254 nm	95%
Target Contaminant	NDMA
Target Contaminant Reduction	1.2 Log NDMA Reduction
Target Contaminant	1,4 Dioxane
Target Contaminant Reduction	0.5 Log 1,4 Dioxane Reduction
Radical Parent Compound	Hydrogen Peroxide
Parent Compound Dose	3 mg/l

The UV system consists of the following major components:

- Trojan UVPhox Model 72AL75 stainless steel pressure reactor vessel; and
- H_2O_2 dosing and storage skid system – Includes metering pumps, H_2O_2 holding tank with double containment, and remote monitoring equipment.

Specifications for the UV /AOP system are provided in **Table 3-9**.

Table 3-9
Trojan UV System Specification

Parameter	**Unit**	**Value**
Manufacturer		Trojan Technologies, Inc
Model and ID Number		UVPhox Model 72AL75
Inside Diameter of Reactor	Inches	75
Lamp Type		LPHO
Enclosure Dimensions (HxWxD)	Inches	84x48x24
Overall Length	Inches	86
End Cap Diameter	Inches	41
Required end space for service	Inches	72

Table 3-9
Trojan UV System Specification

Parameter	**Unit**	**Value**
Flange Size	Inches	(20,16,12,8)
Maximum Operation Pressure	Psi	65
Number of Lamps		72
Electrical Supply		480V, 3 phase
Approximate Panel Draw	kW	18.5
Weight: Dry/Wet	Lb	2100/3700

3.5.5 Auxiliary Systems

The demonstration facility will include several auxiliary systems including:

- Membrane CIP System (MF/UF and RO)
- Chemical Dosing systems
  1. Anti-Scalant
  2. Sulfuric Acid (if required)
  3. Coagulant (if required)
  4. Pre-formed Chloramines
- On-line Water Quality Monitoring Equipment
  1. Turbidimeters
  2. Conductivity/pH meters
  3. ORP Analyzer
  4. Chlorine Analyzers
  5. Total Organic Carbon (TOC) Analyzer
  6. Ultraviolet Transmittance (UVT) Analyzer

3.6 Integrity Monitoring Experimental Methods

Several integrity monitoring techniques will be employed during the demonstration testing period to assess the integrity of the MF/UF and RO membrane systems. Experimental methods for these techniques to be followed during the test period are provided below. The integrity monitoring plan to be implemented during the testing and monitoring period is provided in **Section 5**. **Additional services related to integrity monitoring included November 30, 2010 Final Draft Testing and Monitoring Plan not in the current scope are provided in Section 8.**

3.6.1 Testing of RO Membranes Prior to Installation

As part of this demonstration testing program, RO membrane suppliers will be requested to provide the project team with vacuum decay or pressure hold test results on all membranes supplied for testing. In accordance to American Society for Testing and Materials (ASTM 2003) D3923-94 the acceptable pressure decay rate for RO membranes is 0.2 bar /minute. The manufacturers will be required to provide documentation that all membrane products meet or exceed these criteria. In addition, manufacturers will be requested to provide wet testing data for each membrane which includes measured salt rejection under set flow and recovery conditions. Lastly, the RO suppliers will also be requested to provide a statement that all membranes supplied for testing were selected randomly from a standard production lot.

3.6.2 Vessel Probing

Following complete installation of the membranes into each of the pressure vessels, conductivity probing will be conducted on each vessel to develop product water conductivity profiles.

The probing method to be employed was adapted from specific testing protocols developed by the project team and individual RO membrane manufacturers. (Adham et al., 1998c; Hydranautics 1998; Film Tec 2003). In general, conductivity measurements are made by taking grab samples at various locations along an individual pressure vessel during operation at set flow conditions. A general schematic of the conductivity probing set up which will be used during the test period is provided in **Figure 3-4.**

Each pressure vessel will be equipped with a ½ inch valve and tube connector located at one end to allow permeate samples to be taken from various locations. The location of each sampling point identified along a vessel (typical) is described in **Table 3-10**. Samples will be collected from each sampling point by letting product water flow for several minutes until values stabilize. Conductivity will be measured using a hand held conductivity meter.

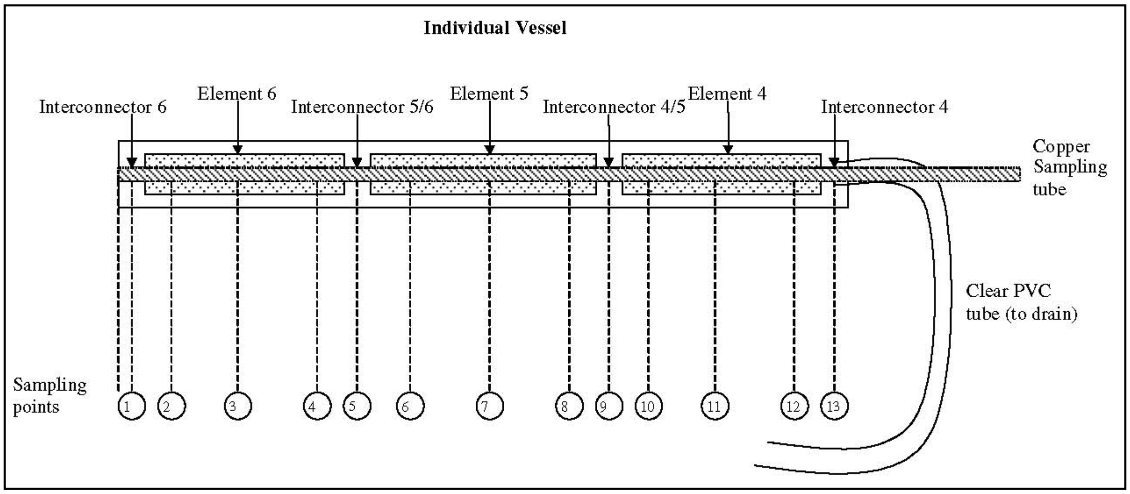

Figure 3-4
Example of RO Vessel Probing Set-up

Table 3-10
Vessel Conductivity Probing Sampling Locations

Location Number	Description	Approx. Distance from edge (Inches)
1	Interconnector 1	3.75
2	Element 1 –12 inch off center	10.75
3	Element 1-center	22.75
4	Element 1-12 inch off center	34.75
5	Interconnector 1/2	42.75
6	Element 2-12 inch off center	50.75
7	Element 2 center	62.75
8	Element 2-12 inch off center	74.75
9	Interconnector 2/3	82.75
10	Element 3-12 inch off center	90.75
11	Element 3-center	102.75
12	Element 3-12 inch off center	114.75
13	Interconnector 3/4	122.75
14	Element 4-12 inch off center	130.75
15	Element 4-center	142.75
16	Element 4-12 inch off center	154.75
17	Interconnector 4/5	162.75
18	Element 5-12 inch off center	170.75
19	Element 5-center	182.75
20	Element 5-12 inch off center	194.75
21	Interconnector 5/6	202.75
22	Element 6-12 inch off center	210.75
23	Element 6-center	222.75
24	Element 6-12 inch off center	234.75
25	Interconnector 6/7	242.75
26	Element 7-12 inch off center	250.75
27	Element 7-center	262.75
28	Element 7-12 inch off center	274.75
29	Interconnector 7	282.75

Section 4
Process Operation, Activities and Schedule

4.1 Operational Test Plan

During the test period, the performance of the various unit processes of the AWP Facility treatment train will be evaluated at different conditions. **Table 4-1** provides values for various operational conditions associated with each unit process to be used over the test period.

Table 4-1
Operational Monitoring Parameters of the AWP Facility Treatment Train

Unit Process	Operational Criteria
Microfiltration / Ultrafiltration	*Pre-treatment*
	Pre-screen (300 micron)
	Free or combined chlorine dose = 3 mg/l
	Sulfuric Acid Dose = 0 to 50 mg/L
	Coagulant dose = 0 to 10 mg/L
	Membrane System
	Flow Mode = direct (dead end filtration)
	Maximum Instantaneous Flux = 30 gfd
	Minimum Feedwater Recovery = 95%
	Backwash Frequency = 15 to 30 min.
	Backwash Flow Rate = 520 to 680 gpm for 1 minute
Reverse Osmosis	*Pre-treatment*
	Anti-scalant dosing = 1 to 3 mg/L
RO System 1: Hydranautics ESPA 2	*Membrane System*
	Number of Stages: 2
	Flux (average)= 11.9 gfd
	Feedwater Recovery = 80%
RO System 2: Toray TML20-400	*Membrane System*
	Number of Stages: 3
	Flux (average)= 11.6 gfd
	Feedwater Recovery = 80%

Table 4-1
Operational Monitoring Parameters of the AWP Facility Treatment Train (Cont.)

Ultraviolet / Advanced Oxidation	Influent Flow = 694 gpm
	Type of UV System= LPHO
	Number of Lamps= 72
	Watts per Lamp= 260 W
	Lamp power setting: 60 to 100%
	Hydrogen peroxide dose = 3 mg/L
	Total Power Draw= 18.5 kW

Testing of the AWP Facility is divided into several components including: Testing, Commissioning, and Start-up; Initial Testing Activities; Phase I Testing; Phase II Testing; and Phase III Testing. A description of each testing period is described below.

4.1.1 Testing, Commissioning, and Start-Up

A 30-day period has been designated to testing, commissioning, and start-up of the AWP Facility. A separate Start-Up Procedures and Operational Plan was developed as part of the project. This document includes details on field functional equipment testing, loop checks, system integration, and acceptance testing, equipment QA/QC, and calibration of instruments, gauges and meters.

4.1.2 Initial Testing Activities

A 10 week period has been designated to conducting initial test activities for the AWP Facility.

Tasks to be completed over this period for each unit process are summarized in **Table 4-2**. As shown, the integrity of the membrane systems will be checked by performing Online turbidity monitoring (MF/UF), Pressure Decay Tests (MF/UF), Online conductivity and TOC monitoring (RO) and vessel probing (RO). In addition, the productivity of the new membranes will be established by measuring the flux and pressure of the membranes. Lastly, the UV system will undergo check of the intensity sensor (if required) along with performance of NDMA spiking experiments to establish flow and power settings required for 1.2-log removal of NDMA. These settings will be used for remainder of the testing period.

Table 4-2
Initial Testing Activities

Unit Process	**Testing Activity**
Microfiltration / Ultrafiltration	Pressure Decay Testing
	Flux Testing
	Calibrate Online Turbidimeters
Reverse Osmosis System (s)	Online Conductivity Monitoring
	Vessel Probing
	Set up chloramines dosing system
	Verify Pressure gage accuracy
	Set up online TOC Analyzer
Ultraviolet / Advanced Oxidation	Calibration of online UVT Analyzer
	NDMA Spiking experiment

Phase I Establishment of Baseline Operating Conditions

Phase I testing will include the operation of the Pall MF and Toray UF systems for a runtime of 60 to 90 days to establish baseline operating parameters including coagulant dose, flux, maintenance cleaning requirements and the feedwater recovery of each system. During this time, filtrate from the two low pressure (MF/UF) membrane systems will be combined to provide feed water to two RO systems, which will utilize Toray Model TML20-400 (Train B) and Hydranautics Model ESPA2 (Train A) membranes, respectfully. Product water from the two RO systems will be combined to supply feed water to the UV/AOP system. Upon completion of the Phase I testing period, all membrane systems will be cleaned, regardless of the degree of fouling that has occurred, to allow fouling trends during Phase II to be established using clean membranes.

During the initial period the MF and UF systems will be operated at a nominal flux and water recovery of 30 gallons per square foot per day (gfd) and 95%, respectively. The actual operating conditions will be based on recommendations provided by the manufacturers, based on the NCWRP tertiary water characteristics, historical performance of the membranes on similar waters and technical judgment of parameters that most likely will result in successful long term operation with minimal membrane cleanings. The performance under these conditions will be judged based on the success criteria and action plan shown in **Table 4-3**. During Phase I testing the MF and UF systems will be operated without the use of coagulant addition pretreatment. Should fouling exceed success criteria, coagulant dosing will be required per the manufacturer's recommendations.

During the initial operating period the Train A and Train B RO systems will be operated with a two and three-stage configuration , respectfully under the flux conditions provided above and an equivalent recovery of 80%. During this time the pH of the feedwater will not be suppressed. Success criteria for the RO systems during Phase I is provided in **Table 4-3**. As shown, if the temperature corrected specific flux either membrane decreases by more that stated limit (after an initial cleaning) and/or the membranes do not produce filtrate total nitrogen (TN) requirement, the recovery for that system may be reduced to 75% for Phase II testing. In addition depending on the type of fouling observed it may be required to suppress the pH of the feed water using sulfuric acid. Note information gained during this time will also be used to adjust operational set points during Phase III of the AWP Facility testing.

During the initial test period the UV/AOP system will be operated under the manufacturers recommend lamp power and peroxide dose settings to achieve 1.2-log removal of NDMA and 0.5-log removal of 1,4-dioxane based on a flow rate of 1 MGD. The performance of the UV/AOP system at various power settings will be verified by conducting spiking experiments. During the initial test period lamp fouling and aging will be assessed per criteria list in **Table 4-3**.

Table 4-3
Phase I Success Criteria / Alternative Action Plan

Measured Parameter	Success Criteria (30 day runtime)	Options if Success Criteria not met
MF/UF Systems		
Increase in Temperature Corrected TMP	Max. Increase 20% (to be confirmed with mfg) from clean membrane TMP in 720 hours.	Perform CIP. Restart system. Lower flux. Add coagulant pre-treatment Phase II. Add chlorine to backwash (BW). Increase BW frequency
Pressure Decay (daily)	<1 psi /min	Repeat PDT test. Repair broken fibers. Check / repair leaks on air lines / fittings.
Turbidity	Filtrate not to exceed 0.15 NTU. Avg 24 hour <0.10 NTU for 95% of the time.	Perform maintenance / calibration of on-line turbidimeter. Perform PD test. Repair fibers.
SDI (207 kPa, 15 mins., 0.45 micron)	Filtrate < 3	Check / flush filtrate storage tank. Perform PD test. Repair fibers.
RO Systems (Toray TML/Hydranautics ESPA2)		
Decrease in Temperature Corrected Specific Flux	Max. 20% from clean membrane value	Clean membranes. Restart. Increase feed chloramines Reduce recovery Acidify feed

Table 4-3
Phase I Success Criteria / Alternative Action Plan

RO Systems (Toray TML/Hydranautics ESPA2)		
Measured Parameter	**Success Criteria (30 day runtime)**	**Options if Success Criteria not met**
Decrease in conductivity rejection	Max. 0.5%	Profiling and probing of pressure vessels. Clean membranes. Restart if decrease occurs again reduce recovery to 75% for Phase II testing
Increase in Feed to Concentrate Differential Pressure (DP)	Max. 7% from initial conditions	Flush feed lines and feed tank. Clean membranes.
Total Nitrogen	Permeate NTE 0.5 mg/L TN	Reduce recovery. Change RO feedwater pH. Assess need for IX. Check for change in feed water concentration.
UV /AOP System		
Lamp fouling /aging	% drop intensity / delivered dose over 720 hours	Clean lamps; flush feed line, replace lamps if needed
Intensity Sensor	Within set % of reference sensor after 720 hours	Replace sensor.
NDMA	1.2 log removal	Adjust lamp power and / or flow settings. Check feedwater concentration: has it changed?
1,4 Dioxane	0.5 log removal	Adjust lamp power and / or flow settings; increase peroxide dose. Check feedwater concentration: has it changed?
Power Draw	~11 kw	Check power setting. Replace bad ballast(s) or lamp(s)
Hydrogen Peroxide Feed Concentration	3 mg/L	Check dosing pump / measure draw down/ adjust pump speed.

Phase II Steady State Operation

Phase II testing will be conducted over a target runtime of 208 days (~5,000 hours) to collect long term operational and water quality performance data of the MF/UF, and RO systems.

The 5,000 hours is based on target runtime of the MF/RO and UF/RO treatment trains at the design flow rate. The 5,000 hours does not include downtime due to routine shutdowns (e.g. maintenance, testing, cleanings, process modifications, etc. which may take from 2 hours to 36 hours). For example, if after operating for 500 hours of continuous operation any component of a train requires to be taken offline for a routine shutdown requiring 24 hours, upon start up the runtime clock for said train would begin at 500 hours. For non-routine events that result in downtimes exceeding 36 hours, the project team will meet with the City and their Project

Management consultant to discuss the most appropriate option to meeting the target 5,000 hours of runtime. Examples of non-routine event may an upset in the NCWRP that may impact the availability of tertiary water in terms of quantity and/or quality, damage to membranes due to chlorine, or irreversible fouling.

During Phase II a key focus of the RO monitoring will be to compare the nitrogen rejection, operating pressure and overall energy consumption of the two RO systems. The Toray TML membrane is designed for higher nitrate rejection but operates and higher pressure. The Phase II will also allow performance data to be collected on a two-stage versus three-stage system.

Phase III Collect Information on Improving Operational Efficiency

Time allowing, the final phase of the overall 12 month testing will be designated to gaining preliminary information on options for increasing efficiency the of the various unit processes based on information obtained during Phase II. Phase III will occur over an approximately 45 day period. Parameters to be considered include:

- Chemical usage
- Membrane flux, recovery
- Backwashing frequency
- Reduction of UV dose
- Others

Upon completion of Phase III testing, the project team will develop pre-qualification criteria to be considered during procurement of equipment for the full scale facility.

4.2 Chemical Addition

4.2.1 Chlorine Dosing / Ammonium Hydroxide & Preformed Chloramines

During part of the testing phase, it is planned to dose free chlorine upstream of the MF and UF systems followed by ammonium hydroxide immediately downstream to form combined chloramines to inhibit microbial growth through the RO membranes. However, as part of the NDMA and Chloramines Investigation Plan provided in **Section 6**, trials with pre-formed chloramines dosed upstream of the MF/UF systems will also be tested to assess inhibition of NDMA formation. The dose rates will be set to 2 to 3 mg/L combined chlorine in the MF/ UF product.

4.2.2 Acid and Anti-scalant

RO performance projections indicate that fouling from calcium carbonate and calcium phosphate can be controlled for the NCWRP water at an 80% recovery without the use of acid. An acid system will be provided should it be required at any point to maintain stable operation. Acid will be fed upstream of the MR/UF systems to prevent plugging of RO membranes from impurities in the acid solution.

Anti-scalant containing a dispersant will be added to the RO influent to minimize precipitation of soluble salts as well as disperse colloidal fouling. A nominal dose of 1 to 3 mg/L, per the manufacturer's recommendations, will be the starting point for anti-scalant design criteria. At least two different anti-scalants provided by different manufacturers will be tested over the demonstration period, including products from King Lee Technologies (San Diego, CA) and Avista Technologies, Inc. (San Marcos, CA).

4.2.3 Coagulant Dosing

Coagulant dosing will be tested as pretreatment to the UF system to enhance membrane productivity by increasing particle floc size, which can lead to decreased pore plugging, reduce cake layer resistance and increase backwashing efficiency. Typical coagulants and doses provided by the manufactures include Poly Aluminum Chloride at 0.5 – 1 mg/L as Al.

4.2.4 Hydrogen Peroxide Dosing

Hydrogen peroxide will be dosed upstream of the UV system to form free-hydroxyl radicals. These strong oxidizing agents will oxidize trace organics including UV photolysis products which can result in the re-formation of NDMA. The nominal dose of peroxide to be employed during normal operation based on experience at currently operating full scale AWP Facilities is 3 mg/L. However spiking experiments will be conducted to assess the impact of operating with lower peroxide dose on 1,4 dioxane removal. Reduction of peroxide dose may reduce the degree of by-product formation and result in overall O&M savings.

4.2.5 Chemical Cleaning of Membranes

The chemical cleaning of the MF/UF systems typically employs a chlorine soak (250 - 500 mg/L) followed by an acid (pH 2-3) cleaning soak. Each cleaning step includes a rinse and drain cycle before the membrane system is returned to operation. Past studies by the project team have shown the free chlorine residual of the filtrate returned to 0 mg/L after the filtration of 2.0 liters per square meter (L/m^2) per unit membrane area following the chlorine cleaning step and the pH returned to background levels after approximately 18 L/m^2 per unit membrane area following the acid cleaning step. This information will be used as a guideline to determine the need to waste filtrate after start up following a cleaning. Specific cleaning protocols to be followed during the testing period have been provided by the MF and UF system by Pall and Toray, respectfully, and are included in **Appendix E**.

The RO membranes will be cleaned using the manufacturers recommended chemical cleaning procedures. In general, the type and concentration of chemicals used for cleaning RO membranes are specific to the type of fouling. For example, for organic fouling which can occur after long term operation of RO membranes on wastewater, cleaning solutions with a high pH (10 - 11) such as sodium hydroxide, in combination with sodium dodecysulfate, are required. A caustic (high pH) cleaning solution is also effective for removing silicates from RO membranes should silica scaling or fouling occur. However, for inorganic fouling, such as metal oxides, a low pH (4) cleaning using a weak acid such as citric acid is required. Specific cleaning protocols to be followed during the testing period have been provided by the RO membrane suppliers, Toray and Hydranautics, respectfully, are included in **Appendix E.**

4.2.6 Calculated Parameters

Membrane Systems

A number of calculated parameters will be needed to establish the performance of the MF, UF, and RO membrane systems. These calculated parameters are defined as follows:

Transmembrane Pressure (TMP)

The average net driving force for the MF/UF and RO membrane systems will be calculated according to the following equation:

$$P_{net} = \frac{(P_i + P_o)}{2} - P_p - \Delta\pi \qquad (1)$$

where,

P_{net} = net driving force

P_i = pressure at the inlet of the membrane module

P_o = pressure at the outlet of the membrane module

P_p = permeate pressure

$\Delta\pi$ = net osmotic pressure of the feed and permeate

It should be noted that osmotic pressure for the MF and UF membranes is negligible since the membranes do not remove dissolved salts. Hence, the net driving force (Pnet) is referred to as the transmembrane pressure by neglecting the net osmotic pressure term from equation 1. Thus, equation 1 reduces to the following:

$$P_{tm} = \frac{(P_i + P_o)}{2} - P_p \qquad (2)$$

where,

Ptm = transmembrane pressure

For the RO membranes equation 1 will be used to determine net operating pressure. An integrated averaging factor (IAF) assuming 100% salt rejection can be used to estimate the average osmotic pressure as follows:

$$\Delta\pi = IAF\,\pi_f$$

where,

πf = osmotic pressure of the feed stream

IAF = Ln [1/(1-R)] / R, (R = recovery expressed as decimal) = 2.2 (for 85% recovery)

The following approximation can be used to determine osmotic pressure of the feed stream:

- 1,000 mg/L NaCl solution ~ 11.6 psi of osmotic pressure, π

A correlation between NaCl concentration and conductivity can be assumed (1.6 micromhos of conductivity = 1mg/l NaCl)

Temperature Adjustment for Flux Calculation

Temperature correction to 20°C for flux of the MF/UF membranes will be made according to Equation 3, which is based on the variation of water viscosity with temperature:

$$J_{tm}(\text{at}20°\text{C}) \equiv \frac{Qp \times e^{-0.0239\times(T-20)}}{S} \qquad (3)$$

Where,

J_{tm} = instantaneous flux, (L/h-m^2)

Q_p = permeate flow, (L/h)

T = temperature, (°C)

S = membrane surface area, (m^2)

Temperature corrections to 25°C for transmembrane flux of the RO membranes will be made according to the manufacturer's temperature correction factors.

Determination of Specific Flux

The specific flux or permeability is the relationship between flux and the net driving pressure. The relationship is defined by the formula:

$$J_{SP} = \frac{J_{tm}}{P_{Net}} \tag{4}$$

where,

J_{SP} = specific flux (lmh/bar)

Likewise, the temperature-corrected specific flux can be calculated using the temperature corrected flux.

Determination of Differential Pressure

Differential pressure of the RO membranes is the difference between the feed pressure and concentrate pressure, calculated as follows:

$$\Delta P = Pf - Pc \tag{5}$$

where,

ΔP = differential pressure

P_p = pressure measured in RO feed

P_c = pressure measured in RO concentrate

Because the differential pressure varies with flow rate and temperature in the spiral wound membrane, values should be normalized to compare measured values with initial values.

Normalized Differential Pressure

Differential pressure of the RO membranes can be normalized with respect to concentrate and permeate as follows:

Where, $$\Delta Pn = \Delta P \frac{(2 * Q_{c0} + Q_{p0})^{1..5}}{(2 * Q_c + Q_p)^{1.5}} \tag{6}$$

ΔPn = normalized differential pressure (bar)

ΔP = differential pressure (bar)

Q_{c0} = initial concentrate flow (lpm)

Q_{p0} = initial permeate flow (lpm)

Determination of Feed Water Recovery (FWR)

The parameter "feed water recovery" (FWR) represents the net water production of the MF/UF and RO systems. The FWR will be calculated according to the following equation:

$$\text{FWR} = [1 - \frac{\text{Vol. of water was ted}}{\text{Vol. of raw water used}}] \text{ x } 100\% \tag{7}$$

FWR represents the percent recovery of feed water and accounts for: (1) the permeate water used for backwashing and maintenance cleaning of the membranes (MF/UF system only), and (2) the concentrate water bleed (RO system only).

Rejection

The rejection of constituents by MF/UF process will be calculated as follows:

$$R = (1 - \frac{C_P}{C_F}) * 100\ \% \tag{8}$$

Where:

R = Rejection,

C_P = Product water concentration, (mg/L)

C_F = Feed water concentration, (mg/L)

Normalized RO Salt Passage (Rejection)

Because temperature and flow impact salt passage through RO, salt rejection is normalized as follows:

$$\mathrm{SP_n} = \left(\frac{Q_p}{Q_{p\,n}}\right) * \left(\frac{STCF_n}{STCF}\right) * SP \tag{9}$$

where,

SP_n = normalized salt passage (%)

SP_a = actual salt passage (%)

Qp = permeate flow rate measured at given temperature

Qp_n = permeate flow rate normalized to 25 deg C

$STCF_n$ = salt transport temperature correction factor at 25 deg C

STCF = salt transport temperature correction factor at given temperature

Actual salt passage through RO is impacted by the feedwater recovery and is calculated as follows:

$$\mathrm{SP_a} = \left(\frac{C_p}{C_{fb}}\right) \tag{10}$$

Where,

SP_a = actual salt passage (%)

C_p = permeate concentration (mg/L)

C_{fb} = feed – concentrate concentration (mg/L) = C_f * IAF

R = Salt Rejection = (1 – SP) * 100

4.3 Testing & Activities Schedule

The schedule for the AWP Facility testing program is provided in **Figure 4-1**. The schedule covers a 24-month period and consists of Tasks 1-5, as described below.

Task 1 will include approximately 12-week period dedicated to the installation and start up of the demonstration equipment to be conducted by the project team's construction group. Starts up activities to be conducted for the 15-day period following equipment installation include: field functional equipment testing, loop checks, and system integration.

Task 2 includes a 12-month testing period of the AWPF which includes four phases. During the initial testing phase (10-weeks) specific testing, as provided in **Figure 4-1,** will be conducted to ensure the membrane processes are intact, determine flow and power settings for the UV/AOP system, optimize chloramines dosing, and assess performance of the systems under "new" conditions. Phase I Testing (12-weeks) is designed to establish baseline operating conditions and performance for each unit process. Specific acceptance criteria and "alterative action" plans for each unit process have been established for this time period as presented in **Table 4-3.** The focus of Phase II testing is to operate the membrane systems for 5,000 hour of operation under steady state conditions to monitor operational and water quality performance. Phase III (time allowing) is planned for 6 weeks to gain additional information on each unit processes based on information obtained during previous testing phase.

Task 3 allocates 6-months to continued operation of the AWP Facility primarily for public tours and education as well as optional additional testing to be conducted at the City's discretion.

Task 4 will span the entire demonstration testing period to assess the operational and water quality performance of the MF, UF, RO and UV/AOP systems. Quarterly progress reports will be produced throughout the 12 month test period. These reports will include valuable information including current performance data on all systems, changes to testing protocols, and overall progress. The PAC members will review the reports to ensure the quality of data and to make any suggestions regarding any necessary changes to the demonstration testing protocols. Should a drastic change occur in performance at any time during the test period the PAC would be notified and provided data immediately via email or telephone to ensure quick feedback on potential cause/solution of the problem. The City will also distribute these reports to the IAP members and Regulatory Agencies for review.

Task 5 allocates 12 months to allow for preparation of the final AWPF. This report shall contain experimental procedures and analytical methods used over the test period, statistical and graphical representation of the results, interpretation of results, regulatory relevance of the results, and optimization of operating conditions.

Other Testing Activities - The schedule also identifies when the various components of the water quality monitoring program and integrity monitoring plan will be implemented. The water quality monitoring plan includes several components including: 1) routine sampling, 2) quarterly sampling, 3) initial CEC monitoring and 4) microbial monitoring As shown in **Figure 4-1**, the routine water quality sampling plan is scheduled to begin 6-weeks after the start of the 12 month test period to allow the treatment systems to stabilize and ensure they are operating at steady state to obtain representative data as recommended by the IAP in comments received on the November 30, 2010 Final Draft Testing and Monitoring Plan. Details on the water quality monitoring program and integrity testing plan are provided in **Section 5**.

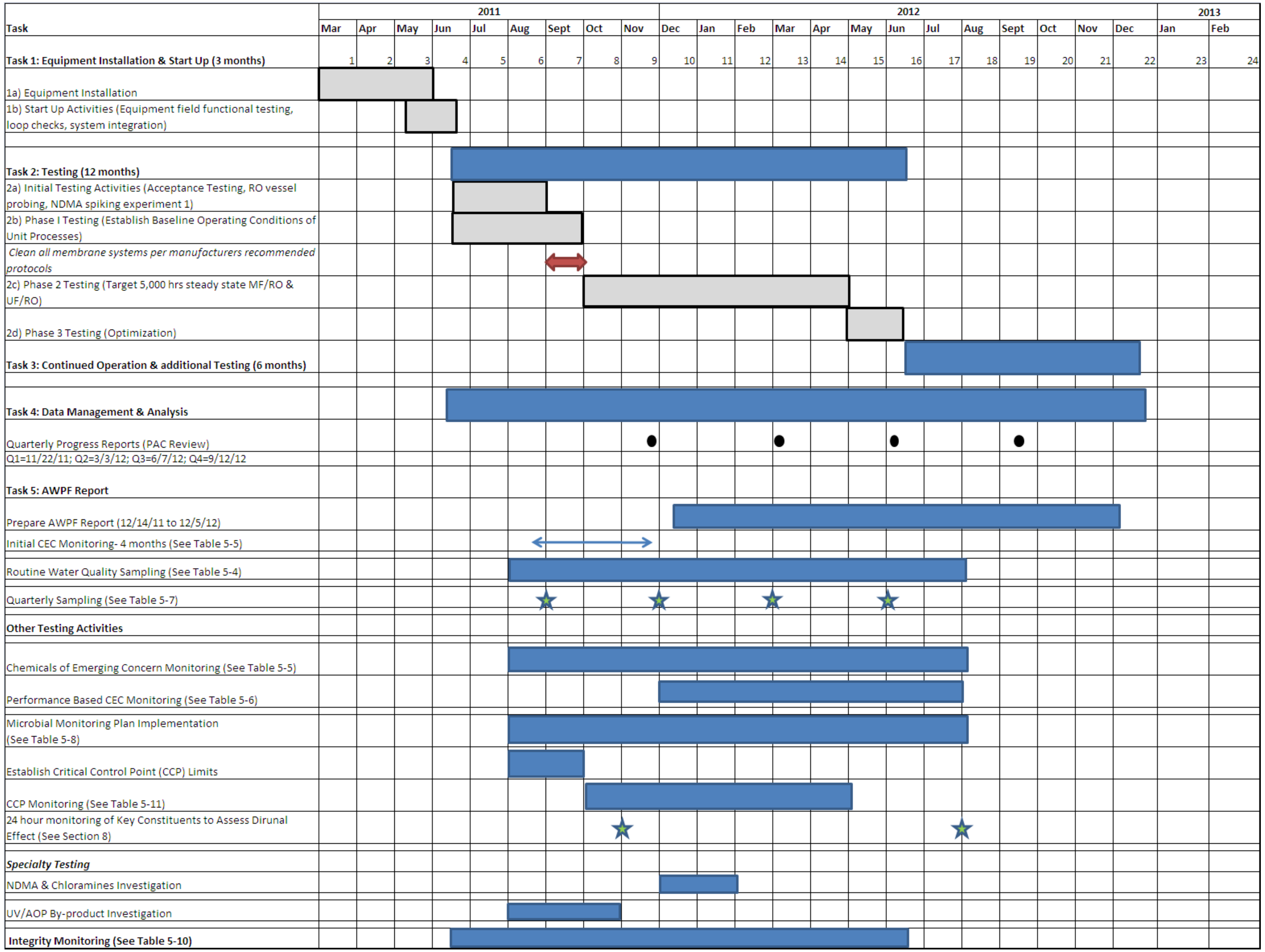

Figure 4-1
Testing Schedule City of San Diego AWP Facility

4.4 Maintenance Requirements for Test Equipment

The maintenance requirements for the AWP Facility test equipment will be included in the vendor-supplied O&M manuals, which will be included in the Start-Up Procedures and Operational Plan. In general, the O&M manuals for the AWP Facility equipment will include the following information. This outline will be tailored for the specific equipment or skid.

1. System description
2. Installation instruction
3. Operations
    a. Start-up
    b. Shut down
    c. Normal operating conditions
    d. Membrane cleaning
4. Maintenance
    a. Spare Parts
    b. Lubricants
    c. Maintenance Records
5. Troubleshooting
6. Warranty

Table 4-4 summarizes the Demonstration Plant major equipment that will require maintenance during the 18-month operational period. The maintenance procedures for this equipment will be included in the Start-Up Procedures and Operational Plan.

Table 4-4
Demonstration Plant Major Equipment Requiring Maintenance

Skid or Equipment	Equipment Requiring Maintenance
MF Skid	Strainer Valves (automatic and manual) Backwash pump and motor Air compressor system and motor Turbidimeter
UF Skid	Strainer Valves (automatic and manual) Backwash pump and motor Air compressor system Turbidimeter
RO Skid	RO feed pumps and motor RO flush pumps and motor Energy recovery system Flow meters Valves (automatic and manual)
UV Skid	UV lamps, Peroxide dosing system, Intensity Sensor
CIP System	CIP pump and motor CIP tank heater Valves (automatic and manual)
Chemical Systems (sulfuric acid, sodium hypochlorite, ammonium hydroxide, antiscalant, and hydrogen peroxide)	Chemical pumps Anti-Siphon valves Pressure Relief valves
Tanks	Valves Level indicators
Sump Pump	Sump pump and motors
Other	Pressure reducing valves (PRVs) on MF and UF influent piping Flow meters Valves (automatic and manual) Pressure Relief valve
Online Instruments	pH/temperature meter Chlorine analyzer ORP analyzer Conductivity analyzer
Field Instruments and Analytical Equipment	See Table 5-3.

4.5 Residuals Management Plan for Process and Cleaning Wastes

This section identifies the residuals that will be generated from the AWP Facility and how the residuals will be managed. **Table 4-5** identifies the process and cleaning wastes that will be generated from the AWP Facility, the frequency of flow (i.e., continuous or intermittent), and the discharge point.

Table 4-5
Residuals Management Plan for Process and Cleaning Wastes

Process and Cleaning Wastes	Continuous (C) or Intermittent (I)	Discharge Point
MF & UF Skids		
Automatic strainer backwash	I	Hard piped to trench drain, pumped to existing 8" AWT SDR with sump pump
MF/UF backwash	I	Hard piped to existing 8" AWT SDR from the MF and UF skids through overhead piping (not pumped with sump pump), drains by gravity (no back pressure on this line)
Chemically enhanced backwash (CEB)	I	Hard piped to existing 8" AWT SDR from the MF and UF skids (not pumped with sump pump)
RO Skid		
Concentrate	C	Hard piped to existing 8" AWT SDR from the RO skid (not pumped with sump pump)
Permeate flush	I	Hard piped to existing 8" AWT SDR from the RO skid (not pumped with sump pump)
MF/UF filtrate tank and RO permeate tank, drains and overflows	I	Temporary piping to trench drain from tank drain when needed, modulate drain flow with tank drain valve so do not overflow sump, pumped to existing 8" AWT SDR with sump pump
Clean-in-place (CIP) tank, drains and overflows[1]	I	Pumped to the existing 8" AWT SDR from the CIP tank by the CIP pumps
Washdown water	I	Drain by gravity across pad to trench drain, pumped to existing 8" AWT SDR with sump pump
Chemical wastes (residual chemicals remaining at end of plant operational period)	I	If there are residual chemicals at the end of the Demonstration Plant operational period, determine if the City can use them in their process or return to chemical vendors

Section 5
AWP Facility Process Evaluation

5.1 Operational Performance Monitoring

The operational performance of each unit process will be monitored by taking frequent manual readings and downloading data from the Supervisory Control and Data Acquisition (SCADA) system. **Table 5-1** provides specific parameters to be monitored from each system along with the manual monitoring frequency of each parameter. Parameters collected by SCADA will be recorded every 2 to 5 minutes and downloaded routinely and as needed. The manual data collection sheets to be used for each unit process are provided in **Appendix F**.

Table 5-1
Operational Monitoring Parameters of the AWP Facility Treatment Train

Monitoring Parameter	Location	Frequency
MF/UF Systems		
Temperature	Feed	1/day
Flow Rate	Permeate, backwash, chemical dosing pumps	1/day
Chlorine Concentration	Permeate (Filtrate)	1/day
Pressure (before and after backwash)	Feed, permeate (Filtrate)	1/day
Power	Main supply	1/day
Reverse Osmosis Systems		
Temperature	Feed	2/day
Flow Rate	Permeate (stage 1/ stage 2 / stage 3), combined, acid dosing pump, anti-scalant dosing pump	1/week
Pressure	Feed, permeate, concentrate (Stage 1 / Stage 2 / Stage 3)	2/day
Conductivity	Feed, permeate (stage 1,2 3 and combined)	2/day
Power	Main supply	2/day
UV/AOP System		
[1] Power	Lamp input	2/day
[2]UV Intensity	UV Chamber/Intensity Sensor	2/day
UV Transmittance	Feed	2/day
Flow rate	Feed, peroxide dosing pump	1/day

[1] A power factor adjustment will be requested from Trojan to estimate full scale power usage of the UV/AOP system based on actual power usage of the demonstration system. [2] Once per quarter the accuracy of the online UV intensity sensor will checked using a reference sensor

Operational data collected from the various unit processes will be used to calculate key performance parameters. Membrane fouling associated with the MF, UF and RO systems will be assessed by monitoring temperature corrected specific flux and TMP throughout the test period. A decrease in the temperature corrected specific flux under constant flux operation will indicate membrane fouling is occurring. When the acceptable drop in temperature corrected flux or maximum TMP level has been reached over the specified time period provided in Table 4-3, membrane cleaning will be performed. RO performance will also be assessed by monitoring the feed to concentrate DP normalized to initial DP values. An increase in normalized DP values with operation time will indicate the feed channels of the membranes have become plugged making it necessary to perform membrane cleaning. In addition, the conductivity rejection of the RO membranes will be continuously monitored. A significant decrease in conductivity rejection will necessitate membrane cleaning or repair of damaged o-rings, as appropriate.

Operational data collected from the UV system will be used to assess fouling and aging associated with UV lamps and intensity sensors along with lamp wiper efficiency. On a quarterly basis the UV intensity sensor will be verified using a reference sensor to assess its accuracy.

5.2 Water Quality Performance Monitoring

The following section outlines the specific treated water quality goals of the AWP Facility based on existing recycled water regulations, as well as anticipated future regulatory requirements specific to the City's proposed full-scale AWP Facility, which would be used to augment the current raw drinking water source at San Vicente Reservoir. The overall approach for water quality performance demonstration monitoring is to collect water quality data at different locations throughout the AWP Facility treatment process to analyze process performance, and to compare treated water quality to objectives, screening levels, and existing water supplies. This water quality monitoring program has four main objectives:

- Assess the overall AWP Facility treatment trains ability to meet the established and anticipated treated water quality goals relevant to the full scale AWP Facility surface water augmentation of San Vicente Reservoir.
- Monitor water quality throughout the treatment train to assess performance and efficiency of each unit process.
- Identify CECs in NCWRP tertiary effluent and evaluate removal efficiency of those CECs by the AWP Facility system.
- Compare AWP Facility system end-of-pipe water quality to the water quality of the City's existing raw water supply.

The water quality monitoring will be conducted through sampling and analysis of AWP Facility system water, at various points through the treatment process, by both on-site and off-site laboratory facilities. Water quality parameters that need to bedetermined frequently to control the operation of the treatment process will be analyzed on-site using batch, on-line, and/or portable water quality test units. On-site monitoring will typically be conducted on a daily basis. Water quality parameters that do not require daily monitoring will be analyzed through sampling sent to one of four off-site laboratories. Off-site facilities utilized in this monitoring program will be MWH Labs, Weck Labs, Biovir Labs, and the Colorado School of Mines Laboratory. For a discussion of qualifications and certifications of each of these facilities, refer to **Section 3**.

Individual analytical parameters are chosen for several different reasons as listed:

- Indicators that assist in monitoring AWP Facility performance;
- Federal and/or state regulated constituents;
- Constituents that are monitored at the request of federal and/or state regulators, but not regulated; and
- CECs as identified by the Recycled Water Science Advisory Panel convened by the SWRCB.

The water quality monitoring plan contains four individual components, which are identified below and described in detailed referenced Sections.

- Routine Water Quality Sampling Plan (Section 5.2.2)
- Chemicals of Emerging Concern Monitoring Plan (Section 5.2.3)
- Quarterly Monitoring Plan (Section 5.2.4)
- Microbial Monitoring Plan (Section 5.2.5)

Note: the specific sampling regimes associated with the various components of the overall water quality sampling plan listed above are subject to modification throughout the testing period based on the project team's assessment of analytical results, comments received from the reviewers of the Quarterly Progress reports and development of regulatory requirements for the potential full scale project. Such changes will be documented in the Quarterly Progress reports and adjustments will be made to the existing sampling regime to ensure the overall analytical budget is not exceeded. Changes which require an increase in the analytical budget would be presented to the City for approval prior to implementation.

5.2.1 Treated Water Quality Goals

The City's IPR/RA AWP Facility includes three separately contracted tasks by others that are underway, but not yet completed. These tasks will provide key information that will shape the final regulatory-based water quality goals for the AWP Facility at NCWRP. The three tasks are:

- Defining state and federal regulatory requirements for a full-scale project;
- Performing a limnology and reservoir study for the San Vicente Reservoir, which will provide recommendations related to controls for nutrients; and
- Providing an independent expert review of the technical, scientific, and regulatory aspects of the project by the IAP.

Since this work is still underway, it is not feasible at this time to define the ultimate regulatory-based water quality goals for the demonstration plant. However, proposed interim goals are presented here for review by CDPH, RWQCB and the IAP as described below.

Regulatory Requirements

The overall purpose of the demonstration project is to prove that the AWP Facility meets all federal and state regulatory requirements that would be applied to a full-scale project as permit limits. These requirements would be primarily based on:

- The CDPH requirements for use of recycled water for nonrestricted recreational impoundments. These regulations require that recycled water meet the requirements for disinfected tertiary effluent, which will be met by the AWP Facility based on design.
- Recommendations from CDPH regarding the use of recycled water for surface water augmentation. CDPH is currently developing draft regulations for this use, but has not yet released a draft for public review. For the time being, a reasonable assumption is that the CDPH treatment conditions for the OCWD's GWR System for 100% reuse of advanced treated recycled water for groundwater recharge can be used as interim requirements in evaluating the AWP Facility. These treatment requirements are:
    - Compliance with primary and secondary drinking water maximum contaminant levels (MCLs) in the final recycled water.
    - TN cannot exceed 5 mg/L.

  - TOC cannot exceed 0.5 mg/L divided by the CDPH-specified maximum average Recycled Water Contribution (RWC)[1]. Based on the OCWD's RWC of 100 percent, the TOC cannot exceed 0.5 mg/L.
  - The turbidity of the RO product water cannot exceed 0.2 NTU more than 5 percent of the time in any 24-hour period and can never exceed 0.5 NTU at any time.
  - The RO permeate UV transmittance must be 90 percent or greater at 254 nanometers (nm).
  - The final recycled water must be disinfected such that the 7-day median number of total coliforms cannot exceed 2.2 total coliform bacteria per 100 mL and the number of total coliform organisms cannot exceed 23 total coliform bacteria per 100 mL in more than one sample in any 30-day period.
  - AOP must achieve at a minimum a 1.2 log NDMA reduction and 0.5 log 1,4-dioxane reduction, whether NDMA and 1,4-dixoane are present or not.

- The Basin Plan, including designated beneficial uses of the San Vicente Reservoir, water quality objectives to protect those uses, the state anti-degradation policy for surface water, and toxicity requirements (including applicable federal and state standards). The Basin Plan establishes beneficial uses for surface waters and groundwater in the region and numeric and narrative water quality objectives to protect those uses. Permit limits are established for those constituents that have the reasonable potential to cause or contribute to an excursion above any water quality objective. The Basin Plan allows for a mixing zone (e.g., dilution factor) to be considered for inland surface waters on a case-by-case basis. If a dilution factor is approved, the permit limit (and reasonable potential evaluation) could be based on this simplified modification of the water quality objectives in the Basin Plan[2]:

$$Ce = Co + Dm\,(Co)$$

where
Ce = the effluent limitation
Co = the water quality objective to be met at the completion of initial dilution
Dm = minimum probable initial dilution expressed as parts water per part wastewater (the Dm is not the same as the CDPH RWC)

The designated beneficial uses of San Vicente Reservoir are:

- Municipal and Domestic Supply (MUN).

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[1] The maximum RWC has not yet been established for the project and is dependent on the outcome of the limnology studies.

[2] This calculation does not consider ambient concentrations of constituents. It will be necessary to work out how a mixing zone would be specifically (if at all) with the RWQCB. For example: Ce = Co + Dm (Co – Cs), where Cs is the background surface water concentration (which must be less than the Co).

- Agricultural Supply (AGR).
- Industrial Process Supply (PROC).
- Industrial Service Supply (IND).
- Contact Water Recreation: fishing from shore or boat is permitted, but other water contact recreational (REC-1) uses are prohibited. However, per Section 115840(a) of the Health and Safety Code, CDPH allows the reservoir to be used for body contract recreation, and thus other REC-1 uses apply.
- Non-body Contact Water Recreation (REC-2).
- Warm Freshwater Habitat (WARM).
- Cold Freshwater Habitat (COLD).
- Wildlife Habitat (WILD)
- Applicable numeric water quality objectives in the Basin Plan include: Total dissolved solids (TDS), chloride, sulfate, percent sodium, iron, manganese, boron, turbidity, color, fluoride, nutrients (nitrogen and phosphorus), unionized ammonia, fecal coliform, dissolved oxygen, pH, primary and secondary MCLs, and phenolic compounds. These requirements are presented in **Appendix G**.

Narrative water quality objectives have been established for oil and grease, pesticides, radionuclides, sediment, suspended and settleable solids, taste and odor, temperature, and toxicity.

Narrative and numeric nutrient requirements are included in the Basin Plan. For waste discharge requirements established for reclaimed water discharges to surface water such as the San Vicente Reservoir, the Basin Plan allows the RWQCB to use the phosphorus goal for flowing waters (0.1 mg/L) as a guideline or to determine compliance with the narrative objective using four factors, including use of best available technology (BAT) economically feasible for the removal of nutrients. Additional input on potential nutrient requirements (including phosphorus and nitrogen) will be available in approximately 6 months after completion and review of the limnology study results.

- Water quality criteria established for priority pollutants by the U.S. Environmental Protection Agency (USEPA). The Clean Water Act (CWA) requires states to adopt numeric water quality criteria for those toxic pollutants which the USEPA has issued advisory CWA 304(a) criteria and which may reasonably be expected to interfere with the maintenance of designated beneficial uses. In 1991, California adopted water quality “objectives” (equivalent to the federal “criteria” component of federal water quality standards) for a number (but not all) of the priority pollutants designated by USEPA in the Inland Surface Waters Plan (ISWP) and Enclosed Bays and Estuaries Plan (EBEP). After adoption, USEPA disapproved portions of the plans because California had not had not issued objectives for all of the priority pollutants. In 1992, USEPA promulgated the National Toxics Rule (NTR) to bring non-complying states into compliance with the CWA. The 1992 NTR established federal standards in California for roughly 40 priority pollutants not covered in the ISWP and EBEP. In 1994, the ISWP and EBEP were overturned in state court in due to failure of the SWRCB to comply with state law in adopting the objectives contained in the plans. In 1995, USEPA elected to proceed with adopting the CWA 304(a) water quality criteria for California.

In 2000, USEPA promulgated the California Toxics Rule, that that included aquatic life criteria for 23 priority pollutants and human health criteria for 57 priority pollutants. In adopting criteria in the CTR, the USEPA updated some of the CWA 304(a) criteria based on new or revised reference doses and cancer potency factors and updated aquatic life toxicity data sets. The human health criteria are comprised of two categories. First are the “water and organism” criteria, which are based on a cancer risk of 10^{-6} and an assumed exposure through consumption of drinking water and eating fish. The “water and organism” criteria are applied to protection of MUN beneficial uses. Second are the “organism only” criteria, which are based on a cancer risk of 10^{-6} and an assumed exposure through eating fish. The “organism only” criteria are applied to protection of REC-1 and REC-2 beneficial uses. The aquatic life criteria are based on toxicity and are applied to pertinent wildlife beneficial uses. For any “discharge” to a water of the United States, the most stringent criteria for all beneficial uses must be met. The CTR criteria are presented in **Appendix G**.

- Implementation procedures for the CTR established by the SWRCB through the Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California (SIP). The SIP includes i) procedures to determine which priority pollutants need effluent limitations (e.g., reasonable potential analysis), ii) methods to calculate water quality-based effluent limitations, and iii) policies regarding mixing zones, metals translators, monitoring, pollution prevention, reporting levels for determining compliance, and whole effluent toxicity control. Permit limits are established for those CTR constituents that have the reasonable potential to cause or contribute to an excursion above any applicable criteria including consideration of dilution (Section 1.3 of the SIP). If a dilution factor is approved, the permit limit would be based on this modification of the water quality criteria in addition to other factors as set forth in Section 1.4 of the SIP.

Water Quality Goals for Regulated Constituents

As part of the AWP Facility demonstration study, two types of monitoring activities will be undertaken for regulated parameters:

- Collection of data for all regulated parameters in the final product water and/or designated points in the treatment process. These data will be compared to anticipated limits. It is expected that for the most part, these constituents will be below reporting levels.

- Targeted collection of data for key regulated compounds (target constituents) to optimize treatment as discussed below.

A review of pilot plant data collected for the City of San Diego Advanced Water Treatment Research Studies (MWH, 2007), provides insight on those regulated compounds that should be more closely evaluated for the demonstration testing (e.g., those compounds that potentially provide a challenge to the treatment process). The goals established for the proposed target constituents will differ from the regulated limits. These goals have been established to ensure optimization of the various treatment processes rather than to establish specific goals for a future full scale AWP Facility. It is expected that additional input will be provided on target constituents based on review by CDPH and the IAP.

Table 5-2 presents a preliminary set of target constituents, anticipated regulatory requirements and proposed demonstration goals.

Table 5-2 Anticipated Water Quality Goals for Regulated Constituents: San Diego AWP Facility

Constituent	Units	Proposed Demonstration Goal (average)	Anticipated Regulatory Limit (maximum)	Basis	Critical Beneficial Use/Issue
Total organic carbon (TOC)	mg/L	0.5	[1]0.5	CDPH	MUN
Ammonia (unionized as N)	ug/L	25	25 or Ce=25+Dm(25)	Basin Plan	Habitat
Nitrate (as N)	mg/L	[2]1	10 or Ce=10+Dm(10)	CDPH & Basin Plan	MUN
Total nitrogen	ug/L	[2]1000	[1]5000	CDPH	MUN
			[1,2]1000	Basin Plan	Biostimulation
Total phosphorus	ug/L	[2]100	[1,2]100	Basin Plan	Biostimulation
N-nitrodisodimethylamine (NDMA)	Log reduction	> 1.2-log	[1]1.2- log	CDPH	MUN
	ng/L	Not detected	[3]0.69 or Ce=0.69+Dm(0.69)	CTR/SIP	
1,4-Dioxane	Log reduction	> 0.5-log	[1]0.5- log	CDPH	MUN
1,2-Dichloroethane	ug/L	< 0.38	[3]0.38 or Ce=0.38+Dm(0.38)	California Toxics Rule	MUN
Total trihalomethanes	ug/L	< 80	[1]80	CDPH	MUN
Bromoform	ug/L	Not detected	[3]4.3 or Ce=4.3+Dm(4.3)	California Toxics Rule	MUN
Chlorodibromomethane	ug/L	Not detected	[3]0.401 or Ce=0.401+Dm(0.401)	California Toxics Rule	MUN
Dichlorobromomethane	ug/L	Not detected	[3]0.56 or Ce=0.56+Dm(0.56)	California Toxics Rule	MUN
Halo acetic acid (HAA)	ug/L	< 60	[1]60	CDPH	MUN
Methylene chloride	ug/L	< 4.7	[3]4.7 or Ce=4.7+Dm(4.7)	California Toxics Rule	MUN
Turbidity	NTU	< 0.2	[1]0.2	CDPH	MUN
Chloride	mg/L	50	[3]50 or Ce=50+Dm(50)	Basin Plan	MUN
Total dissolved solids (TDS)	mg/L	300	[3]300 or Ce=300+Dm(300)	Basin Plan	MUN

1. Potential limit based on best available information developed to date. Value subject to change.
2. Tentative goals based on providing best available treatment economically achievable and achieving Basin Plan total nitrogen and total phosphorus objectives for flowing waters.
3. Based on simplified version for determining California Toxics Rule (CTR) permit limits for priority pollutants. Section 1.4 of the State Implementation Plan contains specific steps and procedures that take into consideration ambient background concentration, the coefficient of variation of measured concentration data, and dilution credit. In some cases, the calculated effluent limitation can be lower than the CTR criterion. Ce - effluent concentration; Dm – dilution factor.

5.2.2 Routine Water Quality Sampling Plan

Table 5-3 and **Table 5-4** present a routine sampling plan which includes parameters that will be measured on-site using handheld and on-site lab equipment along with parameters that will measured by outside certified laboratories, respectfully. Routine sampling is intended to assess performance and control of individual unit processes as well as collect characterization data on NCWRP tertiary water. The routine sampling regime proposed in **Table 5-4** has been developed to assess the ability of the AWP Facility to meet the initial water quality objectives provided in **Table 5-2**. The proposed specific parameters, target demonstration goals, sampling frequency and sample collection methods are based on the following:

1. Input received to date on the anticipated regulatory requirements for the potential full scale AWP facility;
2. Information required to assess treatment performance;
3. Information required to support future permit applications for the potential full scale AWP Facility;
4. Compare the water quality performance of the two RO Systems;
5. Data typically required by CDPH and RWQCB as part of compliance for similar discharges.

Sample locations are defined in the process flow diagram provided in **Figure 5-1** below.

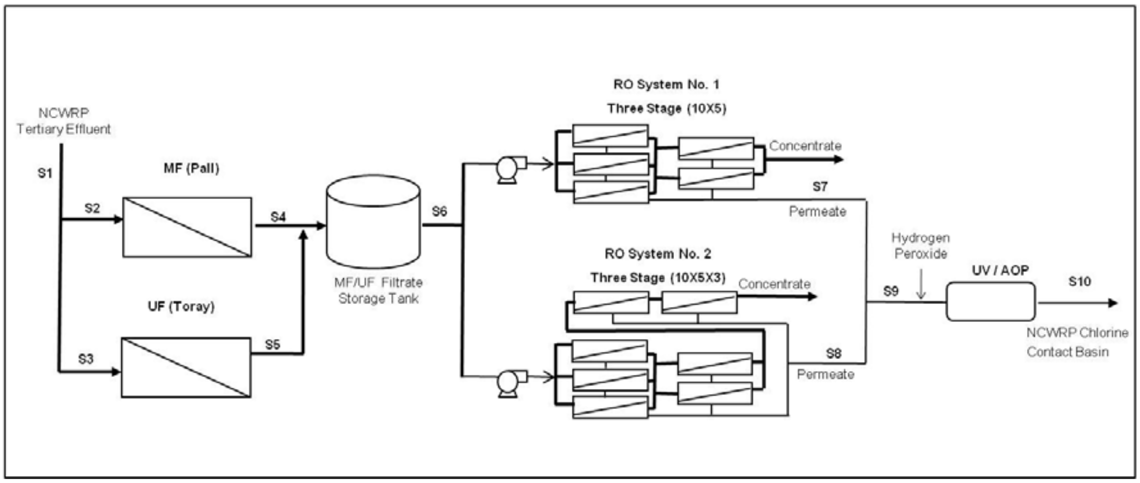

Figure 5-1
AWPF Process Schematic

As indicated in Table 5-3, a portable low range TOC analyzer (dynamic operating range of 0.03 parts per billion [ppb] to 50 ppm) will be used to monitor TOC concentrations at various points in the AWP treatment train to identify any large variations in measured concentrations which would indicate a change in the NCWRP tertiary water quality and / or possible integrity breach of the AWP Facility unit processes(s). The portable unit will be set up for on-line measurement (similar to OCWD Groundwater Replenishment System) of TOC in the RO combined product water. The portable unit will also be used to measure grab samples taken daily from various locations of the AWP train. It should be noted the location of the on-line TOC analyzer may be moved to other locations in the train i.e. RO feed for a short time during the testing period to capture continuous TOC data.

Table 5-3
On-site Routine Water Quality Monitoring Plan for the San Diego AWP Facility

Analyte / Contaminant Group	[1]Sampling Location(s)	[2] Initial Sampling Frequency	Sampling Equipment/ Method	Sample Type
On-site				
Temperature	S1, S6, S9, S10	daily	Portable meter HACH SensION156	Grab
pH	S1, S6, S9, S10	daily	Portable meter HACH SensION156	Grab
Turbidity	S1,S4,S5,S6, S9, S10	daily	HACH 2100 Q Portable Turbidimeter)	Grab
Turbidity	S1, S4,S5	continuous	Turbidimeter (HACH 1720D / FilterTrack 660)	On-line
UV 254	S1, S4, S5, S6, S7, S8	1/week	Spectrophotometer (HACH)	Grab
UV 254	S9, S10	daily	Spectrophotometer (HACH)	Grab
[3]TOC	S7, S8, S10	weekly	[2] GE Sievers 900 Portable TOC Analyzer	Grab
[3]TOC	S6,S9	daily	GE Sievers 900 Portable TOC Analyzer	[4]Grab/Online
Dissolved Oxygen (DO)	S10	weekly	Portable meter HACH SensION156	Grab
Conductivity	S6, S7, S8	daily	Conductivity probe	Online
Conductivity	S6, S7, S8	weekly	Portable meter HACH SensION156	Grab
Silt Density Index	S6	1/week	ASTM D4189	Grab
Total Chorine Residual	S4/S5 combined	daily	HACH CL-17	On-line
Total Chorine Residual	S1, S3, S6, S9, S10	daily	Chlorine Pocket Colorimeter HACH	Grab
Free Chorine Residual	S6	daily	Chlorine Pocket Colorimeter HACH	Grab

1. Sampling locations are shown in Figure 5-1.
2. Sampling frequencies / locations will be reassessed periodically.
3. Dynamic operating range is 0.03 ppb to 50 ppm.
4. S9 to be monitored on-line all other sampling locations via grab sampling.

Table 5-4
Certified Laboratory Routine Water Quality Monitoring Plan for the San Diego AWP Facility

Constituent	[1] Sample Location	[2,3] Type of Sample	[4] Analytical Method	Monitoring Frequency	[5] Total Number of Samples per location
Total organic carbon (TOC)	S6, S7, S8	Grab	SM5310C	Monthly	3
TOC	S9	24-Hour Composite	SM5310C	Monthly	12
TOC	S10	24-Hour Composite	SM5310C	2 per week	104
Ammonia Nitrogen	S6, S7, S8	Grab	EPA 350.1	Bi-weekly (once per 2 weeks	6
Ammonia Nitrogen	S9	24-Hour Composite	EPA 350.1	Bi-weekly (once per 2 weeks	26
Ammonia Nitrogen	S10	24-Hour Composite	EPA 350.1	2 per week	104
Nitrate / Nitrite	S6, S7, S8	Grab	EPA 353.2	[5] Bi-weekly (once per 2 weeks	6
Nitrate / Nitrite	S9	24-Hour Composite	EPA 353.2	[5] Bi-weekly (once per 2 weeks	26
Nitrate / Nitrite	S10	24-Hour Composite	EPA 353.2	2 per week	104
Total Nitrogen	S6, S7, S8	Grab	Various (Determined by Calculation)	[5] Bi-weekly (once per 2 weeks)	6
Total Nitrogen	S9	24-Hour Composite	Various (Determined by Calculation)	[5] Bi-weekly (once per 2 weeks)	26
Total Nitrogen	S10	24-Hour Composite	Various (Determined by Calculation)	2 per week	104
Total phosphorus	S6, S7, S8	Grab	EPA 365.1	[5] Bi-weekly (once per 2 weeks)	104
Total phosphorus	S9	24-Hour Composite	EPA 365.1	[5] Bi-weekly (once per 2 weeks)	6
Total phosphorus	S10	24-Hour Composite	EPA 365.1	2 per week	26
Nitrosamines	S1, S6	Grab	EPA 521	Monthly	12

1. Sampling locations are shown in Figure 5-1.
2. All samples to be taken as grab samples for the initial 2 months due to delays in the receipt and installation of auto-samplers.
3. Composite samples to be collected on a time weighted basis.
4. MDLs, RLs, TATs, sample hold times for each method are provided in Appendix I.
5. Total samples based on a sampling period of 3 months (S6, S7, S8) and 12 months (S1, S9 and S10).

Table 5-4
Certified Laboratory Routine Water Quality Monitoring Plan for the San Diego AWP Facility (Cont.)

Constituent	[1] Sample Location	[2,3] Type of Sample	[4] Analytical Method	Monitoring Frequency	[5] Total Number of Samples per location
Nitrosamines	S7, S8	Grab	EPA 521	Monthly	3
Nitrosamines	S9, S10	24-Hour Composite	EPA 521	Monthly	12
1,4-Dioxane	S6, S7, S8	Grab	EPA 3520C	Monthly	3
1,4-Dioxane	S9, S10	24-Hour Composite	EPA 3520C	Monthly	12
[6]VOCs	S1, S9, S10	Grab	EPA 524.2	Monthly	12
Halo acetic acids (HAA5)	S1, S6	Grab	EPA 552.2	Monthly	12
Halo acetic acids (HAA5)	S7, S8	Grab	EPA 552.2	Monthly	3
Halo acetic acids (HAA5)	S9, S10	24-Hour Composite	EPA 552.2	Monthly	12
Phenols	S10	24-Hour Composite	EPA 8270-SM	Monthly	12
Chloride, Fluoride, Sulfate	S6, S7, S8	Grab	EPA 300.0	Bi-weekly (once per 2 weeks	6
Chloride, Fluoride, Sulfate	S10	24-Hour Composite	EPA 300.0	Bi-weekly (once per 2 weeks	26
Total dissolved solids (TDS)	S6, S7, S8	Grab	SM 2540C	Bi-weekly (once per 2 weeks	3
Total dissolved solids (TDS)	S10	24-Hour Composite	SM 2540C	Bi-weekly (once per 2 weeks	26
Metals (Fe, Na, Mn, B)	S10	24-Hour Composite	SM 2540C	Bi-weekly (once per 2 weeks	26
Color	S10	24-Hour Composite	SM 2540C	Bi-weekly (once per 2 weeks	26

1. Sampling locations are shown in Figure 5-1.
2. All samples to be taken as grab samples for the initial 2 months due to delays in the receipt and installation of auto-samplers.
3. Composite samples to be collected on a time weighted basis.
4. MDLs, RLs, TATs, sample hold times for each method are provided in Appendix I.
5. Total samples based on a sampling period of 3 months (S6, S7, S8) and 12 months (S1, S9 and S10).
6. Include: 1,2 dichloroethane, methylene chloride, tri-halomethanes (THM).

5.2.3 Chemicals of Emerging Concern Monitoring Plan

5.2.3.1 Background

The SWRCB adopted a Recycled Water Policy in February 2009 with the purpose of providing permitting clarity to California projects that use recycled water for non-potable landscape irrigation and for groundwater recharge (surface spreading and injection). The Policy did not address projects that use recycled water for surface water augmentation. A key component of the Policy was how to address new classes of chemicals referred to as CECs. CECs include pharmaceuticals, current use pesticides, and industrial chemicals. Many CECs are potentially present in recycled water however the detection of many is so recent that robust methods for their quantification and toxicological data for interpreting potential human or ecosystem health effects are unavailable.

Under the Recycled Water Policy, the SWRCB established a Science Advisory Panel (SAP) to provide guidance for developing monitoring programs that assess potential CEC threats to human and aquatic.

The SAP included six panel members versed in a mix of disciplines: chemistry, biochemistry, toxicology, epidemiology, risk assessment, and engineering. During September of 2009 and May 2010, four in person meetings and several conference calls occurred. These meetings were designed to allow for stakeholder input to clarify the SAP's charge, exchange information, dialog with the SAP, and allow considerations of public comments in the report. Overall four products were developed by the SAP to assist the SWRCB to refine the direction of the Recycled Water Policy regarding CEC monitoring (SWRCB, 2010):

Product 1 - Conceptual Framework to determine which CEC's to monitor

1) Measured Environmental Concentration (MEC) of CECS in source water (secondary or tertiary effluent) for reuse projects

2) Monitoring Trigger Level (MTL) for each compound or group of compounds based on toxicological relevance

3) Compare MEC to MTL. CECs with MEC/MTL > 1 should be prioritized for monitoring. CECs with a ratio of less than "1" should only be considered if they represent viable treatment process performance indicators; and,

4) Screen the list from step 3 to ensure that a commercially-available robust analytical method is available for that compound.

Product 2 - Application of the framework to identify a list of chemicals that should presently be monitored

1) Through a survey that was shared with Californian stakeholders, the SAP compiled available California MEC data. In this effort, the SAP made conservative assumptions on MEC's: 1) that reported concentrations were representative of the

entire state and 2) that analytical methods used to quantify data are accurate – these two assumptions maximized the number of candidate chemicals that are toxicologically relevant.

2) For groundwater recharge projects (e.g., surface spreading, direct injection), four compounds were identified as possible indicator compound based on their toxicological relevance. In addition, four additional CECs were identified for surface spreading and direct injection operations as viable performance indicator compounds along with certain surrogate parameters (e.g., ammonia, dissolved organic carbon, conductivity). The SAP also recommended method reporting levels (MRLs) that were compound specific and that ranged from 1 to 100 ng/L for the following CECs.

   Indicator compounds based on toxicological relevance:

   a. NDMA,

   b. 17beta-estradiol

   c. Caffeine

   d. Triclosan

   Performance Indicators:

   a. DEET (N,N-Diethyl-meta-toluamide)

   b. Gemfibrozil

   c. Iopromide

   d. Sucralose

The SAP believed it was critical to emphasize that if a compound exceeds its respective MTL at the point of monitoring (POM), the finding does not necessarily indicate a public health risk. The MEC/MTL framework was only developed for the purpose of prioritizing CECs for monitoring. The SAP's proposed MEC/MTL ratios should not be used to make predictions about risk.

Lastly, the SAP strongly recommended to the SWRCB to reapply the prioritization process on at least a triennial basis. The regular review process would fill data gaps for compounds with little or no occurrence and toxicological information in California. In order to fill data gaps for CECs with limited or no information on MECs in California, the SAP suggested that the State initially conduct a more thorough review of CECs likely to occur in recycled water using MEC and predicted environmental concentration (PEC) data from the peer-reviewed literature and occurrence studies outside California. Those CECs that exhibit MEC/MTL ratios above "1" could be placed on a secondary monitoring list that is measured less frequently to confirm absence or presence of these CEC in California. In addition, this secondary monitoring list could be populated by CECs that exhibit a relatively low MTL (less than 500 ng/L) but could have the potential to trigger a MEC/MTL ratio of larger than "1". The Panel suggested monitoring select CECs for which currently no California MECs are available in secondary/tertiary treated effluent but analytical methods exist:

- 1,2,3-Trichloropropane
- Hydrazine
- Quinoline

Product 3 A Sampling design and approach for interpreting results from CEC monitoring programs

The SAP provided recommendations for a phased, performance-based approach for implementing landscape irrigation and groundwater recharge recycled water monitoring programs and multi-tiered framework for interpreting the data. The first phase involves screening that would be initiated at project start-up and continue through the early years of project operation. If a specific CEC consistently exhibits low occurrence, the SAP recommended deleting the CEC from further monitoring provided that production data do not suggest a significant increase in use. If CECs exceed thresholds identified in the report, the SAP recommended moving to a second phase of enhanced monitoring to confirm the presence and frequency of such CEC(s). The third phase, should concentrations continue to be high, would require initiation of source identification and/or toxicology studies. The final phase would involve engineering removal studies and/or modification of plant operation if found to be warranted by the results of the third phase.

Product 4 Priorities for future improvements in monitoring and interpretation of CEC Data

The science of CEC investigation is still in its early stages and the recommended that the State could undertake several activities that would greatly improve both monitoring and data interpretation for recycled water management, including:

- Develop and validate more and better analytical methods to measure CECs in recycled water;
- Encourage development of bioanalytical screening techniques that allow better identification of the "unknown unknown" chemicals; and,

- Develop a process to predict likely environmental concentrations of CECs based on production, use and environmental fate, as a means for prioritizing chemicals on which to focus method development and toxicological investigation.

In addition to these research recommendations, the SAP recommended that the State develop a process to rapidly compile, summarize, and evaluate monitoring data as they become available.

The SWRCB intends to adopt specific recommendations on CEC monitoring for recycled water landscape irrigation and groundwater recharge projects taking into consideration the suggestions from the SAP.[3]

5.2.3.2 Proposed CEC Monitoring Plan for City of San Diego AWP Facility

The project team worked with several SAP members to tailor the overall recommendations of SAP report to produce a monitoring program specific for the City's AWP Facility. The project team acknowledged that the SAP framework was originally not developed for surface water augmentation projects. However, since surface water augmentation requires treatment standards that are similar or potentially more stringent than direct injection projects, applying the SAP framework in concept was deemed appropriate.

In deriving such a monitoring program for the City's AWP Facility, the following aspects were addressed:

- Application of the conceptual framework developed by the SAP to the City's AWP Facility demonstration-scale project
- Comparison of CECs recommended for monitoring identified during the SAP's initial CEC occurrence survey for secondary/tertiary treated effluent in California to CECs quantified in the NCWRP tertiary effluent in the past
- Phased / Performance Based Approach to Monitoring CECs
- Sampling Protocols

Application of SAP Framework to San Diego's AWP Facility

Concentrations of CECs measured in NCWRP tertiary treated effluent based on pilot testing conducted in 2005 are summarized in **Table H-1** (**Appendix H**). The list of CECs has been augmented by chemicals that where identified by the SAP as toxicological relevant. MEC/MTL ratios for each compound based on the SAP report and MEC/MTL values based on average concentrations measured in NCWRP tertiary effluent are also provided in the table. Only two compounds exceed a MEC/MTL

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[3] The SWRCB may adopt recommendation in November 2010.

ratio of 1 and confirm the recommended list of CECs to be included in recycled water monitoring programs as proposed by the SAP.

Table 5-5 provides the proposed CEC monitoring plan for the AWP Demonstration Facility. The overall CEC monitoring plan includes an initial feed water characterization period which includes sampling of the NCWRP tertiary water monthly for the first four months. During this time, samples will be analyzed for a list of ninety-one (91) EDC/PPCP compounds representing a wide range of chemical and physical properties. The sampling locations for this period also include RO feed, combined RO product, UV/AOP product and imported aqueduct water. Information used from the initial characterization period will used to 1) characterize NCWRP tertiary effluent, 2) identify appropriate AWP performance indicator compounds to be monitored on an on-going basis, 3) assess AWP unit process CEC removal performance and 4) compare AWP product water quality to the City's imported raw drinking water. The proposed CEC monitoring plan also includes an initial list of CEC compounds to be monitored on an on-going basis (i.e. sampled quarterly). Currently, the proposed list contains compounds prioritized based on toxicological evidence by the SAP (SWRCB, 2010). These compounds have maximum environmental concentrations (MEC) values that exceeded monitoring trigger limits (MTLs). In addition, the on-going characterization includes specific compounds recommended by the IAP (NWRI, 2010), CDPH and the State Board. As noted in Table 5-4, information obtained from the initial feed water characterization period will be used to make modifications to the list of compounds to be monitored on an on-going basis.

Table 5-5
Proposed CEC Water Quality Monitoring Plan for the San Diego AWP Facility

CEC Contaminant Group	[1] Sampling Locations	Rationale for Monitoring
Initial Feed Water Characterization (sample monthly for the first four months)		
[2] List of 91 CECs analyzed by MWH Laboratories	S1, S6, S9, S10 Imported Aqueduct Water	• Characterize NCWRP tertiary water. • Identify appropriate indicator constituents. • Assess AWP unit process CEC removal performance. • Compare water quality of AWP to imported water.
1, 4-Dioxane	S1, S6, S9, S10 Imported Aqueduct Water	
NDMA	S1, S6, S9, S10 Imported Aqueduct Water	
[3] ***Preliminary List for On-going Characterization (Quarters 3 and 4)***		
Caffeine	S6, S9, S10	Compounds prioritized based on toxicological evidence. Measured environmental concentration (MEC) greater than monitoring trigger level (MTL), as developed in SWRCB, 2010.
E2 (17β-Estradiol)	S6, S9, S10	
NDMA	S6, S9, S10	
Triclosan	S6, S9, S10	
DEET	S6, S9, S10	[4] IAP Sub-committee Recommendation
Carbamazepine	S6, S9, S10	[4] IAP Sub-committee Recommendation / [5] CDPH
Primidone	S6, S9, S10	[4] IAP Sub-committee Recommendation
PFAA's	S6, S9, S10,	[4] IAP Sub-committee Recommendation
1,4 dioxane	S6, S9, S10	[4] IAP Sub-committee Recommendation / [5] CDPH
UCMR3 (selective)	S6, S9, S10	[4] IAP Sub-committee Recommendation
Hydrazine	S6, S9, S10	[4] IAP Sub-committee Recommendation
Quinoline	S6, S9, S10	[4] IAP Sub-committee Recommendation
Nicotine	S6, S9, S10	[4] IAP Sub-committee Recommendation
Bisphenyl A	S6, S9, S10	[5] CDPH/State Board
Chlorate	S6, S9, S10	
Boron	S6, S9, S10	
Chromium, hexavalent (CrVI)	S6, S9, S10	
Diazinon	S6, S9, S10	
Naphthalene	S6, S9, S10	
Nitrosamines (NDPA, NDEA, NPYR, NMEA)	S6, S9, S10	
1,2,3 Trichloropropane	S6, S9, S10	
TCEP	S6, S9, S10	
Vanadium	S6, S9, S10	

[1] Sample locations shown in Figure 5-1.
[2] List contains pesticides, herbicides, PPCPs see **Appendix I** for complete list. :
[3] Compounds selected for On-going characterization may change based on results of initial feed water characterization.
[4] CECs recommended for monitoring memorandum: Findings and Recommendations of the AWPFr Purification Facility Sub-committee Meeting, November 15, 2010, NWRI (Appendix K).
[5] CDPH letter to State Board September 13, 2010 in response to SWRCB 2010 Report.

Performance-Based Approach to Monitoring CECs

Tables 5-6 provides the proposed initial list of surrogate parameters and indicator CECs to be measured for the performance-based monitoring program for the AWP Facility. This program will be initiated after the first quarter of operation is complete and operating at steady state conditions. During the first four weeks, differentials between RO feed and permeate and UV-AOP feed and final product water will be determined for performance surrogate parameters and performance CEC indicators. The operational set-points for RO (i.e., flux and recovery) and the UV/AOP process (i.e., EEO or dose and H_2O_2 dose) shall be maintained constant. After start-up, monitoring for CEC indicators is reduced to quarterly while surrogate parameters are measured more frequently to demonstrate that the pre-determined differential values can be achieved. After start-up, those operational set-points should be selected that were set during the initial performance evaluations. If set-points are modified, the differentials for surrogate and indicator CECs will need to be determined again. Based on recommendations from the IAP sub-committee (NWRI 2010), the initial list of proposed performance indicators will be re-evaluated based on information obtained from the initial feed water CEC monitoring program provided in Table 5-5.

Additional services related to performance based CEC monitoring based on comments received on the November 30, 2010 Final Draft Testing and Monitoring Plan from the CDPH not in the current Testing and Monitoring scope are described in Section 8.

Table 5-6
Proposed performance-based CEC Monitoring Plan for the San Diego AWP Facility

Parameter	Sampling Locations	Purpose
[1] ***Initial RO Performance Characterization***		
Δ Conductivity (online)	S6, S7, S8	Determine initial differential removal of surrogate parameter for process performance validation.
ΔTOC (daily for 2 weeks)	S6, S7, S8	
ΔDEET (once a week for first four weeks)	S6, S7, S8	Identified for surface spreading and direct injection operations as viable performance indicator compounds along with certain surrogate parameters (SWRCB, 2010).
ΔSucralose (once a week for first four weeks)	S6, S7, S8	
ΔNDMA (once a week for first four weeks)	S6, S7, S8	
ΔCaffeine (once a week for first four weeks)	S6, S7, S8	
[1] ***Initial UV/AOP Performance Characterization***		
[2]ΔUVA-254 nm (daily)	S9, S10	Determine initial differential removal of surrogate parameter for process performance validation.
Δ NDMA (once a week for first four weeks)	S9, S10	Identified for surface spreading and direct injection operations as viable performance indicator compounds along with certain surrogate parameters (SWRCB, 2010).
Δ Total Chloramines (daily)	S9, S10	Determine initial differential removal to assess viability of use as a surrogate parameter for process performance validation.).
***On-going Monitoring to Assure RO Performance* (Quarters 2,3,4)**		
ΔConductivity (online)	S6, S7, S8	Determine differential removal of surrogate parameter for process performance validation
ΔTOC (once a week)	S6, S7, S8	
ΔDEET (every quarter)	S6, S7, S8	
ΔSucralose (every quarter)	S6, S7, S8	
ΔNDMA (every quarter)	S6, S7, S8	
ΔCaffeine (every quarter)	S6, S7, S8	
On-going Monitoring to Assure UV/AOP Performance		
ΔUVA-254 nm (daily)	S9, S10	
Δ NDMA (every quarter)	S9, S10	

[1] Note initial performance characterization is to begin after the first quarter of testing is complete.

[2] UV 254 will be measured by grab samples using a HACH DR 4000 Spectrophotometer with 10 cm sample cell to increase accuracy. Values will be compared to UV 254 values calculated from UVT values measured by the on-line analyzer equipped on the feed of the Trojan UV/AOP system. The location of the on-line analyzer will be changed from the feed to product once per day for 1 hour to assess the sensitivity of the on-line analyzer to measure UV 254 removal.

Sampling Protocols

Methods used to quantify indicator CECs need to meet stringent QA/QC measures, including blanks, replication, and matrix spikes. The SAP recommended the use of isotope-dilution and tandem mass spectrometry whenever possible, for details see

SWRCB (2010). Additional details on specific measure to be taken during sampling of CEC is provided in **Section 7**.

5.2.4 Quarterly Monitoring Plan

Table 5-7 identifies various contaminant groups that will be monitored on a quarterly basis by collecting grab samples from various locations throughout the AWP Facility treatment train. The purpose of the quarterly sampling for various groups are categorized as public health regulatory, reservoir regulatory, and AWP Facility unit process performance.

Quarterly sampling locations will include imported aqueduct water collected by the City staff at the Miramar Water Treatment Plant. This will allow comparison of water quality from the AWP Facility to source waters which supply the City's drinking water facilities. As indicated in Figure 4-1, quarterly sampling will not begin until the AWP Facility unit processes have been stabilized and are operating at steady-state conditions, which is anticipated to be 8 weeks after Phase 1 Testing begins.

Table 5-7
Quarterly Water Quality Monitoring Plan for the San Diego AWP Facility

[1] Contaminant Group	[2,3] Sampling Location(s)	Purpose
Compounds regulated under Federal and State Primary and Secondary Drinking Water Standards.	S1, S10, Imported Aqueduct Water	Public Health Regulatory
Disinfection by-products (trihalomethanes, haloacetic acids, bromated chlorite, NDMA, chlorate).	S1, S6, S9, S10, Imported Aqueduct Water	Public Health / Reservoir Regulatory
Compounds included on USEPA's Priority Pollutant List.	S1, S10, Imported Aqueduct Water	Public Health Regulatory
Compounds with current CDPH Notification Limits.	S1, S10, Imported Aqueduct Water	Public Health Regulatory
Unregulated Contaminant Monitoring Rule (UCMR 3) Proposed Contaminants Assessment Monitoring (List 1).	S1, S10, Imported Aqueduct Water	Public Health Regulatory
TOC, Total Nitrogen, Total Phosphorus.	S1, S10, Imported Aqueduct Water	Public Health / Reservoir Regulatory
Unregulated Radionuclides (cesium -137, iodine 129 & 131).	S1, S10, Imported Aqueduct Water	Public Health
Others: Lithium, Benzo(k)fluroanthene, hexavalent chromium.	S1, S10, Imported Aqueduct Water	Public Health Regulatory
CECs.	See Table 5-5	Public Health Regulatory & AWP performance
Surrogates for Performance Assessments.	See Table 5-6	AWP Unit process performance

[1] Individual compounds comprising each contaminant group and information on analytical methods to be employed for each parameter are provided in Appendix G.
[2] Sampling locations designated S# represent various locations in the AWP Facility treatment train-See Figure 5-1.
[3] All Quarterly samples to be collected as grab samples.

5.2.5 Microbial Monitoring Plan

As stated in the Final IAP report, the ability to demonstrate the selected AWP Facility treatment train provides control of microorganisms is a key component of the testing. Based on specific monitoring recommendations provided in the IAP report and input from the project team's water quality experts, a specific microbial monitoring plan has been developed as described below.

5.2.5.1 Routine Bacteria and Virus Surrogate Sampling

The microbial testing program includes routine sampling of fecal indicator bacteria and virus surrogates for a 12 month monitoring period, as provided in **Table 5-8**. The purpose of the routine microbial sampling regime is to enumerate bacterial and viral surrogates after each step of the AWP Facility train. This will capture seasonal variability of the AWPF performance (if any). The routine bacteria and virus surrogate sampling plan includes the measurement of total and fecal coliform, F-coliphage and Somatic coliphage before and after each treatment stage of the AWPF. After 1-month of data collection, the sampling frequency for parameters being measured daily (e.g., total & fecal coliform) will be reduced to weekly. Likewise, the sampling frequency for parameters being measured weekly (F-coliphage and Somatic coliphage) will be reduced to monthly after 3 months of data collection.

Additional services related to microbial monitoring based on comments received on the November 30, 2010 Final Draft Testing and Monitoring Plan from the IAP not in the current Testing and Monitoring scope are described in Section 8.

Table 5-8
Routine Bacteria and Virus Surrogate Monitoring Plan for the San Diego AWP Facility

Monitoring Parameter	**Units**	**[1]Analytical Methods**	**MDL**	**[2]Sampling Location**							**[3] Initial Sampling Frequency**	**Monitoring Period** (months)
				S1	**S4**	**S5**	**S6**	**S7**	**S8**	**S10**		
Total & Fecal Coliform	MPN	SM 9221B	2/100 ml	√	√	√	√	√	√	√	Daily (Mon-Fri)	12
F-& Somatic coliphage	pfu/ml	EPA 1602	1 /100 ml	√	'---	'---	'---	'---	'---	'---	Weekly	12
F-& Somatic coliphage	pfu/ml	EPA 1601	Presence/Absence in 1000 ml		√	√	√	√	√	√	Weekly	12

[1] TATs, sample hold times for each method are provided in Appendix I.
[2] Sampling locations are shown in Figure 5-1.
[3] Initial sampling frequencies will be reduced to weekly and monthly after the first month and third month of the test period for parameters being measured daily and weekly, respectfully.

5.2.6 Integrity Monitoring Plan

The integrity of the various AWP Facility processes is a crucial aspect of ensuring the overall system meets the water quality objectives, and achieves the multiple barrier concept required by the Department of Public Health. The following section provides a specific Integrity Monitoring Plan (IMP) to be implemented during the demonstration test period. The main purpose of the IMP is to provide a systematic approach to apply existing tools, techniques, and practices that have been developed to monitor and maintain the integrity of the various AWP Facility unit processes. Key components of the plan which have been adopted from published Guidance Manuals (USEPA 2005) and studies (USBR 2000, MWH 2006) follow:

- Confirm and establish baseline performance of each unit process under "intact" conditions prior to start–up;
- Maintain continuous verification of integrity throughout the operational period;
- Implement on-going maintenance and operational practices to mitigate integrity breaches on all unit processes;
- Record and analyze collected integrity data; and
- Develop measurable performance criteria and action plans if changes in performance occur due to breaches in integrity.

A key objective of the AWP Facility demonstration program is to demonstrate the reliability of the membrane processes (MF/UF and RO) to consistently produce, high-quality product water. As a result, an integrity-monitoring plan will be implemented throughout the test period to verify the membrane systems are intact at the onset of testing and assess any degradation of integrity which may occur during long term operation. This will be accomplished by performing different types of direct and indirect monitoring techniques.

5.2.6.1 Integrity Monitoring Methods & Implementation Schedule

A summary of the various integrity methods and techniques to be used for each unit process is provided in **Table 5-9**. Information for each method includes the purpose, frequency of implementation and at what stage(s) in the AWP Facility construction and operation the methods will be employed. Specific information and testing protocols to be used for each method are provided in **Section 3**.

The integrity of the MF and UF systems will be assessed directly by conducting periodic air pressure hold tests. This test can be conducted on several membrane elements (modules) simultaneously; thus, it can test the integrity of a full rack of membrane elements used for full-scale systems. The test is conducted by pressurizing the filtrate side of the membrane lumen after which the pressure will be held and the decay rate will be monitored over time. Minimal loss of the held pressure at the feed side indicates a passed test, while a significant decrease of the held pressure indicates a failed test. The MF and UF systems will include an automated air pressure-hold test function, which can be initiated from the system's control panel. This function will also allow the user to adjust the time interval between tests. In addition to pressure decay, the integrity of the MF/UF will be assessed by continuously monitoring the filtrate turbidity of the system by a highly sensitive turbidity meter. An intact MF/UF membrane is expected to produce product water with turbidity ≤0.2 NTU.

Several methods will be employed at various times during the test period to assess the integrity of the RO membrane systems, which serve as the heart of the overall AWP Facility treatment train. As part of this demonstration testing program, RO membrane suppliers have been be requested to provide the project team with vacuum decay or pressure hold test results on all membranes supplied for testing. In accordance to ASTM D3923-94 the acceptable pressure decay rate for RO membranes is 0.2 bar/minute. After installing the membranes, the integrity of the membrane systems will be assessed by conducting probing of each pressure vessel. This method involves measuring conductivity at various locations along the inside of the RO membrane element's permeate tubes of an individual vessel as the system is operating. Because salts are being rejected in the direction of the feedwater flow a gradual increase in permeate conductivity is expected in intact vessels. A sudden spike or jump in conductivity at a given location inside the permeate tube often indicates a breach in system integrity. Such breaches could be due to membrane defects and/or faulty or misaligned o-rings, interconnectors or end caps.

During the operations phase, RO membrane integrity will be monitored continuously by on-line measurement of electrical conductivity in the feed and permeate. Loss of integrity in the RO membrane elements, o-rings, interconnectors and/or end caps may be detected by detecting an increase in the RO permeate conductivity by this indirect method. In addition, TOC will be monitored in the feed and permeate of the RO systems by taking daily grab samples. Measurement of TOC will be made on-site using a highly sensitive analyzer to allow a higher log removal than the conductivity monitoring method. As an overall integrity check of the RO systems and to detect changes in the NCWRP tertiary water quality, the TOC analyzer will also be used to provide on-line measurement of the combined RO product water.

In addition to the implementation of the methods described above periodic monitoring of select water quality parameters for each unit process will be employed through the test period. This will allow verification of integrity throughout the operational period. The specific parameters selected are based on treatment removal mechanism of each unit process and past performance data, as described in **Section 5**.

Table 5-9
Summary of Integrity Monitoring Methods proposed for the San Diego AWP Facility

Unit Process	Method	Purpose	Plant Stage	Frequency
MF/UF	Pressure Decay Testing	Direct check of membrane integrity	Start up and Operation	1 per 24 hours
MF/UF	On-line turbidity monitoring	Indirect check of membrane integrity	Start Up and Operation	Continuous
RO	Vacuum decay / pressure hold testing	Direct check of membrane integrity (glue lines, tears / holes in membrane material)	Prior to delivery of RO products from suppliers	One time unless used as diagnostic tool for individual elements
RO	Vessel Probing (conductivity)	Indirect check of RO membrane system integrity (o-rings, inter-connectors, end caps, etc.)	Post RO membrane installation and during operation if needed	One time all vessels with periodic checks of individual vessels as needed
RO	Continuous on-line RO permeate conductivity monitoring	Indirect method of checking RO membranes, o-rings, interconnectors and end caps.	Post RO membrane installation and continuously during operation	Continuous
RO	RO permeate TOC monitoring	Indirect method of checking RO membranes, o-rings, interconnectors and end caps.	Post membrane installation and daily during operation	On-line RO product combined. Grab RO feed Daily
MF, UF, RO, UV	[2] Indicator / Surrogate Monitoring	Indirect check of integrity / system performance	Start Up and during Operation	Periodic

[1] Based on guidelines integrity methods used for membrane systems to comply with the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR).[2] See Table 5-5 for specific performance indicators / surrogates to be measured for each unit process throughout the test period.

5.2.7 Critical Control Point Monitoring

A key component of the integrity monitoring plan will be to develop a procedure to identify any change in the performance of the treatment process that can adversely impact the final water quality before the out of specification water leaves the plant. One approach that can be used to assess the performance of the treatment process without the need for end point monitoring is the use of Hazard Analysis and Critical Control Point (HACCP) techniques. HACCP techniques were developed for the food industry and codified in the Guidelines for the Application of the Hazard Analysis Critical Control Point (HACCP) System (Codex Alimentarius, ALINORM 95/13, Annex to Appendix III).

The HACCP process is used to identify specific potential hazard(s) that can be present in the feed to a recycled water treatment process and establish preventative measures for their control. The HACCP process results in the development of a management system that monitors, evaluates and controls the potential hazards, rather than relying on analysis of the final product water quality inspection.

An important part of the HACCP process is the identification of key monitoring points at different stages of the treatment process. Analysis at these monitoring sites can provide information that can be used as a critical control point (CCP) or a quality control point (QCP). The purpose of the critical control point is to monitor a process parameter, such as turbidity, conductivity, power consumption, chlorine residual and total organic carbon that relates to the reduction in concentration of specific hazards at that part of the treatment process. Operational limits are established for these critical control points so that continuous monitoring of the CCP parameters will provide information on how the treatment process is performing on the removal of these parameters.

An important part of this study will be to use the HACCP process to establish CCP's for the dual membrane and AOP process and set performance limits and a set of procedures for corrective actions that would be taken in the event that the limit values are exceeded. **Table 5-10** provides a summary of the CCP monitoring to be conducted as part of Phase II testing. The specific baseline values, alert limits, critical limits and corrective action plans corresponding to each CCP will be established during the Phase I testing period.

Table 5-10

Summary of Critical Control Point Monitoring for the San Diego AWPF

Critical Control Point	Critical Limit Parameter	Monitoring Frequency	[1]Alert Limit	[1]Critical Limit	[1]Corrective Action
MF/UF	Pressure Decay	1 per day	Value above baseline that approaches Critical limit.	1 per 24 hours	Confirm Results. Assess fiber breakage.
RO	TOC UVT	Continuous	% change of measured concentration in combined RO permeate.	Above value which changes LRV.	Monitor individual RO trains. Verify analyzer accuracy. Conduct vessel probing..
UV/AOP	Reactor Power Draw	Continuous	Value above baseline that approach critical limit.	One time unless used as diagnostic tool for individual elements	System alarm and shutdown. Check / replace lamps and/or ballasts.
UV/AOP	Hydrogen peroxide dose rate	1 per day by draw down	Value above baseline that approach critical limit.	Below minimum dose to provide 3 mg/L peroxide.	Check dosing system. Recalibrate pump.

[1] specific limit values and corrective actions to be established during Phase I Testing.

Section 6
Specialty Testing

6.1 Introduction

Several specialty testing evaluations will be conducted during the course of the demonstration testing period. Specific evaluations include:

- Spiking experiments on the UV/AOP system to determine reactor power and hydrogen peroxide set points to achieve 1.2 log removal of NDMA and 0.5 log removal using product water from the RO systems.
- Chloramines and nitrosamines investigations to evaluate and compare sequential versus preformed chloramines application to inhibit organic and biological fouling of the RO systems and assess nitrosamines formation.
- Evaluation of UV/AOP by-products.

The above testing activities were identified based on recommendations and technical issues identified in the IAP report and CDPH comment responses along with input from the project team's PAC. Details on the specific objectives and test methods to be employed for each evaluation are provided below.

6.2 NDMA and 1,4-Dioxane Spiking Experiment

6.2.1 Background/Objective

The testing outlined in this section will demonstrate the specific NDMA and 1,4-Dioxane reduction ability of the AWP Facility UV/AOP process. The design criterion stipulates that the UV System will achieve 1.2 $\log_{10}$ reduction of NDMA and 0.5 log reduction of 1,4-Dioxane at a system peak flow rate of 1 MGD.

The City conducted a pilot test of the proposed AWP Facility train (MWH 2007)) and demonstrated that the effluent water downstream of the NCWRP contained background concentrations of NDMA ranging between 10 to 80 ng/L (10 to 80 parts per trillion [ppt]) that were too low to obtain the necessary resolution to demonstrate the required resolution; therefore, NDMA will be spiked to concentrations between 700 to 1000 ng/L.

Similar to NDMA, concentrations of 1,4-Dioxane are not present in the effluent water at levels to obtain the necessary resolution to demonstrate the required removal rate and therefore 1,4-Dioxane will be spiked. A concentrated NDMA and 1,4-Dioxane solution will be injected upstream of the inline static mixer designed for mixing of hydrogen peroxide.

The specific objectives of the NDMA and 1,4-Dioxane investigation are as follows:

- Establish and confirm manufacturers' reactor power set point to achieve 1.2 log removal of NDMA for the TrojanUVPhox Model 72AL75 UV-AOP system under the design flow and UVT conditions.
- Determine the maximum NDMA log removal rate of the TrojanUVPhox Model 72AL75 UV-AOP system under design flow rate and UVT conditions.
- Collect data on the impact of H2O2 dose on the removal of 1,4-Dioxane by UV/AOP.

6.2.2 Mixing Study

A mixing test to be performed with H2O2 to measure the residence time distribution within the system and determine the equilibration time required for the subsequent tests. The test will determine the relevant hydraulic residence times (HRT) that the experiment should be allowed to run before obtaining samples after a process change. The test involves the following steps:

- H_2O_2will be turned off for a period of 15 minutes prior to the test to ensure that it is flushed from the system. Samples will be collected at the AOP effluent to verify that there is no H_2O_2 residual using a Hydrogen Peroxide Test Kit (HACH Model HYP-1). Once it is verified no $H_2O_2$is present, the test can begin.
- The mixing test will be completed by starting the hydrogen peroxide injection at t=0. H_2O_2will be continuously injected at 3 mg/L into the influent stream with the UV lamps off. Samples will be collected at the UV system influent (after static mixer) and the effluent to capture the start of H_2O_2 injection and will continue until the H_2O_2concentration is at steady state concentrations, typically 2-3 HRT's. The results of the mixing study will be used to optimize the spiking experiments.

6.2.3 NDMA and 1,4-Dioxane Spiking Test Plan

The test plan consists of two separate spiking experiments. During experiment one NDMA only will be spiked upstream of the UV/AOP and the reactor power will be varied between the minimum and maximum settings. During this experiment the reactor will be operated at the design flow rate of 1 MGD and UV transmittance (UVT) of approximately 97%. In addition, the expected chloramines residual present in the UV/AOP is 3 mg/L. The log removal of NDMA will be determined for each set point. In addition 1,4 dioxane will be measured in the UV/AOP feed and effluent to assess removal of inherent concentrations present. The results will be plotted to establish the relationship between NDMA LRV and reactor power under design conditions. In addition, values of electrical energy per order (EEO) for the reactor will be calculated based on results of the spiking experiment.

During experiment two NDMA and 1,4 dioxane will be spiked upstream of the UV/AOP and the peroxide dose will be varied between 1 and 5 mg/L. It should be noted during normal operation and sampling events the UV/AOP peroxide dose will be set at 3 mg/L based on the dose currently approved by CDPH for the OCWD Groundwater Replacement System. However, the purpose of the spiking experiment is to gain information on the impact of peroxide dose on 1,4 dioxane removal by the UV/AOP. During this experiment the reactor will be operated under the reactor power conditions determined in Experiment 1 to achieve 1.2 log removal of NDMA. The log removal of 1,4 dioxane & NDMA will be determined for each set point.

The testing apparatus/equipment required to conduct the spiking experiments shall be per **Figure 6-1** and is comprised of the following equipment:

- Chemical Storage tank and cover– 30 gallon black polyethylene
- Chemical Storage tank mixing rod
- Chemical dosing pump
- Hydrogen Peroxide monitoring kit
- Piping and valving to make the connections between the components
- Stock spiking solution 1 L prepared by certified laboratory experienced with preparing spiking solutions.

Table 6-1 provides details on the experimental test runs that will be conducted as part of spiking experiment 1. The log removal of NDMA and 1,4-Dioxane will be calculated.

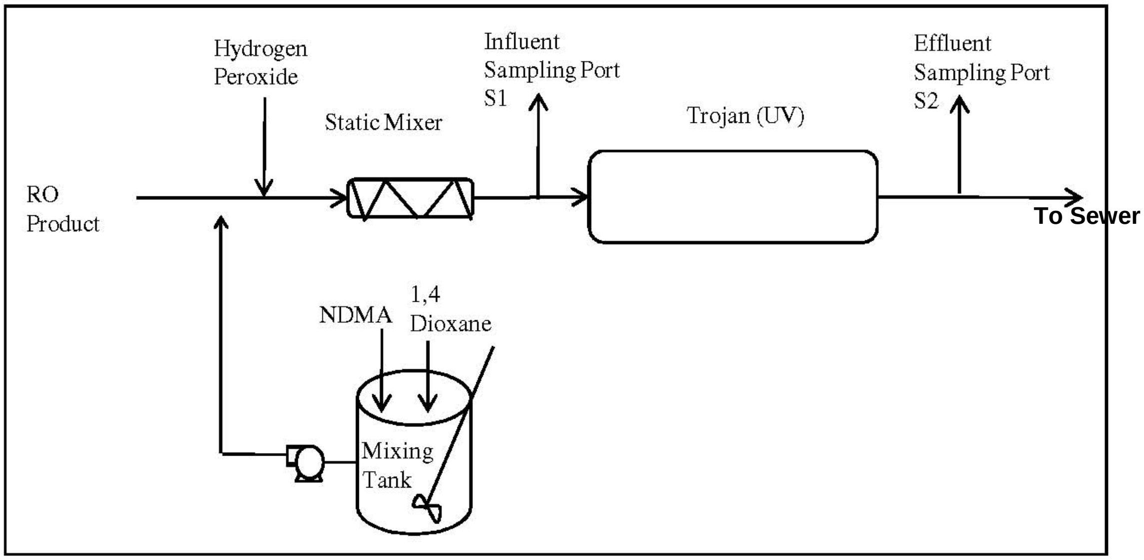

Figure 6-1
Spiking Set-up

Table 6-1
Spiking Experiment 1

Sample ID	Target LRV	Target Flowrate (gpm)	Target UVT (%)	Target NDMA Feed Concentration (ng/l)	[1] Target Reactor Power (%)	Target Peroxide Dose (mg/L)
Batch	NA	NA	NA	NA	NA	NA
Control IN	0	695	97	1000	0	0
Control OUT	0	695	97	1000	0	0
Control IN	0	695	97	1000	0	3
Control OUT	0	695	97	1000	0	3
RUN 1	1.2	695	97	1000	66	3
RUN 2	1.6	695	97	1000	80	3
RUN 3	1.0	695	97	1000	60	3
RUN 4	2.5	695	97	1000	100	3

[1]. Target reactor power settings were recorded from the TrojanUVPhox Model 72AL75 human interface (HMI) screen at different Target LRV's (user set point) during operation at the target flow and UVT.

For each sample run, three individual 1.0 L influent samples will be taken from the influent sample port and three effluent samples will be grabbed from the effluent sample port. Samples will be collected in UV proof (dark glass bottles) bottles with preservative. Samples will be sent to a certified lab and tests shall be performed per EPA analytical methods. All samples will be analyzed for NDMA and 1 influent and 1 effluent will be analyzed from each run will be analyzed for 1,4 dioxane.

Concurrent sampling and recording of feed UVT, effluent H_2O_2concentration, feed flow, temperature, target reactor power, actual reactor power, target LRV, actual LRV EEO, and lamp hours will be performed. Documentation of the number of lamps in service will also be recorded.

- Control – The test plan includes two runs in which the UV unit is in the off position. This will act as the control experiment. Samples will be collected from the influent and effluent with and without peroxide.

- Run 1 will consist of operating the UV unit at the manufacturers recommended power setting to achieve 1.2 log removal of NDMA at 695 gpm. The H_2O_2 will be dosed at 3 mg/L. Three influent and three effluent samples will be collected at approximately 5 minutes apart.

- Run 2 will increase the UV power setting to 80% of the maximum output of the UV unit and the H_2O_2 will be dosed at 3 mg/L. Three influent and three effluent samples will be collected at approximately 5 minutes apart.

- Run 3 will reduce the UV power settings approximately 60% (minimum power setting). Three influent and three effluent samples will be collected at approximately 5 minutes apart.
- Run 4 will reduce the UV power settings approximately 60% (minimum power setting). Three influent and three effluent samples will be collected at approximately 5 minutes apart.

A total of (29) NDMA and (8) 1,4 dioxane samples will be collected analyzed as part of this spiking experiment. The spiking experiment will last approximately 2 to 2-1/2 hours. The first 15-30 minutes will be to set-up and verify that the testing and dosing apparatus are operating correctly and to give the system time to reach equilibrium as determined in the mixing study per **Section 6.2.2**.. During the spiking experiment the UV/AOP effluent will be directed to sewer. Any remaining volume in the mixing tank at the conclusion of the experiment will be run through the UV unit to completely destroy any remaining chemical. A minimum of two mixing tank volumes of clean water will be run through the testing apparatus to flush the system of chemicals prior to putting UV/AOP product back into the NCWRP recycled water system.

Table 6-2 provides details on the experimental test runs that will be conducted as part of Spiking Experiment 2. The purpose of this experiment is to assess the impact of hydrogen peroxide concentration on 1,4 dioxane removal by UV/AOP.

Table 6-2
Spiking Experiment 2

Sample ID	Target NDMA / 1,4 dioxane LRV	Target Flowrate (gpm)	Target UVT (%)	Target NDMA & 1, 4 Dioxane Feed Concentration (ng/l)	[1] Target Reactor Power (%)	Peroxide Dose (mg/L)
Batch	NA	NA	NA	NA	NA	NA
Control IN	0	695	97	1000	0	0
Control OUT	0	695	97	1000	0	0
Control IN	0	695	97	1000	0	3
Control OUT	0	695	97	1000	0	3
RUN 1	1.2 / 0.5	695	97	1000	66	1
RUN 2	1.2 / 0.5	695	97	1000	66	3
RUN 3	1.2 / 0.5	695	97	1000	66	5

1. Final flow and power set points to be based on spiking experiment 1 result.

For each sample run, three individual 1.0 L influent samples will be taken from the influent sample port and three effluent samples will be grabbed from the effluent sample port. Samples will be collected in UV proof (dark glass bottles) bottles with preservative. Samples will be sent to a certified lab and tests shall be performed per EPA analytical methods. All samples will be analyzed for 1,4 dioxane and 1 influent and 1 effluent will be analyzed for NDMA.

Concurrent sampling and recording of feed UVT, effluent H_2O_2concentration, feed flow, temperature, target reactor power, actual reactor power, target LRV, actual LRV EEO, and lamp hours will be performed. Documentation of the number of lamps in service will also be recorded.

- Control – The test plan includes two runs in which the UV unit is in the off position. This will act as the control experiment. Samples will be collected from the influent and effluent with and without peroxide.
- Run 1 will consist of operating the UV unit at the manufacturers recommended power setting to achieve 1.2 log removal of NDMA at 695 gpm. The H_2O_2 will be dosed at 1 mg/L. Three influent and three effluent samples will be collected at approximately 5 minutes apart.
- Run 2 will consist of operating the UV unit at the manufacturers recommended power setting to achieve 1.2 log removal of NDMA at 695 gpm. The H_2O_2 will be dosed at 3 mg/L. Three influent and three effluent samples will be collected at approximately 5 minutes apart.
- Run 3 will consist of operating the UV unit at the manufacturers recommended power setting to achieve 1.2 log removal of NDMA at 695 gpm. The H_2O_2 will be dosed at 5 mg/L. Three influent and three effluent samples will be collected at approximately 5 minutes apart.

A total of (23) 1,4 dioxane and (11) NDMA samples will be collected analyzed as part of this spiking experiment. The spiking experiment will last approximately 2 to 2-1/2 hours. The first 15-30 minutes will be to set-up and verify that the testing and dosing apparatus are operating correctly and to give the system time to reach equilibrium as determined in the mixing study per **Section 6.2.2**. During the spiking experiment the UV/AOP effluent will be directed to sewer. Any remaining volume in the mixing tank at the conclusion of the experiment will be run through the UV unit to completely destroy any remaining chemical. A minimum of two mixing tank volumes of clean water will be run through the testing apparatus to flush the system of chemicals prior to putting UV/AOP product back into the NCWRP recycled water system.

6.3 Chloramines and Nitrosamines Investigation

6.3.1 Background/Objective

The City's AWP Facility will utilize chloramines to control organic and biological fouling of the MF, UF, and RO membranes. It is well documented that the combination of chloramines and nitrogenous precursors present in wastewater, such as dimethylamine (DMA), are common pathways for disinfection by-product (DBP) formation (Mitch et al., 2003). Previous research shows that NDMA formation is dependent on such factors as the individual water matrix, the level of chlorine/chloramines addition and pH (Mitch et al., 2004). In addition, the formation is linked directly to the chloramines dose, pH and hence chloramines species. Formation control and treatment processes are used to limit NDMA in treated water. Chloramines can be created either by sequential addition of ammonia (aqueous ammonia) and chlorine (sodium hypochlorite) directly to the wastewater or by a side stream process that pre-forms chloramines prior to application to the wastewater. The latter has been shown to be an effective method to reduce by-product formation as it results largely in mono-chloramines formation (MWH, 2010).

The specific objectives of the chloramines and nitrosamine investigation follows:

- Gain operational performance data on the RO systems at different chloramines feed concentrations to optimize and develop criteria for the full-scale AWP Facility.
- Evaluate nitrosamines formation under different chloramines application conditions including pre-formed, sequential with and without acid addition (will acid make a difference?).

6.3.2 Description of Chloramines Dosing Alternatives

Figure 6-2 provides a general flow schematic of the chloramine dosing alternatives to be evaluated during the testing period. Option 1 will include sequential addition of sodium hypochlorite (NaOCl) the tertiary water upstream of MF and UF followed by ammonium hydroxide (NaOH) to the MF/UF product water. Option 2 will include the addition of ammonium hydroxide into a carrier water (RO permeate) followed by subsequent dosing with sodium hypochlorite. The solution will then be stored in a large pressure vessel to allow for approximately 10 minutes of detention time to form monochloramine (NH_2Cl), which will be dosed into tertiary water upstream of the MF and UF systems.

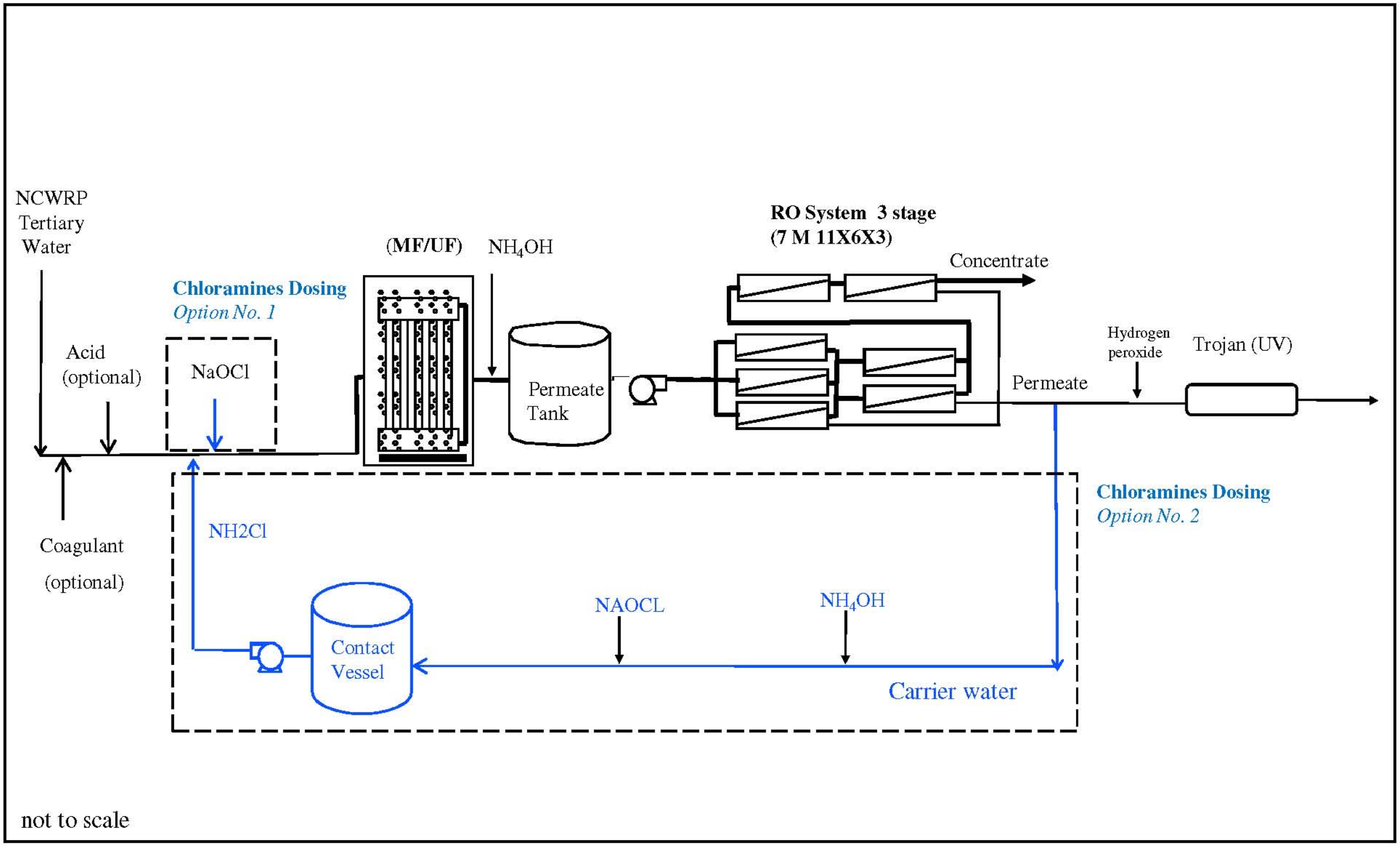

Figure 6-2
General schematic of chloramines dosing alternatives

6.3.3 Performance Monitoring

A sampling regime will be put in place during phase II of the demonstration test period to compare the two chloramines dosing alternatives described above. **Table 6-3** provides the specific parameters, locations, and frequency of the proposed sampling regime. Samples will be collected weekly from the tertiary water and RO feed to assess NDMA formation associated with chloramination. Other nitrosamines, less likely to be formed, along with precursors (DMA) will be measured once over the test period. The various forms of chloramines, along with free chlorine, total chlorine, free ammonia, temperature and pH will be monitored daily for process control. Nitrosamines samples will be sent to off-site certified laboratories for analysis, all other parameters will be analyzed in the on-site lab. The sampling regime will be conducted over a 2 month period with 30 days designated to using sequential chloramines application, followed by a 30 day period during which pre-formed chloramines will be utilized. Two alternatives will be compared in terms of NDMA formation, mono-chloramines production, stability, etc. Based on results, one of the two alternatives will be selected for use during remainder of the 12 month test period. Optimization of the selected chloramines dosing strategy including the identification of the minimal dose necessary to prevent RO fouling will be completed during the testing period. The starting dose of chloramines will be based on the RO manufacturer's permissible limits. The impact of adding acid to the feed water for RO scaling control on chloramines specification and NDMA formation will also be evaluated during this time.

Table 6-3
[1]NDMA and Chloramines Sampling Regime

Parameter	Sampling Location	Frequency
NDMA	S1, S6, S10	1/week
DMA	S1, S6, S10	1/month
NDEA	S1, S6, S10	1/month
NMEA	S1, S6, S10	1/month
NPIP	S1, S6, S10	1/month
NYPR	S1, S6, S10	1/month
NDBA	S1, S6, S10	1/month
Total Chloramine	S6, S9, S10	1/day
Mono Chloramine	S6, S9, S10	1/day
Di Chloramine	S6, S9, S10	1/day
Nitrogen trichloride	S6, S9, S10	1/day
Free Chlorine	S6, S10	1/day
Free ammonia	S6, S10	1/day
pH	S6, S10	1/day
temperature	S6	1/day

[1] Note the sampling regime provided will be conducted over two 30 day periods. During the first 30 days, option 1 - sequential chloramines conditions will be in place. For the next 30 day period, option 2 -pre-formed chloramines conditions will be in place. Sampling locations shown in Figure 5-1.

6.4 UV/AOP By-product Evaluation

Comments made by the CDPH on the IAP report indicate that by-products of NDMA and 1,4-Dioxane from the UV/AOP process may be a concern. There has been limited research into by-product formation and as part of development of this Testing and Monitoring Plan, a review of past research was performed by Dr. William J. Cooper at the University of California, Irvine. A summary of key findings and recommendations are provided below.

6.4.1 N-Nitrosodimethylamine (NDMA)

The UV/H_2O_2 process when applied to NDMA is a two step process, 1) photolysis of the NDMA by 254 nm UV light, and 2) oxidation of the products primarily thorough the hydroxyl radical (•OH) mediated reactions. The photolysis of NDMA has been studied at pH 3 and 7 with the major difference being the rate of destruction, i.e. at pH 3 NDMA is destroyed approximately six times faster than at pH 7. In both cases the major organic reaction by-product was DMA. Formaldehyde was observed at both pH 3 and 7 and was shown to be tenfold less that the DMA at pH 3 and fivefold less than DMA at pH 7. Therefore, the lower the pH during the photolysis, the more effective the photolysis of NDMA.

The advanced oxidation of DMA has not been studied in any detail; however, it is possible that decomposition would likely form formaldehyde and thus is the source of that observed in the studies reported.

6.4.2 1,4-Dioxane

The oxidation of 1,4-dioxane is considerably more complicated than that of NDMA. Focusing only on hydroxyl radical (•OH) oxidation there was a comprehensive study conducted by Stefan and Bolton (2002) and documented the loss of the parent compound (1,4-dioxane) and the formation of a number of reaction by-products. These by-products were 1,2-ethanediol diformate; 1,2-ethanediol monoformate; methoxyacetic acid, acetic acid, formic acid, oxalic acid, glyoxal, acetaldehyde and formaldehyde.

For the most part, these by-products will be easily biodegraded and likely cause no alarm. The one exception may be formaldehyde. As both NDMA and 1,4-dioxane result in the formation of formaldehyde this may be the compound to analyze to determine the efficiency of the processes.

Table 6-4 presents the predicted formaldehyde concentrations (by-product formation from UV/AOP process) expected from 100 ng/L NDMA and 1,4-dioxane concentration doses.

Table 6-4
Predicted Formaldehyde Formation from UV/AOP Process

Compound	Parent Concentration		pH	Formaldehyde Concentration	
	Weight concentration	Molar concentration		Weight concentration	Molar concentration
NDMA[1]	100 ng/l	1.4 nM	3	10.4 ng/l	0.14 nM
NDMA	100 ng/l	1.4 nM	7	21 ng/l	0.28 nM[2]
1,4-dioxane[3]	100 ng/l	1.14 nM	Not specified	17 ng/l	0.19 nM

[1] Stefan, Mihaela I.; Bolton, James R. UV direct photolysis of N-nitrosodimethlyamine (NDMA): kinetic and product study. *Helvetica Chimica Acta*, **2002**, *85(5)*, 1416-1426.
[2] The maximum concentration of formaldehyde was observed after 60 minutes irradiation, pH = 7, which was the time it took in lab experiments to approach 1.2 log removal of the NDMA. The concentration was 10 % of the influent NDMA concentration. Therefore it appears that at lower the lower pH the reaction will be faster and less formaldehyde will be formed.
[3] Stefan, Mihaela I.; Bolton, James R. Mechanism of the Degradation of 1,4-Dioxane in Dilute Aqueous Solution Using the UV/Hydrogen Peroxide Process. *Environmental Science and Technology*, **1998**, *32(11)*, 1588-1595.

During the 2005 AWT studies conducted at NCWRP NDMA was measured in the NCWRP tertiary effluent at concentrations ranging from 14-80 ng/l. Based on the data presented in **Table 6-4** the expected formaldehyde concentration that would result from UV/AOP would be significantly less than the current CDPH Drinking Water Notification Level of 0.1 mg/L. Also the concentration of 1,4-dioxane measured in the RO feed ranged from 43 to 71 ug/L (43,000 to 71,000 ng/L) and in the RO permeate ranged from 4.7 to 6.9 ug/L (4,700 to 6,900 ng/L). Based on the predicted rate of formation, it is expected that formaldehyde concentrations of 0.007 to 0.012 mg/L may be formed which is significantly below the Notification Levels for formaldehyde.

Recommended AOP Byproduct Monitoring Plan

Based on information found in peer reviewed literature and past pilot testing conducted at NCWRP it does not appear UV/AOP byproduct formation will be an issue. These findings will be confirmed by taking grab samples from (S9) and (S10) and measuring formaldehyde on a weekly basis during the 8 weeks of the routine sampling period. Based on results bench scale experiments may be developed and employed to gain further insight on UV/AOP byproducts. The bench scale experiments will be conducted at concentrations higher than found in natural waters so as to enable the identification of reaction by-products. From these, a kinetic model that describes the destruction of the parent compounds and the reaction by-products will be developed. A UV 254 irradiation system will be used and methods that they have been used for determining reaction mechanisms for other DBPs, and for evaluating AOP destruction of methyl tert-butyl ether (MTBE), emerging CECs, harmful algal bloom toxins and pharmaceuticals. LC/MS and LC/MS-MS and LC/MS-MS-MS and high resolution NMR for reaction by-product identification will be employed.

Section 7
Quality Assurance/Quality Control (QA/QC)

The following section provides a general description of QA/QC procedures to be employed during the demonstration testing period, including data analysis, lab testing, field sampling procedures, sample handling and storage, data validation and equipment.

7.1 Data Analysis and Laboratory Testing

Some of the analysis required for routine sampling will occur at the on-site laboratory, while more specialized analyses will be sent to a certified laboratory. All laboratory testing procedures conducted on-site and at the external laboratory will comply with EPA testing procedures. Laboratories will follow protocols of California ELAP, TNI2011 standards, and the 5th Edition EPA Manual for the Certification of Laboratories for Drinking Water, as applicable.

Data collected and analyzed on-site will be regularly verified with data from the certified laboratory analyses. This will result in a comprehensive database, which can be used for data analysis, retrieval, reporting and graphics. All data will be checked and verified by the operations manager / project engineer before and after entry into the database. The collection of data files will be sent to selected PAC members on a regular basis for review and analyses. **Table 7-1** shows QA/QC measures to be taken for onsite and laboratory analysis. **Table 7-2** displays specific laboratory QC procedures that will be utilized during CEC analysis, as provided by MWH Laboratories.

Table 7-1
On-Site & Certified Laboratory QA/QC Measures

pH (report to nearest 0.1 pH unit)	Weekly 3 point calibration with certified pH buffers in the range of measurements (4.0, 7.0 and 10.0)
Temperature (report to nearest 0.1 ° C)	Initial and quarterly verification against NIST thermometer
Turbidity, online (report to nearest 0.05 NTU for filtrate)	Weekly comparison to bench top turbidimeter; recalibrate if difference is > 20%
Turbidity, bench top (report to nearest 0.05 NTU for filtrate)	Initial and weekly calibration with primary standards of 20 ,100 and 800 NTU. Daily verification with 10 NTU standard.
Conductivity, online	Weekly comparison to portable meter, recalibrate if difference is > 20%
Conductivity, portable meter	Initial and weekly calibration with primary standards of 23 uS/cm and 2,764 uS/cm.
Water Quality Analysis Outside Laboratories	Follow California ELAP procedures, TNI2011 standards, and the 5th Edition EPA Manual for the Certification of Laboratories for Drinking Water, as applicable
Microbial Analysis Outside Laboratory	Follow federal NELAP and California ELAP procedures, and USEPA Standards and Protocols for Testing Microbial Water

Table 7-2
Laboratory QC Measures for CEC Analysis

Quality Control	**Criteria**
Method Blank	< MRL
MRL Level Check Sample	50 - 150%
LCS and LCSD	70 - 130% or 60 - 140%, depending on compound
MS / MSD	60 – 140%

7.2 Sampling Procedures

The following sections describe the equipment and procedures that will be utilized to collect demonstration water quality samples. A summary of the proposed water quality monitoring and sampling plan is provided in **Section 5** of this report.

Water sample collection activities will be conducted by two project team operations personnel with the exception of sample processing, which will be conducted by the contracted laboratory. Sampling procedures will be provided by the contracted laboratories to follow USEPA guidelines.

7.2.1 General Sampling Procedures

Sampling personnel will utilize clean handling techniques when processing the samples such that only new powder- and phthalate-free vinyl gloves (nitrile) will be worn when handling the sample bottles. In general, personnel will wear clean vinyl gloves during all sample retrieval operations and change gloves frequently, usually with each change in task.

After opening stainless steel sample location valves and allowing treated water to flow for two to three minutes, personnel will collect water samples from appropriate locations along the AWP Facility treatment train, label sample collection bottles appropriately, and place them into coolers packed with ice packs/blue ice at the conclusion of the sampling event. Personnel will then ship the sealed coolers under chain-of-custody to the contracted laboratory. The laboratory will process and analyze the samples in accordance with their standard operating procedures.

Strict adherence with the sample volume quantities, preservation methods and hold times provided by the certified laboratories for each analytical method will be followed in order to meet reporting limits.

7.2.2 CEC Sampling Procedures

In addition to the above general sampling procedures, certain steps will be taken to ensure the integrity of samples that will be analyzed for trace CECs. These steps include avoiding smoking and handling or ingesting pharmaceuticals or caffeinated beverages shortly before and during sampling events. Contracted laboratories will follow additional protocols and recommendations set forth in the Science Advisory Panel's *Monitoring Strategies of Chemicals of Emerging Concern in Recycled Water* Final Report.

7.2.3 Microbial/Biological Parameters Sampling Procedures

Collecting water samples for analysis for biological parameters requires additional procedures to ensure sample integrity. A general description of sampling procedures to be followed for various microbial parameters is provided below with more detailed information provided in **Appendix J**.

Bacterial parameters

- Requires sterilization of the sample valve prior to collecting the grab sample. Sterilization will be conducted with a hand-held propane torch.

- Samples will be stored with blue ice and at a target temperature of 3-8 °C.

- Follow sample collection and handling procedures as specified in USEPA Methods 1602 (F- and somatic coliphage), 1682 (salmonella), and SAP 2009 Draft (E. coli O157), and method SM 9221 (coliform).

Virus analysis

- Follow sampling procedures detailed in the USEPA *Information Collection Requirements Rule – Protozoa and Enteric Virus Sample Collection Procedures*.
    - Note: This method (1995) specifies a 1MDS electropositive filter, the filter type now being used is a NanoCeram electropositive filter.
- Requires the use of a virus sampling apparatus (chlorine sterilized filter concentrator).
    - The sampling apparatus, and training on the use of the device, will be provided by Biovir Laboratories.
    - Prior to sampling the apparatus must be flushed with 20 gallons (76 liters) of water.
- Samples for virus analysis will be stored with blue ice and at a target temperature of 4 ° C.

Cryptosporidium (not in current sampling plan)

- Follow sample collection procedures detailed in Biovir's Example Procedure for Collecting Filtered Water Samples (Using HV Envirochek Capsule Filters) for Method 1622/23 Analysis.
- Samples will be cooled as quickly as possible by immersion in an ice bath, and kept at a target temperature of 4 ° C. Care will be taken to avoid shipping samples with unnecessary ice/cold packs to keep from freezing the filter element.
- Sample will be dechlorinated using sodium thiosulfate.

7.2.4 Sampling Equipment and Supplies

Sampling equipment and supplies include the equipment required for the collection of demonstration water quality samples, associated sample collection and handling supplies, decontamination equipment, sample collection bottles and coolers, etc. Equipment to be utilized during sampling events includes the following:

- Gloves
- Rinse Bottles
- Ice packs
- Coolers
- Propane Torches (microbial)

- Timers
- Virus Sampling Apparatus (Chlorine Sterilized Filter Concentrator)

7.3 Sample Designation and Handling

Sample handling and designation procedures are included to provide sufficient project-specific QA/QC measures. Project-specific QA/QC requirements and procedures described in the following sections include:

- QC sample collection requirements.
- Sample container requirements and preservation.
- Sample documentation and handling.
- Chain-of-custody documentation.

7.3.1 QC Sample Collection Requirements

Field and laboratory QC samples will be collected and analyzed as a quality check of sampling and analytical procedures, as described below. Quality Control sample collection frequencies for this project are presented below in **Table 7-3**. The following field and laboratory QC samples will be collected during the demonstration period:

- Field Duplicate. A portion of the collected sample volume will be analyzed identically to evaluate laboratory precision, reproducibility of sample handling and analytical procedures, sample heterogeneity, and analytical procedures.
- Split Sample. A portion of the collected sample volume will be analyzed by a separate laboratory with overlapping capabilities utilizing identical analytical methods to evaluate laboratory accuracy, reproducibility of sample handling and analytical procedures, sample heterogeneity, and analytical procedures.

Table 7-3
QC Sampling

QC Sample Type	Frequency	Sample Location
Duplicate Sample	Collect one blind duplicate per quarterly sampling event	Rotated quarterly
Split Sample	**First Quarter**: Collect split sampling for all quarterly monitoring parameters listed in Table 7-4. **Quarterly**: Collect split sampling for CECs	UV/AOP product water

Laboratories split analysis responsibilities for samples collected during quarterly monitoring are presented below in **Table 7-4**.

Table 7-4
Quarterly Sampling Event Split Sampling

Contracted Laboratory	Split Analysis Responsibilities
MWH Labs	• Primary State/Federal Drinking Water Standards • Secondary State/Federal Drinking Water Standards • USEPA Priority Pollutants • Potential AOP Byproducts • CDPH Drinking Water Notification Compounds
Colorado School of the Mines	• Constituents of Emerging Concern

7.3.2 Sample Containers

The contract laboratories will provide certified clean sample collection containers as appropriate for the required analyses. Sample container quality protocols will be strictly enforced and assured by the laboratory. The laboratory will retain certificates of analyses from each lot of containers for a period of at least 5 years. Sample containers will be kept closed until used. The sample containers, preservation, and holding time requirements for this project are presented in **Appendix J**.

7.3.3 Sample Preservation and Holding Time

The use of proper chemical and thermal preservation is critical to maintain the validity of project samples. Sample bottles will be placed into a cooler packed with wet ice. The target temperature for the cooler is 6° C, with the exception of coolers containing samples for biological parameters which will be cooled as is described in the above microbial/biological parameters sampling procedures. If samples are received by the lab the same day as sampling occurred target temperatures need not be reached; however, samples must show evidence of chilling. Samples will be shipped under chain-of-custody to the contract laboratory as soon as possible after sample collection activities. The laboratory will document the sample temperature upon receipt.

7.3.4 Sample Storage, Packaging, and Transport

Proper sample handling procedures will be followed so sample quality is not compromised after the collection of the sample and prior to submitting the sample to the laboratory. Each sample will be handled according to the protocol specific to the environmental media.

Sample Storage

Collected samples will remain in the possession of a designated project team representative at all times until custody is relinquished to the laboratory (in person or through shipment), or until the samples are placed in a secure storage location.

Sample Packaging

Samples will be transported in the same coolers used for temporary sample storage. Samples will be accompanied by a completed chain-of-custody form, sealed in a Ziploc® or equivalent bag to prevent damage to the document, and taped inside the lid of the cooler. Individual glass sample containers will be wrapped in bubble wrap bags or placed in foam packaging, and placed in polyethylene bags to prevent any potential compromising of sample integrity.

Sample Transport

Samples destined for out-of-area laboratories will be repackaged (as necessary) for shipping. Bubble wrap and foam will be used to help prevent sample bottle breakage during shipping. Samples will be placed into coolers packed with wet ice and labeled appropriately for shipping. Express delivery from common carriers will be used for shipping. A chain-of-custody form will accompany each cooler during shipment.

7.4 Documentation

Verifiable sample custody is of primary importance during field and laboratory procedures. Such practices ensure samples have been properly acquired, preserved, and identified. This information will be collected in a variety of formats, specific to the function they perform in the sampling procedure (e.g., field logbooks, sampling field forms, sample labels, chain-of-custody forms, etc.). Sampling records create a complete record of field procedures, including circumstances of collection and integrity of the samples. This will also allow for detailed tracking of each sample from collection through transport and laboratory analysis. The following information outlines specific procedures that will be implemented during sampling events.

7.4.1 Logbook

Sampling activities will be documented in a logbook. The first entry at the beginning of each sampling event will include the date and time, project number, names of personnel on-site, and the purpose of the sampling event (e.g., routine monitoring, quarterly monitoring). Each subsequent page will be started with the project number and the date.

Information included in the field logbook will include the following items:

- Observations relevant to the sampling event, equipment conditions, and events that may have occurred prior to sampling that may influence the integrity or the representativeness of the sample.

- Observations of site activities not covered under regular activities, including presence of persons on-site not related to the sampling activities, and actions by those people affecting work performance.

- Sketches of relevant information.

- Information relevant to a change in scope or change in Work Plan procedure, with documentation of subsequent approval.

- Type and/or level of health and safety equipment used.

Information compiled in the field logbook will be written legibly in language that is clear, concise, and without interpretation.

7.4.2 Chain-of-Custody Procedures

The chain-of-custody is an integral component of the sampling process as it stands as a permanent record of sample holding and shipment. Sample custody is documented from collection through transport, analysis, and reporting.

Samples will remain in the custody of authorized personnel or appropriate staff until receipt by the laboratory or relinquished to the shipper. The corresponding chain-of-custody form will be in plain view at all times, in physical possession, or in a locked location where no tampering will occur. The chain-of-custody form will be crosschecked for errors and signed by the sampler.

Coolers with their respective chain-of-custody form(s) will be checked into the laboratory by a laboratory representative, and the chain-of-custody form will be relinquished to the laboratory by signing and dating the custody form appropriately. The project team operations staff will retain one copy of the signed chain-of-custody form for the project files. The laboratory representative will verify cooler temperature, sample designation, and other relevant sample conditions. The original chain-of-custody form or a photocopy will be returned to the project manager with the analytical results and kept in the project files.

7.5 Data Analysis

The data collected for this project will be reviewed prior to reporting. The following sections describe data validation and preliminary statistical analysis that will be performed on collected laboratory analytical data.

7.5.1 Data Validation Review

A complete third-party data validation of the <u>AWP Facility product water (S10)</u> will be performed on laboratory results obtained for the <u>first quarterly sampling event</u>. Results of this validation will be used to determine data quality and review laboratory procedures. Labs will make procedural alterations based on this data validation as necessary.

Third party validation is beneficial whenever analytical data may be subject to intense scrutiny that could result in the accuracy of the reported data being challenged in a court of law. The USEPA issued guidance documents detailing analytical data evaluation and review processes for inorganic and organic data produced under the USEPA Contract Lab Program (CLP). The CLP supports a major portion of the sample analysis needs of the USEPA Superfund Program. Due to the potential for legal challenges, samples submitted under this program must be analyzed in conformance with specified analytical protocols and the assembled data package must go through a technical quality assurance review (validation) prepared by an independent third party. In 1986, the Director of the Office of Emergency and Remedial Response proposed several levels of data validation.

Commercial third party specialists performing water quality data validation utilize the guidance issued under the USEPA CLP program. Level IV review is the most rigorous and is characterized by QA/QC protocols and documentation resulting in a complete qualitative and quantitative analysis of the analytical data (USEPA 1987). Data that fulfills the requirements of this level of third party validation fulfills the minimum data quality standards needed to allow the data to be used for its intended objective.

The data validation will consist of an evaluation of sample and measurement collection, custody, analysis, and reporting to identify any quality control deficiencies. Data collected will either be used as reported, qualified as estimated, or rejected for its intended use.

Analytical data validation will comprise the bulk of the data validation effort, and will be performed in accordance with applicable USEPA data validation guidelines for organic and inorganic parameters. LDC, Inc., an independent, third-party, will evaluate the quality of the work based on this document and an established set of laboratory guidelines to ensure the following:

- Sample preparation information is correct and complete.
- Analysis information is correct and complete.
- Appropriate procedures have been followed, specifically with adherence to holding times.
- Analytical results are correct and complete.
- Laboratory QC check results for absence of blank contamination, initial and continuing calibrations, surrogate compound recoveries within limits, allowable matrix spike/duplicate recoveries, accurate internal control standard recoveries, and adequate instrumental performance, are within appropriate QC limits (**Table 7-2**).

- Documentation is complete (observed anomalies in the preparation and analysis have been documented and holding times are documented).
- Laboratory qualifiers have been assigned to each sample with data usability limitations.

7.5.2 Data and Statistical Analysis

Following each quarterly sampling event, validated results for all CEC data will be provided to PAC members. Those PAC members will produce a letter providing scientific interpretation of the data, identifying any anomalies, and providing recommendations for re-sampling or increases in sampling frequency.

Final review of the reported data performed by project team personnel will include an examination of the data in terms of the qualitative data quality objectives and the logbook will be reviewed for completeness and correctness. The data may be qualified based on significant concerns related to representativeness, comparability, and completeness. Each will be discussed, as appropriate, in terms of the deficiencies and associated project impacts. A basic statistical analysis of the data will be performed for collected quarterly monitoring data including determination of the mean, variance and standard deviation for all monitored constituents. The results of this statistical analysis will be provided to select PAC members for final QA/QC and recommendations.

7.5.2.1 Determination of the Number of Samples to Obtain Statistically Significant Data

A key component of the design of the water quality monitoring plan for the AWP Facility is the determination of the number of samples to be collected for the various parameters of interest. A proposed strategy was presented in **Section 5** based on the overall objective of the demonstration program and to provide an acceptable level of effectiveness based on the budget for the demonstration project. The design also took into consideration variability in the NCWRP tertiary water, data from the prior AWT pilot testing, and performance results from full-scale AWT facilities, such as those operated by OCWD for the GWR System and West Basin Municipal Water District for the West Basin Barrier Project. For most parameters the historical AWT data are at or below levels of detection; for detected constituents, the concentrations are typically below regulatory levels. Thus, the sampling frequency for the AWP Facility will generate sufficient numbers of samples to further substantiate this historical data set. The purpose of this section is to review that design in light of the 2009 IAP recommendations and subsequent input from CDPH.

In its 2009 report, the IAP recommended that:

> *"The frequency of monitoring should be adequate to enable statistical analysis of the data and provide the public with confidence on the*

> *performance of the treatment technologies and the extent to which wastewater-derived contaminants are controlled."*

For chemicals, the IAP did not provide a specified sampling frequency. For pathogens, the IAP provided recommendations on initial sampling frequencies for different methods in **Table 6.3.**.. In its comments on the IAP report, CDPH indicated that 1) a UV system designed to achieve a 1.2-log NDMA reduction would provide higher doses than what is required for adenovirus; and 2) requested more information on the specifics of the epifluorescence microscopy program.

The project team proposes a framework for discussion with the IAP and CDPH to define what criteria will drive the data collection needs for statistical certainty. The proposed approach would allow various analytes to be sorted into higher or lower monitoring levels.

Criteria requiring higher statistical certainty which will mean more frequent initial monitoring (at least initially):

- Variations in influent concentration and low effluent requirements (i.e. nitrogen);
- Need to consistently demonstrate non-detects through direct measure and/or indirect surrogate measure (e.g. emerging contaminants); and
- Process operations outside of previously demonstrated envelope.

Based on comments received by the IAP Subcommittee on the initial Draft Testing and Monitoring Plan (NWRI, 2010), factors to consider for the routine sampling plan:

- Appropriate sample volumes required to meet target detection limits;
- Sampling frequency and timing;
- Parameters to be collected using grab samples versus composite sampling;
- The need to collect composite samples on a time weighted or flow paced basis;
- Statistical analysis to be performed on water quality data sets to determine statistical certainty.

7.6 AWP Facility Equipment

All equipment associated with the AWP Facility unit process equipment such as pressure gages, flow meters, and safety switches will be calibrated on-site or checked for factory calibration during start up. In addition the accuracy of key components will be check on a periodic basis as summarized in **Table 7-5**.

Table 7-5
Equipment QC Criteria

Parameter	Equipment	Frequency	Acceptance Criteria
Flow Rates	On-line turbidity meters	Daily	+/- 20%
	Chemical dosing pumps	Daily	+/- 15%
	System rotameters and digital flow meters	Quarterly	+/- 10%
Pressure Gages	System pressure and vacuum gauges	Quarterly	+/- 5%

Calibration or verification records will be kept for flow meters, pressure gages, and on-line water quality analyzers.

Section 8
Additional Scope of Services

The following section provides details of additional scope of services outside of the Final Testing and Monitoring Plan. Theses scope items were either included in the November 30, 2010 Draft Testing and Monitoring Plan (Draft T&M Plan) or developed by the project team based on comments received from the IAP/CDPH/RWQCB on the Draft T&M Plan (**See Appendix K**). The project team will implement all or select scope items upon authorization from the City.

8.1 Integrity Monitoring Methods

Two additional integrity RO monitoring methods identified in the Draft T&M Plan include challenge testing with MS2 virus and TRASAR fluorescent dye. The City will reassess the possibility of MS2 virus challenge testing in the 3rd quarter once the regulatory requirements for the full scale project become more defined. Detail of each method is provided in the following sections.

8.1.1 MS2 Virus Challenge Testing

Though it is not an objective of the testing plan to demonstrate the ability of the RO membranes to remove viruses, conducting virus challenge experiments is a powerful means of monitoring RO system integrity. Accordingly, an optional service for consideration, challenge experiments can be performed on each RO system during start up and upon completion of the target 5,000 hour test period.

If required, challenge experiments would be conducted using MS2 virus. MS2 virus is not a human pathogen; however, this organism is similar in size (0.025 microns), shape (icosahedron) and nucleic acid (RNA) to polio virus and hepatitis virus. Because MS2 is not a human pathogen, live MS2 virus will be used in the seeding experiments. Organism stocks can be obtained from Biovir laboratories and upon receipt would be stored refrigerated at 4 C in the dark for less than 2 days prior to being used in the seeding experiments. The ATCC strain number of the virus to be used is 15597 and the bacterial host will be E.Coli (ATCC#700891).

A schematic of the proposed virus seeding set up is provided in **Figure 8-1.** The figure is based on a three stage system operating at 75% recovery. Samples will be taken from the following seven locations for the 3-stage system:

- S1 - RO feed (common)
- S2 - RO stage 1 permeate
- S3 - RO stage 2 permeate

- S4 - RO inter-stage 1/2
- S5 - RO stage 3 permeate
- S6 – RO inter-stage 2/3
- S7 – RO system 1 permeate (combined)

All samples will be analyzed by Biovir Laboratories, which is State-certified to perform MS2 analysis.

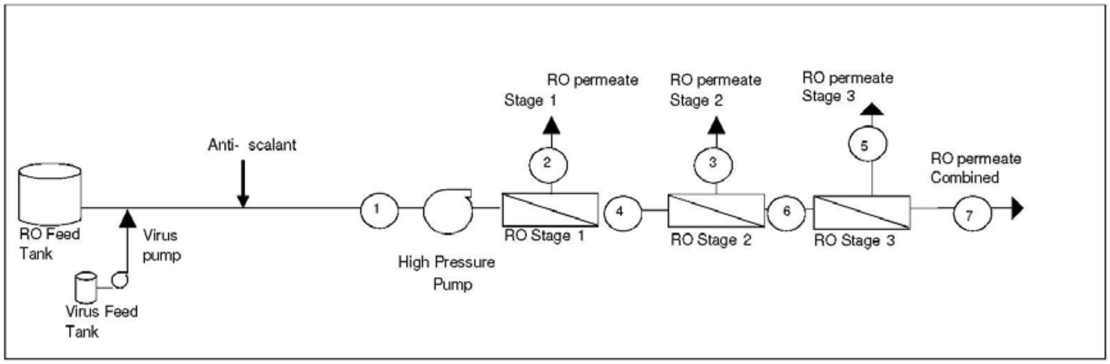

Figure 8-1
Virus Seeding Set-up 3-Stage RO System

Table 8-1 provides details on the sampling locations, QA/QC samples and total number of samples required per challenge experiment. Challenge experiments will be scheduled to be conducted one per system during start up to establish baseline performance and one following 5,000 hours of operation to demonstrate performance reliability over the test period.

Table 8-1
Sampling Details for MS2 Virus Challenge Experiments (Optional)

RO System	RO System Sample Frequency	QA/QC Sample quantity and description	Total number of samples per experiment	Scheduled experiments
3-stage Toray	Samples to be collected: S1, and S7 every 5 min. for 30 min.	2 samples @ virus feed tank (begin and end of experiment) 1 negative control samples experiment @ RO permeate prior to MS2 injection	17	(1) during start up; (1) @ completion of testing
2-stage Hydranautics	Samples to be collected: S1 and S7 every 5 min. for 30 min.	2 samples virus feed tank (begin and end of experiment) 1 negative control samples experiment @ RO permeate prior to MS2 injection	17	(1) during start up; (1) @ completion of testing

Table 8-2 provides details associated with virus seed stock and RO feed concentrations, based on 1.20 MGD RO feed flow.

Table 8-2
MS2 Phase Challenge Experiment Details Required for 1.20 MGD Feed Flow

Stock Volume Required (mL)	1000
Stock Virus Concentration (pfu/mL)	1.00E+11
Total MS2 virus in Send Tank (pfu)	1.00E+14
Seed Tank Volume (gallons)	50
Virus Injection Concentration (pfu/mL)	5.29E+08
Injection flow rate (mL/min)	4000
Feed Flow (gpm)	868
Feed Virus Concentration (pfu/100mL)	6.44E+07
Time Stock will last (minutes)	47.3

8.1.2 TRASAR Challenge Testing

Should the City choose to add it, challenge experiments can also be conducted during the testing period using a chemical product named TRASAR® offered by Nalco, Inc (Naperville, IL). TRASAR® is composed of fluorescent molecules (molecular weight

[MW] = 614 grams per mol [g/mol]) and has been historically used for chemical dosing control in drinking water and industrial applications (Zeiher et al, 2003). Dosing control can be achieved by adding a known quantity of TRASAR® to a given chemical (such as antiscalant) and measuring its concentration using Nalco's trace leak detection (TLD) system. The TLD system detects TRASAR® by measuring fluorescence. A feedback control system can then be used to adjust the chemical dose based on the measured TRASAR® concentration.

Recently, Nalco has further modified the TLD system to detect TRASAR® at low concentrations (ng/L) which enables it to act as an RO integrity monitoring system (Zeiher et al., 2002). In principle for RO membrane system integrity monitoring, the TRASAR® is injected into the RO feedwater and if the membrane system is intact, then the TRASAR® is rejected by the RO membranes and is not detected in the RO permeate. If there is a breech in the integrity of the RO membrane system which allows the TRASAR to leak into the RO permeate the TLD system should detect its presence and thus signal a loss of membrane integrity. Details of the TRASAR system provided by Nalco are provided in **Appendix D**. For challenge testing TRASAR® will be dosed continuously over a 10-minute period to the feed of the RO system to achieve a target concentration between 10-15 mg/L and upto 5-6 LRV sensitivity.

8.2 CEC Spiking Experiment to Assess UV/AOP Efficacy

The CDPH comments (CDPH, 2011) on the Draft T&M Plan suggested a Surrogate / Indicator Framework including challenge or spiking studies be applied during the AWPF testing to assess the effectiveness of the AOP process. Based on this comment, the project team recommends one spiking experiment be conducted after the first quarter of testing is complete to demonstrate the removal of several indicator compounds with the removal of surrogate parameters (UVA, chloramines), which can be easily measured on a frequent basis. The indicator compounds to be included in the spiking experiment will be based on occurrence data collected in the feed and product water of the AOP process with the overall goal of selecting compounds that will serve as good indicator compounds representative of wide range of characteristics for ongoing monitoring. The project team will work closely with the project advisory committee including Dr. Jorg Drewes and Dr. Shane Snyder to develop the list of compounds to be included in the CEC spiking experiment. The CEC spiking experiment will be conducted under UV/AOP conditions determined from the results of the NDMA, 1,4 dioxane spiking experiment presented in Section 6.2 using a similar experimental set up.

This added scope item would require the following:

- Certified lab preparation of the spiking solution containing (10) selected indicator compounds.

- Certified lab analysis of approximately 12 samples taken from the influent and effluent of the UV/AOP system including control samples.
- Labor required for set up and administration of the spiking experiment.
- Supplies and equipment.
- Data analysis.

8.3 Assessment of AWPF Product Water Stabilization Requirements

Upon review of the Draft T&M Plan, the IAP Subcommittee provided the project team with a series of comments including a recommendation to consider evaluating options to stabilize the AWPF product water (NWRI, 2010). The primary objective of the assessment would be to determine the extent to which secondary disinfection and / or corrosion control in addition to lime treatment may be required for the potential full-scale AWPF. The IAP Subcommittee presented the option of conducting pilot testing using a pipe-loops or annular reactors to achieve the aforementioned objectives. After consideration of this information, the project team recommends the City consider conducting an initial bench scale study during the AWPF Demonstration phase to gain insight on corrosion and biogrowth potential of AWP product water and to identity possible post treatment strategies that could be considered from the full scale AWPF. Based on the information gained from the bench testing, the City may decide to conduct pipe-loop studies at a later stage in the approval and decision process to move forward with a full- scale AWPF.

The specific objectives of the proposed product water stabilization bench scale testing follow:

- Assess the microbial re-growth and corrositivity potential of the AWPF product water.
- Identify possible post treatment strategies to inhibit corrosion of the conveyance system of the full scale AWPF.
- Identify possible secondary disinfection strategies to inhibit bio-growth in the conveyance system of the full scale AWPF.
- Assess nitrogenous disinfection byproduct (DBP) formation potential of the AWP product water under various secondary disinfection strategies
- Provide recommendation on further testing required prior to the selection and design of the post treatment system for the potential full-scale AWPF

8.3.1 Bench Scale Testing Approach

The following provides a proposed outline of the bench scale testing approach to meet the above objectives:

The specific objectives of the proposed product water stabilization bench scale testing follow:

- Characterize the assimilable organic carbon (AOC) and biodegradable organic carbon (BDOC) content of the AWPF Demonstration product water.
- Collect, treat and analyze batch samples of the AWPF product water to evaluate options for achieving a neutral or slightly positive Langelier Saturation Index (LSI). Strategies to be considered include: 1) increasing the hardness and alkalinity using lime or calcite contractor along with carbon dioxide addition for pH adjustment, 2) adding polyphosphate or silicate inhibitor 3) simply raising the pH with lime addition only.
- Perform chlorine demand decay tests of the AWPF product water to determine the chlorine demand and Nitrogenous DBP formation potential.
- Assess biofilm growth and corrosion of pipe coupons configured in an annular reactor (with and without secondary disinfection & corrosion control) using pipe material and hydraulic detention times under similar conditions being considered with regards to the conveyance system for the full-scale AWPF.

8.4 Microbial Monitoring

Upon review of the Draft T&M Plan, the IAP suggested that it may be possible to reduce the monitoring frequency for Cryptosporidium (before MF/UF) by sampling for aerobic spores like B. subtilis as potential surrogates for Cryptosporidium. B subtilis are much smaller than Cryptosporidium and thus would be a conservative indicator that can be analyzed quickly and inexpensively. B. subtilis analyses could be performed in conjunction with Cryptosporidium studies and more frequently as potential MF/UF process performance indicators. The use of aerobic spores would be appropriate if the spores service the prior disinfection process. This would need to be evaluated.

The project team agrees B. subtilis may serve a good surrogate for Cryptosporidium as it is smaller and should be removed by sieving. However, it is unknown if the spores will survive the addition of chloramines upstream of the MF/UF systems to have substantial levels. Also, it may be difficult to differentiate whether observations of reduced concentrations in the MF/UF filtrate is due to disinfectant contact time during filtration, or actual removal. In order to answer these questions, the project team would recommend conducting conventional microbial inactivation bench scale experiments using B. subtilis under various conditions including chloramines concentration, pH and contact time.

8.5 Provisions to Address the State Water Board's draft Policy for Toxicity Assessment and Control

The RWQCB's comments (California Regional Water Quality Control Board – San Diego Region, 2011) on the Draft T&M Plan specified that the Plan should include provisions for addressing the State Board's draft Policy for Toxicity Assessment and Control.

Based on this comment, the project team recommends discussing with the State Board the option of conducting quarterly Whole Effluent Toxicity testing on the AWPF effluent using current Standard EPA test methods. Each test would include 3 freshwater species (algae, fish and invertebrate) per the EPA protocol. The initial sample volume per test would be 5 gallons with 3 discreet samples required per test over a 7 day period. Based on their local experience conducting similar testing for Padre Dam Municipal Water District it is recommended that Nautilus Environmental Laboratories (NEL) perform the testing. Based on initial discussion with NEL it is suggested AWPF effluent samples be remineralized to specific pH, alkalinity and hardness prior to conducting the testing. Turnaround time on the analytical results in approximately 2weeks.

8.6 Assessment of Diurnal Effect on Key Constituents

Per comments received by the CDPH on the November 30, 2010 Final Draft Testing and Monitoring Plan, it is recommended that two 24 hour sampling events during the 12 month operating period be conducted to assess diurnal variations of key constituents by collecting grab samples of the RO feed (S6) every 4 hours for the following compounds:

- Caffeine (14 samples total)
- Sucralose (14 samples total)
- Total nitrogen(14 samples total)
- Nitrate / Nitrite(14 samples total)
- Total phosphorus (14 samples total)
- 1,4 dioxane (14 samples total)
- NDMA(14 samples total)

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Section 9
References

1. ASTM. Standard Practice for Detecting Leaks in Reverse Osmosis Devices, Designation D3923- 94 (reapproved 2003)
2. City of San Diego. *Water Reuse Study, Final Draft Report*. March, 2006.
3. CDPH. Letter: *Detailed comments Water Purification Demonstration Project – Revised Draft Testing and Monitoring Plan for the Advanced Water Purification Facility*, Dated January 31, 2011.
4. EPA 540/G 87/003A, Data Quality Objectives For Remedial Response Activities, March 1987
5. McGuire Environmental Consultants, Inc. *Science, Technology, and Regulatory Issues Associated With Non-Potable and Indirect Potable Recycled Water Uses.* January 2005.
6. United States Environmental Protection Agency (USEPA). *Membrane Filtration Guidance Manual. 815-R-06-009.* November 2005.
7. MWH. *Aqua 2030 Research Center, Advanced Water Treatment Research Studies.* Prepared for the City of San Diego, August 2007.
8. American Water Works Association Research Foundation. *Microbial Removal and Integrity Monitoring of High-Pressure Membranes.* 2003
9. Anderson, P.; Denslow, N.; Drewes, J.E.; Olivieri, A.; Schlenk, D.; Snyder, S. *Monitoring Strategies for Chemicals of Emerging Concerns (CECs) in Recycled Water: Recommendations of a Science Advisory Panel. Convened* by the State Water Resources Control Board. June, 2010.
10. National Water Research Institute. *Final Report of the May 11-12 2009, Meeting of the Independent Advisory Panel.* Prepared for the City of San Diego. September 2009.
11. National Water Research Institute. *Findings and Recommendations of the Advanced Water Purification Facility Subcommittee Meeting.* Memorandum, November 15, 2010.
12. MWH. Based on data collected from the full scale application of preformed chloramines Gibson Island Advanced Water Treatment Plan, Brisbane Australia, 2010
13. MWH. *Aqua 2030 Research Center, Impact of UV on Emerging Contaminants of Concern.* Prepared for the City of San Diego. December 2004.
14. MWH. *Aqua 2030 Research Center, Reverse Osmosis Membrane Integrity* . Prepared for the City of San Diego. August 2006.

15. Mitch, W. A., Sharp, J. O., Trussell, R. R., Valentine, R. L., Alvarez-Cohen, L., Sedlak, D. L., "N-Nitrosodimethylamine (NDMA) as a Drinking Water Contaminant: A Review", Environmental Engineering Science, 20(5), 2003, 389-404
16. Mitch, W., Sedlak, D. L., "Characterization and Fate of N-nitrosodimethylamine Precursors in Municipal Wastewater Treatment Plants", Environmental Science and Technology, 38(5), 2004, 1445-1454
17. Trussell, S. R. , Chiu, L.; *Technical Memorandum: North City Water Reclamation Plant Denitrification and Recycled Water Quality Improvement Project.* Trussell Technologies, Inc. March 2010.
18. Environmental Monitoring and Technical Services; Public Utilities Department, City of San Diego. *North City Water Reclamation Plant: Annual Monitoring Report 2009.* City of San Diego, January 2010.
19. Montgomery Watson Harza Laboratories. *PPCP Sample Collection Protocols.* April, 2010.
20. United States Environmental Protection Agency (USEPA). *Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule.* Office of Water (4601) EPA 815-R-06-007. November 2006.
21. USBR, *Evaluation of Methods for Monitoring the Integrity of Reverse Osmosis Membrane Systems*, Denver, CO; April 2000
22. California Department of Public *Health. Draft Groundwater Recharge Reuse Regulations*. August 2008.
23. California Regional Water Quality Control Board- San Diego Region. *Water Quality Control Plan for the San Diego Basin*. April 2007.
24. California Regional Water Quality Control – San Diego Region. Letter: *Water Purification Demonstration Project, November 30, 2010 Draft Testing and Monitoring Plan and Regulation of Project under Order No. 97-03*, Dated February 28, 2011.
25. Adham et al, 1998c, Monitoring the integrity of RO membranes, Desalination, 119 (1998) 143-150
26. Hydranautics, 1998, Technical Service Bulletin 114: Procedure for Pressure Vessel Probing
27. Filtmtec, 2003, Technical Fact Sheet from Dow Filmtec
28. www.epa.gov/superfund/programs/clp/download.fgorg.pdf
29. 1 www.epa.gov/superfund/programs/clp/download/fginor.pdf
30. 1 EPA 540/G 87/003A, Data Quality Objectives For Remedial Response Activities, March 1987

1,4-Dioxane

31. Beckett, Michael A.; Hua, Inez. *Elucidation of the 1,4-Dioxane Decomposition Pathway at Discrete Ultrasonic Frequencies.* Environmental Science and Technology. 34(18), 3944-3953, 2000.

32. Beckett Michael A; Hua Inez. *Enhanced sonochemical decomposition of 1,4-dioxane by ferrous iron.* Water Research. 37(10), 2372-2376, 2003.

33. Coleman, H. M.; Vimonses, V.; Leslie, G.; Amal, R. *Degradation of 1,4-dioxane in water using TiO_2 based photocatalytic and H_2O_2/UV processes.* Journal of Hazardous Materials. *146(3)*, 496-501, 2007.

34. Ghosh, Prabir; Samanta, A. N.; Ray, S. *Oxidation kinetics of degradation of 1,4-dioxane in aqueous solution by H_2O_2/Fe(II) system.* Journal of Environmental Science and Health, Part A: Toxic/Hazardous Substances & Environmental Engineering. *45(4)*, 395-399, 2010.

35. Kim Chang-Gyun; Seo Hyung-Joon; Lee Byung-Ryul. *Decomposition of 1,4-dioxane by advanced oxidation and biochemical process.* Journal of Environmental Science and Health. Part A, Toxic/Hazardous Substances & Environmental Engineering. 41(4), 599-611. 2006.

36. Kishimoto, Naoyuki; Yasuda, Yuuji; Mizutani, Hiroshi; Ono, Yoshiro. *Applicability of ozonation combined with electrolysis to 1,4-dioxane removal from wastewater containing radical scavengers.* Ozone: Science & Engineering. *29(1)*, 13-22, 2007.

37. Nakajima, Akira; Tanaka, Megumi; Kameshima, Yoshikazu; Okada, Kiyoshi. *Sonophotocatalytic destruction of 1,4-dioxane in aqueous systems by HF- treated TiO_2 powder*. Journal of Photochemistry and Photobiology, A: Chemistry, *167(2-3)*, 75-79, 2004.

38. So, M. H.; Han, J. S.; Han, T. H.; Seo, J. W.; Kim, C. G. *Decomposition of 1,4-dioxane by photo-fenton oxidation coupled with activated sludge in a polyester manufacturing process.* Water Science and Technology, *59(5)*, 1003-1009, 2009.

39. Son, Hyun-Seok; Choi, Seok-Bong; Khan, Eakalak; Zoh, Kyung-Duk. Removal of 1,4-dioxane from water using sonication: *Effect of adding oxidants on the degradation kinetics.* Water Research. *40(4)*, 692-698, 2006.

40. Son, Hyun-Seok; Im, Jong-Kwon; Zoh, Kyung-Duk. *A Fenton-like degradation mechanism for 1,4-dioxane using zero-valent iron (Fe0) and UV light***.** Water Research, *43(5)*, 1457-1463, 2009.

41. Stefan, Mihaela I.; Bolton, James R. *Mechanism of the Degradation of 1,4-Dioxane in Dilute Aqueous Solution Using the UV/Hydrogen Peroxide Process.* Environmental Science and Technology, *32(11)*, 1588-1595. 1998.

NDMA

42. Andrzejewski, Przemyslaw; Nawrocki, Jacek. *N-nitrosodimethylamine (NDMA) as a product of potassium permanganate reaction with aqueous solutions of dimethylamine (DMA). Water* Research. *43(5)*, 1219-1228, 2009.

43. Chaplin Brian P; Schrader Glenn; Farrell James. *Electrochemical oxidation of N-nitrosodimethylamine with boron-doped diamond film electrodes.* Environmental Science & Technology. *43(21)*, 8302-8307, 2009.

44. Chaplin, Brian P.; Schrader, Glenn; Farrell, James. *Electrochemical Destruction of N-Nitrosodimethylamine in Reverse Osmosis Concentrates using Boron-doped Diamond Film Electrodes*. Environmental Science & Technology. 44(11), 4264-4269, 2010.

45. Kommineni, Sunil; Ela, Wendell P.; Arnold, Robert G.; Huling, Scott G.; Hester, Beverley J.; Betterton, Eric A. *NDMA Treatment by Sequential GAC Adsorption and Fenton-Driven Destruction.* Environmental Engineering Science. *20(4)*, 361-373, 2003.

46. Lee, Changha; Choi, Wonyong; Kim, Young Gyu; Yoon, Jeyong. *UV Photolytic Mechanism of N-Nitrosodimethylamine in Water: Dual Pathways to Methylamine versus Dimethylamine.* Environmental Science and Technology. *39(7)*, 2101-2106, 2005.

47. Lee, Changha; Choi, Wonyong; Yoon, Jeyong. *UV Photolytic Mechanism of N-Nitrosodimethylamine in Water: Roles of Dissolved Oxygen and Solution pH.* Environmental Science and Technology. *39(24)*, 9702-9709, 2005.

48. Lee Changha; Yoon Jeyong; Von Gunten Urs. *Oxidative degradation of N-nitrosodimethylamine by conventional ozonation and the advanced oxidation process ozone/hydrogen peroxide.* Water Research. *41(3)*, 581-90, 2007.

49. Mezyk, Stephen P.; Cooper, William J.; Madden, Keith P.; Bartels, David M. *Free Radical Destruction of N-Nitrosodimethylamine in Water. Environmental* Science and Technology. *38(11)*, 3161-3167, 2004.

50. Plumlee, Megan H.; Reinhard, Martin. *Photochemical Attenuation of N-Nitrosodimethylamine (NDMA) and other Nitrosamines in Surface Water.* Environmental Science & Technology. *41(17)*, 6170-6176, 2007.

51. Poussade, Y.; Roux, A.; Walker, T.; Zavlanos, V. *Advanced oxidation for indirect potable reuse: a practical application in Australia.* Water Science and Technology. *60(9)*, 2419-2424, 2009.

52. Stefan, Mihaela I.; Bolton, James R. *UV direct photolysis of N-nitrosodimethylamine (NDMA): kinetic and product study*. Helvetica Chimica Acta. *85(5)*, 1416-1426, 2002.

53. von Gunten, Urs; Salhi, Elisabeth; Schmidt, Carsten K.; Arnold, William *A. Kinetics and Mechanisms of N-Nitrosodimethylamine Formation upon Ozonation of*

N,N-Dimethylsulfamide-Containing Waters: Bromide Catalysis. Environmental Science & Technology. 44(15), 5762-5768, 2010.

54. Xu, Bingbing; Chen, Zhonglin; Qi, Fei; Ma, Jun; Wu, Fengchang. *Inhibiting the regeneration of N-nitrosodimethylamine in drinking water by UV photolysis combined with ozonation.* Journal of Hazardous Materials. *168(1)*, 108-114, 2009.

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APPENDIX A – AWP FACILITY DRAFT PFD & SITE LAYOUT

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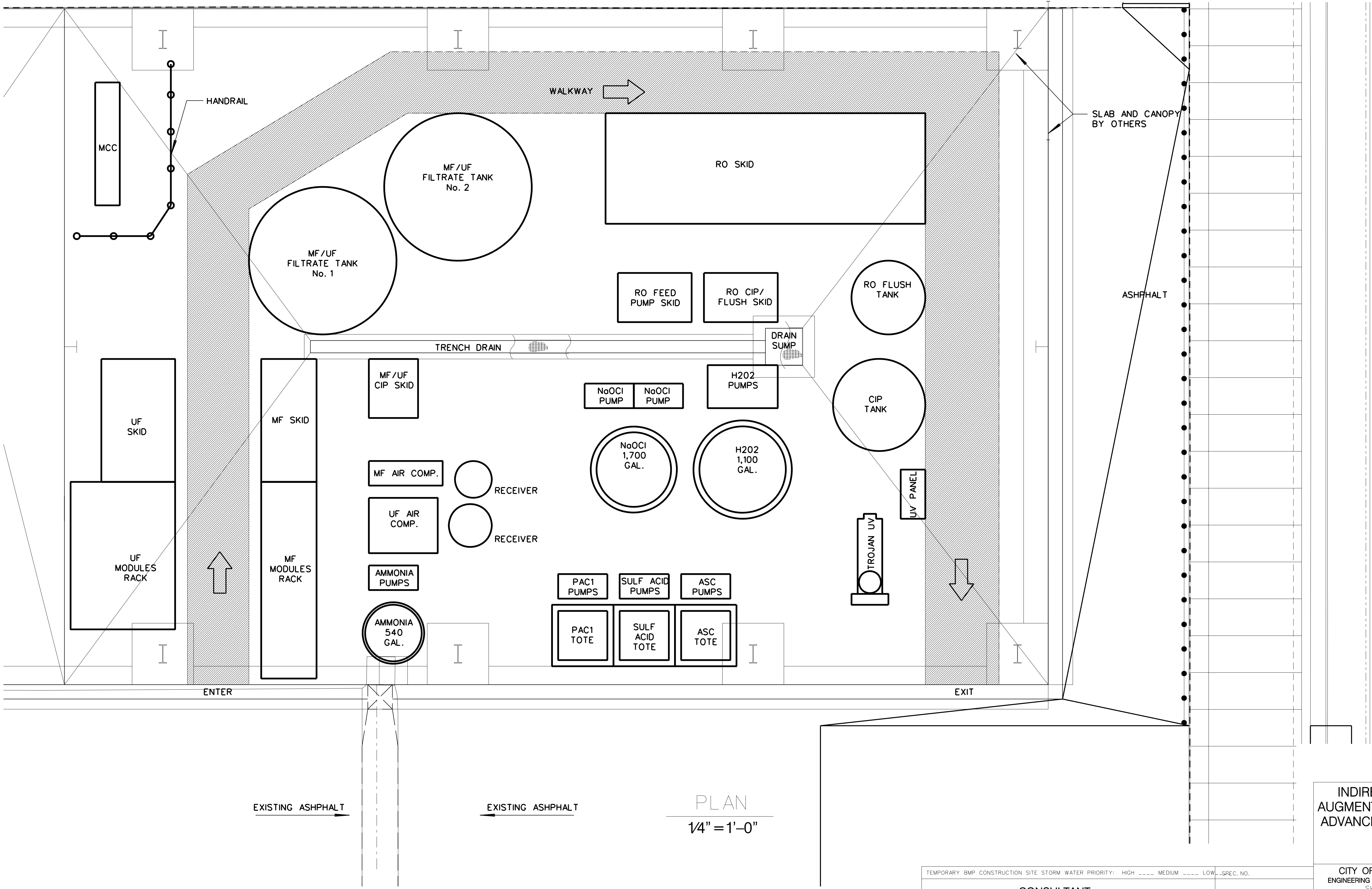

PLAN

1/4" = 1'-0"

A-1

INDIRECT POTABLE REUSE/RESERVIOR AUGMENTATION DEMONSTRATION PROJECT ADVANCED WATER PURIFICATION FACILITY

MECHANICAL PLAN

TEMPORARY BMP CONSTRUCTION SITE STORM WATER PRIORITY: HIGH ____ MEDIUM ____ LOW ____ SPEC. NO.

CONSULTANT

CONSULTANT

STAMP

CITY OF SAN DIEGO, CALIFORNIA
ENGINEERING AND CAPITAL PROJECTS DEPARTMENT
SHEET OF SHEETS

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WBS 0-00000

APPROVED:

FOR CITY ENGINEER DATE

SUBMITTED BY:

ASSOCIATE ENGINEER

DESCRIPTION	BY	APPROVED	DATE	FILMED
ORIGINAL	XX/XX			

PROJECT ENGINEER

SEE SHEETS
CCS27 COORDINATE

SEE SHEETS
CCS83 COORDINATE

CONTRACTOR ____________ DATE STARTED ____________
INSPECTOR ____________ DATE COMPLETED ____________

19905–XX–D

CONSTRUCTION CHANGE / ADDENDUM

CHANGE	DATE	AFFECTED OR ADDED SHEET NUMBERS	APPROVAL NO.

WARNING
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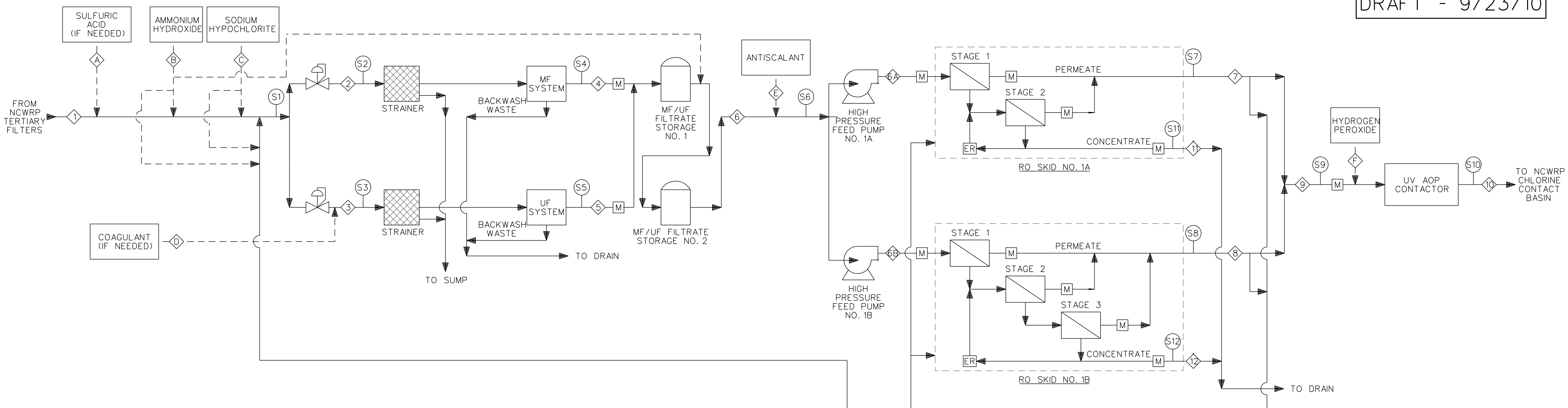

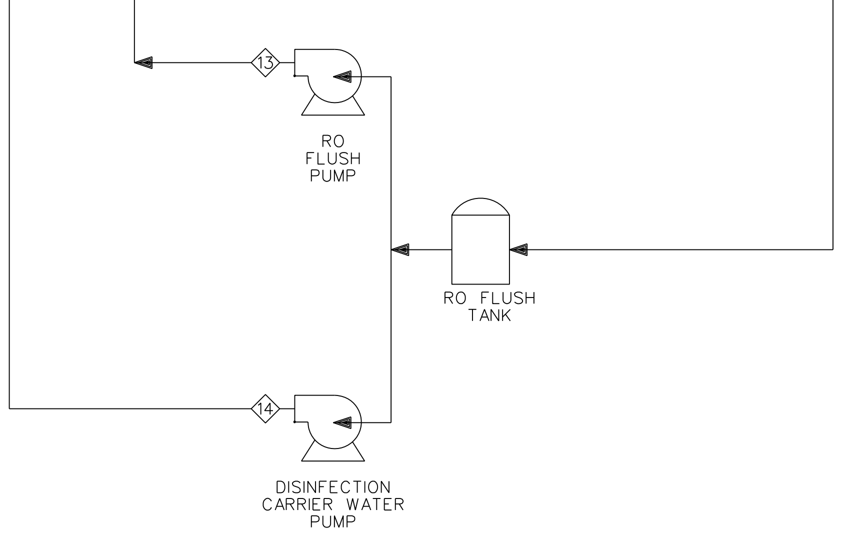

	AWT INFLUENT	MF FEED	UF FEED	MF FILTRATE	UF FILTRATE	RO FEED	RO TRAIN NO. 1A FEED (HYDRANAUTICS ESPA2)	RO TRAIN NO. 1B FEED (TORAY TML20)	RO TRAIN NO. 1A PERMEATE (HYDRANAUTICS ESPA2)	RO TRAIN NO. 1B PERMEATE (TORAY TML20)	UV FEED	UV PRODUCT	RO TRAIN NO. 1A CONCENTRATE	RO TRAIN NO. 1B CONCENTRATE	RO FLUSH WATER	DISINFECTION CARRIER WATER		SULFURIC ACID (IF NEEDED)	AMMONIUM HYDROXIDE	SODIUM HYPOCHLORITE	COAGULANT (PACl) (IF NEEDED)	ANTISCALANT	HYDROGEN PEROXIDE
PROCESS STREAM ID	1	2	3	4	5	6	6A	6B	7	8	9	10	11	12	13	14	CHEMICAL ID	A	B	C	D	E	F
DESIGN PARAMETERS																							
RECOVERY (%)				93%	93%				80%	80%													
SALT REJECTION (%)									97%	98%													
TOC REJECTION (%)									99%	99%													
																	CHEMICAL DOSE, AVG. (mg/L)	0	1	4	0	3	2
																	CHEMICAL DOSE, MAX. (mg/L)	50	1	10	3	3	10
FLOWS																							
DESIGN FLOW (mgd)	1.34	0.67	0.67	0.63	0.63	1.25	0.63	0.63	0.50	0.50	1.00	1.00	0.13	0.13	-	0.003							
DESIGN FLOW (gpm)	933	467	467	434	434	868	434	434	347	347	694	694	87	87	180	2							
																	FEED FLOW, AVG., EA. (gph)	0	0.4	1.4	0	0.14	0.25
																	FEED FLOW, MAX., EA. (gph)	1.6	0.4	3.6	0.64	0.14	1.3
PRESSURES																							
PRESSURE, AVG. (psi)	60	30	50	0.4	0.4	0.4	217	217	4.3	4.3	4.3	4.3	0	0	60	65							
PRESSURE, MAX. (psi)	60	30	50	5.6	5.6	5.6	228	228	4.3	4.3	4.3	4.3	0	0	60	75							
CONSTITUENTS																							
pH, AVG.	7.1	7.2	7.2	7.2	7.2	7.2	7.2	7.2	5.9	5.2	5.6	5.6	7.8	7.8	5.6	5.6		0.03	11.6	12	1.5-2	2-4	3.3
pH, MIN.	7.0	6.4	6.4	6.4	6.4	6.4	6.4	6.4	5.1	4.6	4.9	4.9	7.0	7.0	4.9	4.9							
pH, MAX.	7.3	7.7	7.7	7.7	7.7	7.7	7.7	7.7	6.4	6.2	6.3	6.3	8.3	8.0	6.3	6.3							
TDS, AVG. (mg/L)	920	925	925	925	925	925	925	925	28	19	23	23	4510	4550	23	23							
TDS, MAX. (mg/L)	980	991	991	991	991	991	991	991	30	20	25	25	4840	4880	25	25							
TOC, AVG. (mg/L)	8.5	8.5	8.5	8.5	8.5	9.4	9.4	9.4	0.1	0.1	0.1	0.1	47	47	0.1	0.1							
TOC, MAX. (mg/L)	10	10	10	10	10	11	11	11	0.1	0.1	0.1	0.1	55	55	0.1	0.1							
TOTAL CL2, AVG. (mg/L)	0.0	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5							
TOTAL CL2, MAX. (mg/L)	0.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0							

SYMBOL LEGEND

S#	SAMPLING LOCATION
M	FLOW METER
◇2	STREAM ID
◇B	CHEMICAL ID
ER	ENERGY RECOVERY DEVICE

NOTES

BACKWASH SYSTEMS FOR MF AND UF AND CIP SYSTEMS FOR MF, UF AND RO ARE NOT SHOWN FOR CLARITY.

A-2

INDIRECT POTABLE REUSE/RESERVIOR AUGMENTATION DEMONSTRATION PROJECT ADVANCED WATER PURIFICATION FACILITY

PROCESS FLOW DIAGRAM

TEMPORARY BMP CONSTRUCTION SITE STORM WATER PRIORITY: HIGH ____ MEDIUM ____ LOW ____ SPEC. NO.

CONSULTANT

CDM
Camp Dresser & McKee Inc
1925 Palomar Oaks Way, Suite 300
Carlsbad, California 92008
Tel: (760) 438-7755

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IN ASSOCIATION WITH
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SHEET __ OF __ SHEETS

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APPROVED:
FOR CITY ENGINEER
DATE

SUBMITTED BY:
ASSOCIATE ENGINEER

PROJECT ENGINEER

DESCRIPTION	BY	APPROVED	DATE	FILMED
ORIGINAL	XX/XX			

SEE SHEETS
CCS27 COORDINATE

SEE SHEETS
CCS83 COORDINATE

CONTRACTOR ____________ DATE STARTED ____________
INSPECTOR ____________ DATE COMPLETED ____________

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APPENDIX B – TECHNICAL MEMORANDUM: SURVEY OF NCWRP INDUSTRIAL DISCHARGERS PREPARED BY RMC

Technical Memorandum

City of San Diego Water Purification Demonstration Project

Subject: **Survey of North City Water Reclamation Plant Industrial Dischargers**
Prepared For: City of San Diego Public Utilities Department
Prepared by: Tish Berge
Reviewed by: Tom Richardson
Date: June 21, 2010
Reference: 0104-004

The purpose of this technical memorandum is to outline the process used to identify specific contaminates of concern in the North City Water Reclamation Plant (NCWRP) sewershed based on industrial discharger information and to report the results of this process. This TM is organized as follows:

- Background
- Approach
- Findings

1 Background

The scope of services for the City of San Diego Water Purification Demonstration Project Advanced Water Purification (AWP) Demonstration Plant includes a Local Contaminates Investigation. The RMC team was tasked with identifying specific contaminates of concern in the NCWRP sewershed based on industrial discharger information. This information will be provided to the AWP consultant for use in identifying analytes and indicators included in a Testing and Monitoring Plan.

1.1 NCWRP Sewershed Industrial Base

The NCWRP sewershed has a large concentration of pharmaceutical/research and development (R&D) facilities. Generally only R&D biomedical industry activity is conducted in the area and the discharge may differ daily due to the intermittent nature of the business and frequent turnover of tenants. The team worked with the City of San Diego Public Utilities Industrial Wastewater Control Program to identify the information available for these dischargers via the industrial permitting process.

1.2 City of San Diego Pretreatment Program Permits

The City of San Diego Industrial Wastewater Control Program issues permits to industrial dischargers in San Diego and the 16 Participating Agencies that constitute the Metro sewer system tributary area. Permits issued are based upon industrial type and flow as follows:

- Class 1 – Federally regulated industry **-** pharmaceutical manufacturer.
- Class 2 – Potential for toxics – laboratories are required to follow Best Management Practices and Toxic and Prohibited Organic Chemical Management Plan (TOMP). For reference, these documents are provided at the end of this technical memorandum as Attachments 1 and 2.
- Class 3 – Potential for conventional pollutants (i.e. biochemical oxygen demand [BOD] and total suspended solids [TSS]) in quantities that could interfere with the collection system or upset the wastewater treatment plant's biological processes. Class 3 permits are not discussed further here

as typical Class 3 pollutants are not discharged in large quantities from R&D biomedical industries.

- Class 4 – Flow is less than 25 gallons per day and permit is not necessary. Class 4 permits are not discussed further as R&D biomedical industries generally done fall within this category.

1.2.1 Class 1 Permits

The US Environmental Protection Agency (EPA) regulates certain classes of industrial waste dischargers as significant industrial users. Significant Industrial User is defined by the US EPA as an industrial user that discharges process wastewater into a publicly owned treatment works (POTW) and meets at least one of the following:

1. All industrial users subject to Categorical Pretreatment Standards under the Code of Federal Regulations - Title 40 (40 CFR) Part 403.6, and CFR Title 40 Chapter I, Subchapter N- Effluent Guidelines and Standards; and
2. Any other industrial user that:
    a. Discharges an average of 25,000 gallons per day or more of process wastewater to the POTW (excluding sanitary, non-contact cooling and boiler blowdown wastewater); or
    b. Contributes a process wastestream which makes up 5 percent or more of any design capacity of the POTW treatment plant; or
    c. Has a reasonable potential for adversely affecting the POTW's operation or for violating any pretreatment standard or requirement.

1.2.2 Class 2 Permits

Each industry is required to submit a list of chemicals stored or used onsite with the initial permit application and every four years thereafter. Most of the chemicals are not expected to be found in the sewer as the discharge of concentrated toxic organics to the sewer is prohibited.

The TOMP requires the following:

- No disposal of chemicals to the sewer
    - There may be a small amount of chemical disposed due to laboratory glassware washing
    - Materials are concentrated and disposed of as a liquid/solid waste
- Provide an inventory of chemicals, which is included in the permit application
- Certify twice a year that the facility is following the TOMP

1.2.3 Permit Information Available

Each permit file includes the permit application, the TOMP, and lists other chemicals maintained on site. The TOMP identifies the CWA priority pollutant toxic organics used (using a checklist and separating into halogenated and non-halogenated) and flammable chemicals used or stored. For the other chemicals maintained and used on site, the type and quantity of data varied greatly with some users reporting in excess of 10,000 chemicals. Data were available in either electronic of hardcopy format. Larger hardcopy files were scanned for text recognition using optical character recognition.

2 Approach

Given the number of permits for industries in the NCWRP sewershed, and the extensive lists of chemicals associated with those industries, the team decided to use a representative subset of industries in developing the inventory. Within the NCWRP sewershed, there are 198 industries with City of San Diego permits. Of these 198 industries, 102 are either biotech R&D or some other type of R&D with the remaining 96 industries covering 49 different industry types from car washes and gas stations to electronic equipment manufacturers and veterinary services. Due to the large prevalence of biotech and

R&D industries within the sewershed, the team selected a subset of these 102 industries. The subset totaled 30 industries and included the following:

- All (two total) Class 1, federally regulated, pharmaceutical manufacturers;
- Twenty Class 2 industries with the greatest industrial wastewater flow; and
- Nine industries (mainly R&D) geographically clustered on Nancy Ridge Drive, including one Class 2 industry.

2.1 Data Review

With the assistance of the City of San Diego Public Utilities Industrial Wastewater Control Program, the team reviewed the permit files for each of the selected industries. Based on information provided in the TOMP, the team compiled a list of the toxic organics used by each industry. Each industry also included a comprehensive list of other chemicals stored or used on site. These varied from one list of just a dozen chemicals/products to lists of more than 10,000 chemicals / products. Therefore, the team decided to use the US EPA’s Contaminant Candidate List 3 (CCL3) to prioritize the chemicals and aid in review.

As a result, the final data list provides a listing of toxic organics used (as identified in the TOMP), flammable chemicals used/stored (as identified in the TOMP), and CCL3 chemicals used/stored.

2.1.1 Chemicals of Emerging Concern (CEC)

Constituents/chemicals of emerging concern (CECs) represent a challenging problem for regulators to address, owing to the lack of approved analytical methods to identify and quantify the presence of CECs and limited scientific knowledge about their sources, fates, and effects. The California State Water Resources Control Board (SWRCB) recently issued a Recycled Water Policy that, among other efforts, attempts to incorporate the most current science on CECs into regulatory policies for use by various state agencies. As a part of this policy, Southern California Coastal Water Research Project (SCCWRP) was asked to convene a panel of six experts to provide recommendations to the SWRCB. This "blue ribbon" panel addressed several questions, including:

1. What are the appropriate constituents to be monitored in recycled water, and what are the applicable monitoring methods and detection limits?
2. What are the possible indicators (i.e. surrogates) that represent a suite of CECs?

Based on the information compiled by the SCCWRP panel, the team used the List of Contaminants on US EPA’s Contaminant Candidate List 3 (CCL3) [Table D-1, Final Report (Draft for Public Comments) Monitoring Strategies for Chemicals of Emerging Concern (CECs) in Recycled Water Recommendations of a Science Advisory Panel, April 15, 2010]. The U.S. Government has a long history of developing regulations for contaminants in drinking water to protect public health; the process has evolved over several decades and includes the placement of currently non-regulated contaminants to be further evaluated on the USEPA’s Candidate Contaminant List (or CCL). The most recent CCL is CCL3, which utilized the expert opinions provided by the National Research Council as well as the National Drinking Water Advisory Council. This multi-step process includes three key elements:

- Identification of a broad universe of potential biological chemical and chemical contaminants (CCL Universe);
- Application of screening criteria based on potential occurrence and human health relevance (preliminary CCL or PCCL); and,
- Selection of priority contaminants based on more detailed occurrence and health effect data as well as expert judgment, public comment, and external advisory committees (draft and final CCL).

A draft of the CCL3 was released in February of 2008 and the final CCL3 was published in October of 2009; the list was then referenced in the recent report by the “blue ribbon” panel.

3 Findings

Based on the available data set and the criteria for review, the team assembled a comprehensive listing of chemicals used or stored by facility. This table appears on the following page.

Facility No.	02-0033	02-0043	02-0059	02-0332	02-0518	02-0641	02-0715	02-0721	02-0730	02-0744	02-0751	02-0752	02-0756	02-0880	02-0761	02-0762	02-0795	02-0803	02-0806	02-0808	02-0843	02-0861	02-0913	02-0939	02-0961	02-0972	02-0978	02-1047	03-1041	03-1081
TOXIC ORGANIC, HALONGENATED																														
aldrin																										x				x
benzofluoranthene																										x				
carbon tetrachloride	x		x	x			x	x	x	x		x								x			x			x				X
chlordane																										x				
chlorinated benzenes	x		x			x	x	x	x			x								x						x				X
chloroalky ethers																				x						x				
chlorinated naphthalene								x	x																	x				X
chlorinated phenols						x	x	x	x			x								x			x			x				
chloroform	x	x				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	X
chlorinated cresols																										x				
DDT and metabolites							x			x																x				
dichlorobenziden																							x			x				
dichloroethylenes			x						x																	x				
dichloropropane									x										x							x				
dichloropropene																										x				
dieldrin																										x				x
endrin and metabolites																										x				
fluoranthene																										x				
freons							x		x	x		x														x				
haloethers						x						x			x					x			x			x				
halomethanes (inc. methylene chloride)	x					x	x	x	x	x		x			x	x		x	x	x		x	x	x		x				x
heptachlor and metabolites																										x				
hexachlorobutadiene																										x				
hexachlorocyclohexane									x																	x				
hexachlorocyclopentadiene	x								x																	x				
pentachlorophenol							x		x			x														x				

Facility No.	02-0033	02-0043	02-0059	02-0332	02-0518	02-0641	02-0715	02-0721	02-0730	02-0744	02-0751	02-0752	02-0756	02-0880	02-0761	02-0762	02-0795	02-0803	02-0806	02-0808	02-0843	02-0861	02-0913	02-0939	02-0961	02-0972	02-0978	02-1047	03-1041	03-1081
polychlorinated byphenyls (PCBs)																										x				
2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)																														
tetrachloroethylene	x		x			x			x			x														x				
toxaphene																										x				
1,1,1-trichloroethane									x	x																x				
trichloroethylene				x				x	x			x		x									x			x				
vinyl chloride																										x				
chlorinated ethanes								x																						
TOXIC ORGANIC, NON-HALOGENATED																														
acenapthene																										x				x
acrolein	x					x		x	x			x							x	x			x			x				
acrylonitrile	x					x			x			x	x							x			x			x				x
benzene	x		x			x	x	x	x	x		x							x	x		x	x			x				x
benzidine	x						x		x														x			x				
chrysene									x			x														x				
2,4-dimethylphenol									x			x														x				
dinitrotoluene						x			x			x														x				
diphenylhydrazine									x			x														x				
endosulfan and metabolites												x														x				
ethylbenzene			x				x		x			x														x				x
isophorone									x																	x				
napthalene	x		x			x	x		x				x									x	x			x				x
nitrobenzene	x					x		x	x			x									x		x			x				
nitrophenols	x					x	x	x	x	x		x						x					x			x				
nitrosamines												x														x				
phenol	x	x				x	x	x	x	x		x						x	x		x	x	x		x	x	x		x	
phthalate esters						x			x																	x				x

Facility No.	02-0033	02-0043	02-0059	02-0332	02-0518	02-0641	02-0715	02-0721	02-0730	02-0744	02-0751	02-0752	02-0756	02-0880	02-0761	02-0762	02-0795	02-0803	02-0806	02-0808	02-0843	02-0861	02-0913	02-0939	02-0961	02-0972	02-0978	02-1047	03-1041	03-1081
polynuclear aromatic hydrocarbons						x			x			x														x				
toluene	x	x	x			x	x	x	x	x		x		x	x	x		x	x	x	x	x	x	x		x				x
CHEMICAL OF EMERGING CONCERN (CCL3)																														
1,1,2,2-tetrachloroethane									x														x							
1,1-dichloroethane									x																					
1,1-dichloropropene																														
1,2,4-trimethylbenzene									x																					x
1,2-diphenylhydrazine									x			x														x				
1,3-dichloropropane																														
1,3-dichloropropene									x																					
2,2-dichloropropane									x																					
2,4,6-trichlorophenol									x														x							
2,4-dichlorophenol									x														x							
2,4-dinitrophenol	x						x		x	x			x																	x
2,4-dinitrotoluene									x																					
2,6-dinitrotoluene									x																					
2-methyl-Phenol (AKA o-cresol)								x	x																					
Acetochlor																														
Alachlor ESA & other acetanilide pesticide degradation products																							X							
Aldrin																										x				x
Aluminum									x														x							
atrazine-desethyl																														
Boron																														
Bromobenzene								x	x														x							x
DCPA de-acid																														

Facility No.	02-0033	02-0043	02-0059	02-0332	02-0518	02-0641	02-0715	02-0721	02-0730	02-0744	02-0751	02-0752	02-0756	02-0880	02-0761	02-0762	02-0795	02-0803	02-0806	02-0808	02-0843	02-0861	02-0913	02-0939	02-0961	02-0972	02-0978	02-1047	03-1041	03-1081
degradate																														
DCPA mono-acid degradate																														
DDE									x																					
Diazinon	x																													x
Dieldrin																										x				x
Disulfoton																														
Diuron									x																					
EPTC (s-ethyl-dipropylthiocarbamate)																														
Fonofos																														
Hexachlorobutadiene																										x				
Linuron																														
Manganese									x				x																	
Methyl bromide (AKA Bromomethane)								x	x																					
Methyl-t-butyl ether (MTBE)							x		x	x			x			x		x					x							
Metolachlor																														
Metribuzin																														
Molinate																														
Naphthalene	x		x			x	x		x				x									x	x			x				x
Nitrobenzene	x					x		x	x			x									x		x			x				
Organotins																														
Perchlorate																														
p-Isopropyltoluene (p-cymene)									x																					
Prometon																														
RDX																														
Sodium	x						x		x	x			x										x							
Sulfate																														

Facility No.	02-0033	02-0043	02-0059	02-0332	02-0518	02-0641	02-0715	02-0721	02-0730	02-0744	02-0751	02-0752	02-0756	02-0880	02-0761	02-0762	02-0795	02-0803	02-0806	02-0808	02-0843	02-0861	02-0913	02-0939	02-0961	02-0972	02-0978	02-1047	03-1041	03-1081
Terbacil																														
Terbufos																														
Triazines & degradation products of triazines including but not limited to Cyanazine																														
Vanadium																														

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ATTACHMENT 1

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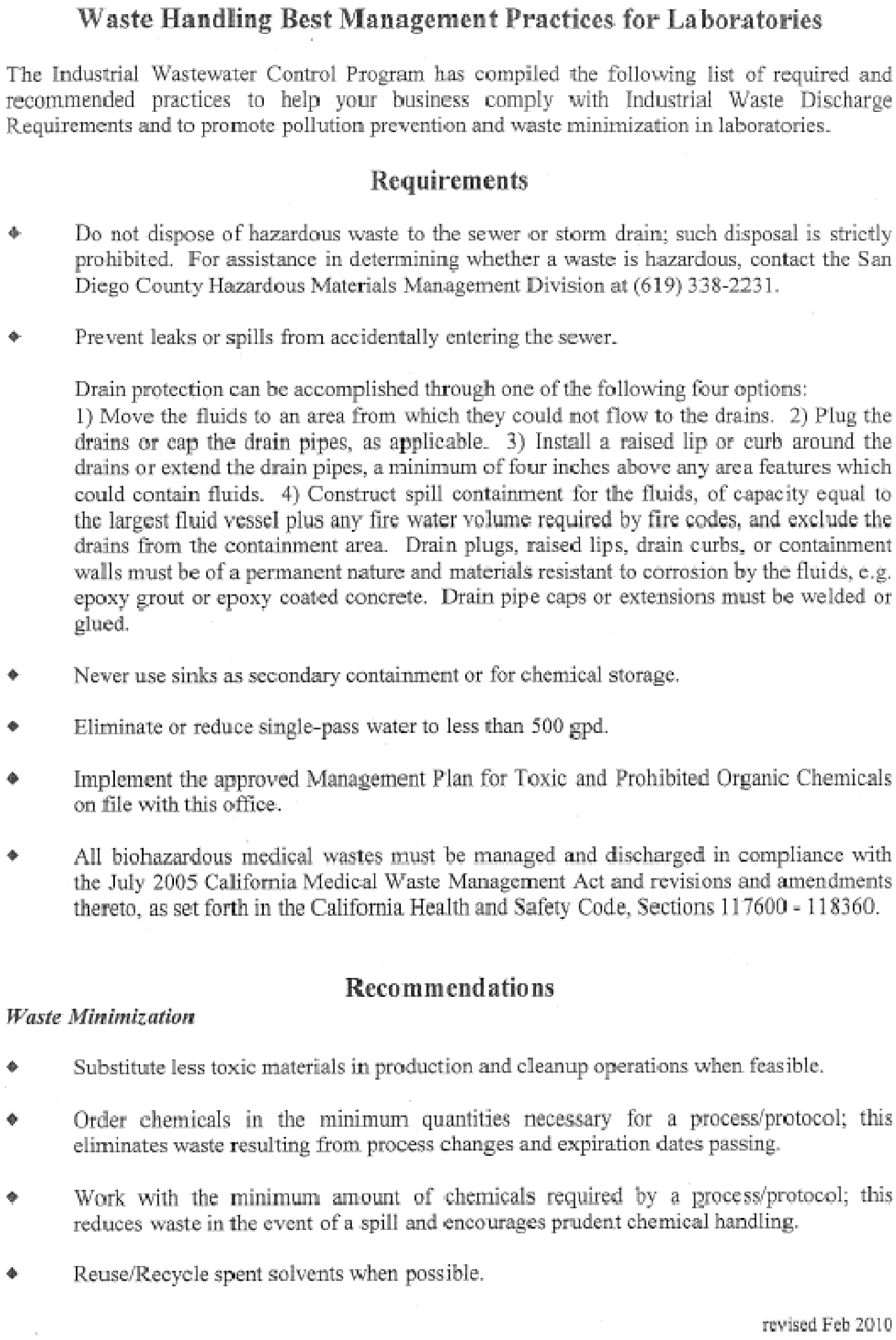
Best Management Practice Requirements for Laboratories within NCWRP Sewershed



Waste Handling Best Management Practices for Laboratories

The Industrial Wastewater Control Program has compiled the following list of required and recommended practices to help your business comply with Industrial Waste Discharge Requirements and to promote pollution prevention and waste minimization in laboratories.

Requirements

- Do not dispose of hazardous waste to the sewer or storm drain; such disposal is strictly prohibited. For assistance in determining whether a waste is hazardous, contact the San Diego County Hazardous Materials Management Division at (619) 338-2231.

- Prevent leaks or spills from accidentally entering the sewer.

  Drain protection can be accomplished through one of the following four options: 1) Move the fluids to an area from which they could not flow to the drains. 2) Plug the drains or cap the drain pipes, as applicable. 3) Install a raised lip or curb around the drains or extend the drain pipes, a minimum of four inches above any area features which could contain fluids. 4) Construct spill containment for the fluids, of capacity equal to the largest fluid vessel plus any fire water volume required by fire codes, and exclude the drains from the containment area. Drain plugs, raised lips, drain curbs, or containment walls must be of a permanent nature and materials resistant to corrosion by the fluids, e.g. epoxy grout or epoxy coated concrete. Drain pipe caps or extensions must be welded or glued.

- Never use sinks as secondary containment or for chemical storage.

- Eliminate or reduce single-pass water to less than 500 gpd.

- Implement the approved Management Plan for Toxic and Prohibited Organic Chemicals on file with this office.

- All biohazardous medical wastes must be managed and discharged in compliance with the July 2005 California Medical Waste Management Act and revisions and amendments thereto, as set forth in the California Health and Safety Code, Sections 117600 - 118360.

Recommendations

Waste Minimization

- Substitute less toxic materials in production and cleanup operations when feasible.

- Order chemicals in the minimum quantities necessary for a process/protocol; this eliminates waste resulting from process changes and expiration dates passing.

- Work with the minimum amount of chemicals required by a process/protocol; this reduces waste in the event of a spill and encourages prudent chemical handling.

- Reuse/Recycle spent solvents when possible.

revised Feb 2010

- Practice water conservation by installing flow restrictors and recycling water when possible.

Drain Protection

- Utilize secondary containment to prevent leaks or spills from accidentally entering the sewer. Trays or plastic holders can be used for small volumes; larger volumes should be stored in bermed or diked storage areas. Secondary containment should be kept dry. Never store incompatible chemicals together in the same containment area. Other spill prevention measures include:

    - Using coated containers to reduce spills caused by breakage.
    - Storing chemicals in latched cabinets and using shelf barriers.
    - Checking storage container integrity on a regular basis.
    - Storing chemicals in approved cabinets or on low shelves.

- Maintain a written spill response plan and be sure that all employees are familiar with it. Be sure that spill clean up supplies are adequately stocked and easily accessible.

- Keep a mercury spill clean up kit in labs where mercury is used. Consider substituting electronic sensing devices for mercury containing equipment to prevent spills associated with breakage. Mercury in thermometers is the most likely source of this contaminant in labs.

Other

- Post signs next to lab sinks and drains to remind employees that disposal of hazardous waste to the sewer is prohibited.

- Practice good housekeeping by cleaning up spills immediately, clearly labeling all containers, utilizing proper chemical storage practices, and keeping clutter to a minimum.

- Be sure that all employees have been informed of your company's chemical handling and disposal protocols as well as the spill response plan. Periodic refresher training will keep employees informed of changes and updates.

- Film Processing: Refer to the City's Best Management Practice Requirements for Silver-Rich Solutions.

For more information, contact:

The City of San Diego
Industrial Wastewater Control Program
9192 Topaz Way, MS 901D
San Diego, CA 92123-1119
(858) 654-4100

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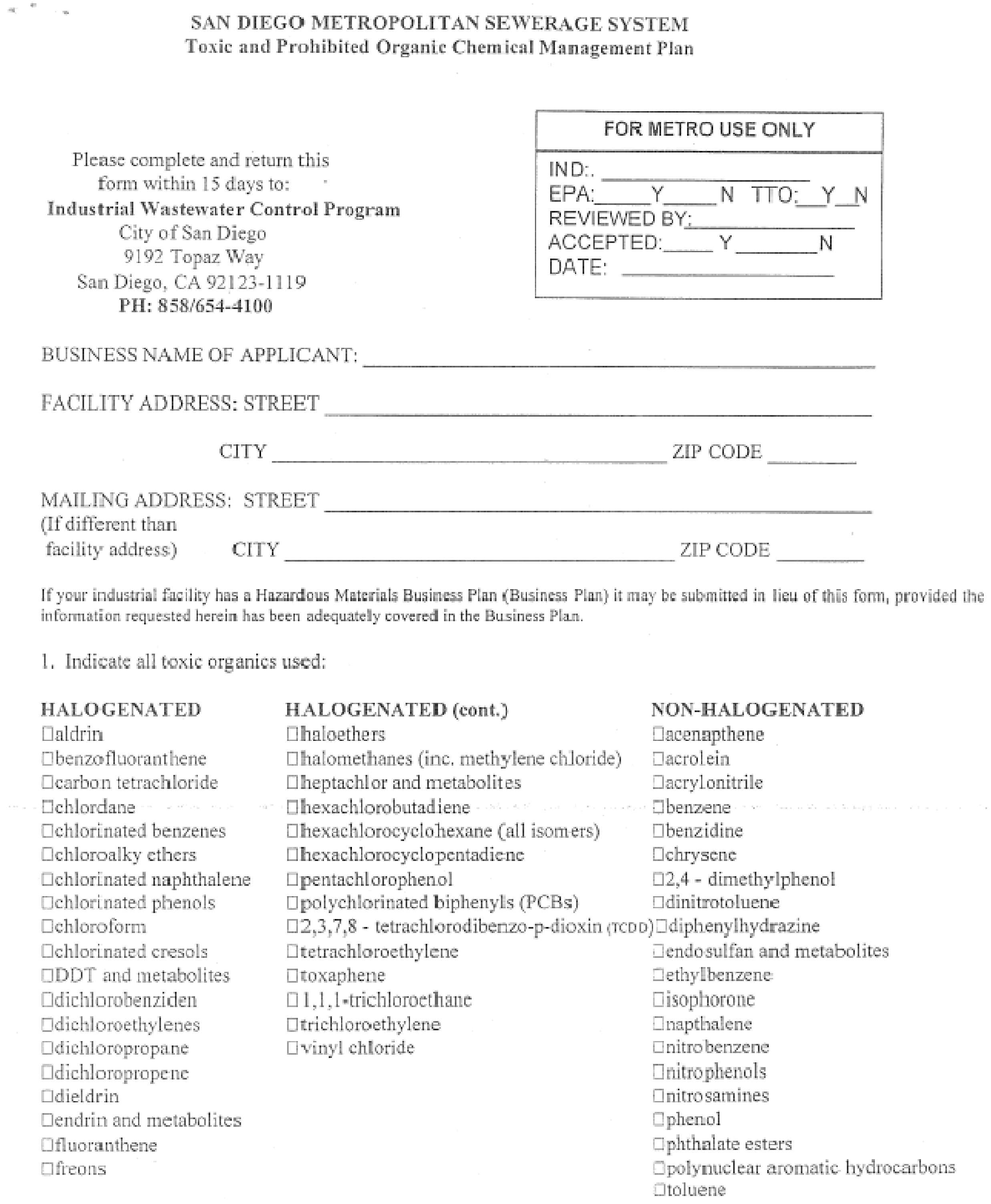
ATTACHMENT 2

TOMP for Industries within NCWRP Sewershed



SAN DIEGO METROPOLITAN SEWERAGE SYSTEM
Toxic and Prohibited Organic Chemical Management Plan

FOR METRO USE ONLY

IND:. ____________________
EPA:_____Y_____N TTO:__Y__N
REVIEWED BY:________________
ACCEPTED:_____ Y________N
DATE: ____________________

Please complete and return this
form within 15 days to:
Industrial Wastewater Control Program
City of San Diego
9192 Topaz Way
San Diego, CA 92123-1119
PH: 858/654-4100

BUSINESS NAME OF APPLICANT: ____

FACILITY ADDRESS: STREET ____

CITY ________________________________ ZIP CODE ________

MAILING ADDRESS: STREET ____
(If different than
facility address) CITY ________________________________ ZIP CODE ________

If your industrial facility has a Hazardous Materials Business Plan (Business Plan) it may be submitted in lieu of this form, provided the information requested herein has been adequately covered in the Business Plan.

1. Indicate all toxic organics used:

HALOGENATED
☐aldrin
☐benzofluoranthene
☐carbon tetrachloride
☐chlordane
☐chlorinated benzenes
☐chloroalky ethers
☐chlorinated naphthalene
☐chlorinated phenols
☐chloroform
☐chlorinated cresols
☐DDT and metabolites
☐dichlorobenziden
☐dichloroethylenes
☐dichloropropane
☐dichloropropene
☐dieldrin
☐endrin and metabolites
☐fluoranthene
☐freons

HALOGENATED (cont.)
☐haloethers
☐halomethanes (inc. methylene chloride)
☐heptachlor and metabolites
☐hexachlorobutadiene
☐hexachlorocyclohexane (all isomers)
☐hexachlorocyclopentadiene
☐pentachlorophenol
☐polychlorinated biphenyls (PCBs)
☐2,3,7,8 - tetrachlorodibenzo-p-dioxin (TCDD)
☐tetrachloroethylene
☐toxaphene
☐1,1,1-trichloroethane
☐trichloroethylene
☐vinyl chloride

NON-HALOGENATED
☐acenapthene
☐acrolein
☐acrylonitrile
☐benzene
☐benzidine
☐chrysene
☐2,4 - dimethylphenol
☐dinitrotoluene
☐diphenylhydrazine
☐endosulfan and metabolites
☐ethylbenzene
☐isophorone
☐napthalene
☐nitrobenzene
☐nitrophenols
☐nitrosamines
☐phenol
☐phthalate esters
☐polynuclear aromatic hydrocarbons
☐toluene

2. List all flammable chemicals used/stored:

- ☐ acetonitrile
- ☐ acetone
- ☐ ethanol
- ☐ ethyl acetate
- ☐ fuels
- ☐ methanol
- ☐ mineral spirits/paint thinner
- ☐ pyridine
- ☐ toluene
- ☐ xylene
- ☐ other ____________________

____

____

3. Total volume of waste organics generated monthly ______________________________

4. Do you routinely dispose of any of the chemicals listed in 1) or 2) above to the sewer? __ Y __ N

5. Do you segregate organic wastes for disposal? __ Y __ N. List the segregation criteria/categories.

____

____

____

6. How do you manage/dispose of organic wastes?

☐ On-site recovery/reuse

Contract hauling for:

☐ Off-site recovery/reuse ☐ Incineration

☐ Energy recovery ☐ Landfill

7. What is the largest volume of chemicals

a) Stored in a single container? ________

b) Moved as one load? ________

8. Are there any drains leading to the sewer in areas of chemical storage or use? ___ Y ___ N

9. What spill **prevention** measures does your company have in place?

☐ Training ☐ Equipment

Describe: ____

____

____

10. What spill **containment** provisions does your company have?

☐ Training ☐ Equipment

Describe: ____

____

____

Attach any sketches, plans, procedures, or extra sheets required to describe your facility=s organic chemical management plan.

CERTIFICATION: (This plan must be signed by an authorized representative.)

I hereby certify that the information provided in this questionnaire is familiar to me, is complete, and represents an accurate statement of fact to the best of my knowledge.

PRINT NAME: ______________________________ TITLE: ____________________

SIGNATURE: ______________________ DATE: __________ PH: ( ) ____________

APPENDIX C – TECHNICAL MEMORANDUM: INITIAL PLANNING FOR THE UV/AOP COMPONENT OF THE AWP FACILITY PREPARED BY CDM/MWH

CDM

1925 Palomar Oaks Way, Suite 300
Carlsbad, CA 92008
Ph: (760) 438-7755
Fax: (760) 438-7411

Attachment A

Memorandum

To: *Anthony Van, Bill Pearce - City of San Diego*

From: *Randy Hill, Greg Wetterau (CDM), Jay DeCarolis (MWH)*

Date: *May 21, 2010*

Subject: Initial planning for the UV/AOP component of the City of San Diego AWT Demonstration Plant, in response to CDPH comments to the UV System section of the IAP Report

Background

The purpose of this technical memorandum is to document the CDM/MWH's initial recommendation with regards to the selection of the UV system to be procured and operated as part of the City of San Diego's AWT Demonstration Project. The memorandum is written to address comments presented by the California Department of Public Health (CDPH) in regards to the IAP report as provided below:

CDPH Comment: "The Trojan Phox ultraviolet (UV) system at Orange County Water District (OCWD) consists of three reactors per treatment train (8.75 millions of gallons per day [mgd] capacity). Each reactor has two chambers. Each chamber has 72 lamps. Conceivably, if the exact same reactor is used, the capacity of one chamber is 1.46 mgd. OCWD's demonstration project was 5 mgd. The specifics of the UV demonstration unit should be addressed in the engineering report that is submitted for our review and approval.

UV Reactor Selection

As part of developing recommendations on the specific UV unit(s) to be tested during the City of San Diego's AWT demonstration project, the CDM/MWH team 1) reviewed the design and operation of the OCWD's UV/AOP system used at the GWRS and 2) spoke with representatives from Trojan.

Review of design and operation of OCWD AOP system used for the GWRS.

A basic flow diagram of the OCWD GWRS UV system is provided in Figure 1 (attached). As shown, the configuration of each train is consistent with the CDPH comment (see above). Each train passes a total flow of 8.75 mgd, contains three (3) reactors, and each reactor contains 2 chambers each with 72 lamps. Other pertinent information considered when reviewing the OCWD system follows:

- The system contains 8 primary trains configured in parallel; however, the (3) three reactors of each individual train are stacked vertically and configured in series, with two chambers in series within each reactor.

- Based on the series configuration, 8.75 mgd flows through each train, reactor, and chamber, resulting in significantly different hydraulic conditions than a single chamber reactor operated at 1.46 mgd. The GWRS UV system is configured to provide sufficient contact time and optimal hydraulics in the six chambers to achieve the required log removal established by CDPH.

Discussions with Trojan

The project team contacted Trojan to assess the feasibility of using a single reactor of the exact same model used in the OCWD train (dual chamber UVPhox Model D72AL75) operated at a flow rate needed to achieve an identical residence time as the OCWD reactors. Trojan confirmed that a flow rate of 2.92 mgd would be required to achieve an identical residence time with this dual chamber reactor; however, the hydraulics would remain considerably different due to the reduced flow rate when using a single reactor rather than the three in series used at OCWD. Because the demonstration plant is being sized for 1 MGD product capacity, operating the UV at 2.92 mgd in batch mode would require a large volume storage tank, VFD driven pumps, and additional controls, and would prevent the ability to continuously operate the AOP system at the demonstration plant.

As an alternative, Trojan recommended using a UVPhox Model 72AL75, which is a single chamber version of the reactors used at OCWD (In the name designation, "D" represents a dual chamber reactor, "72" the number of lamps per chamber, and "75" the diameter of the reactor in centimeters). Trojan has projected that this reactor will achieve 1.3-log NDMA removal at 1 mgd, with a hydraulic residence time roughly 33 percent longer than the OCWD reactors. It should be noted that a flow of 1.46 mgd would be required to achieve an identical residence time as the OCWD reactors, however, Trojan has projected that only 1.1-log destruction of NDMA would be achieved at this higher flow rate due to the poorer hydraulic conditions at the demonstration plant compared with the multiple reactors in series used at OCWD. At the 1-mgd flow, lamp intensity would need to be reduced to achieve 1.2-log NDMA destruction during operation and water quality monitoring at the demonstration plant.

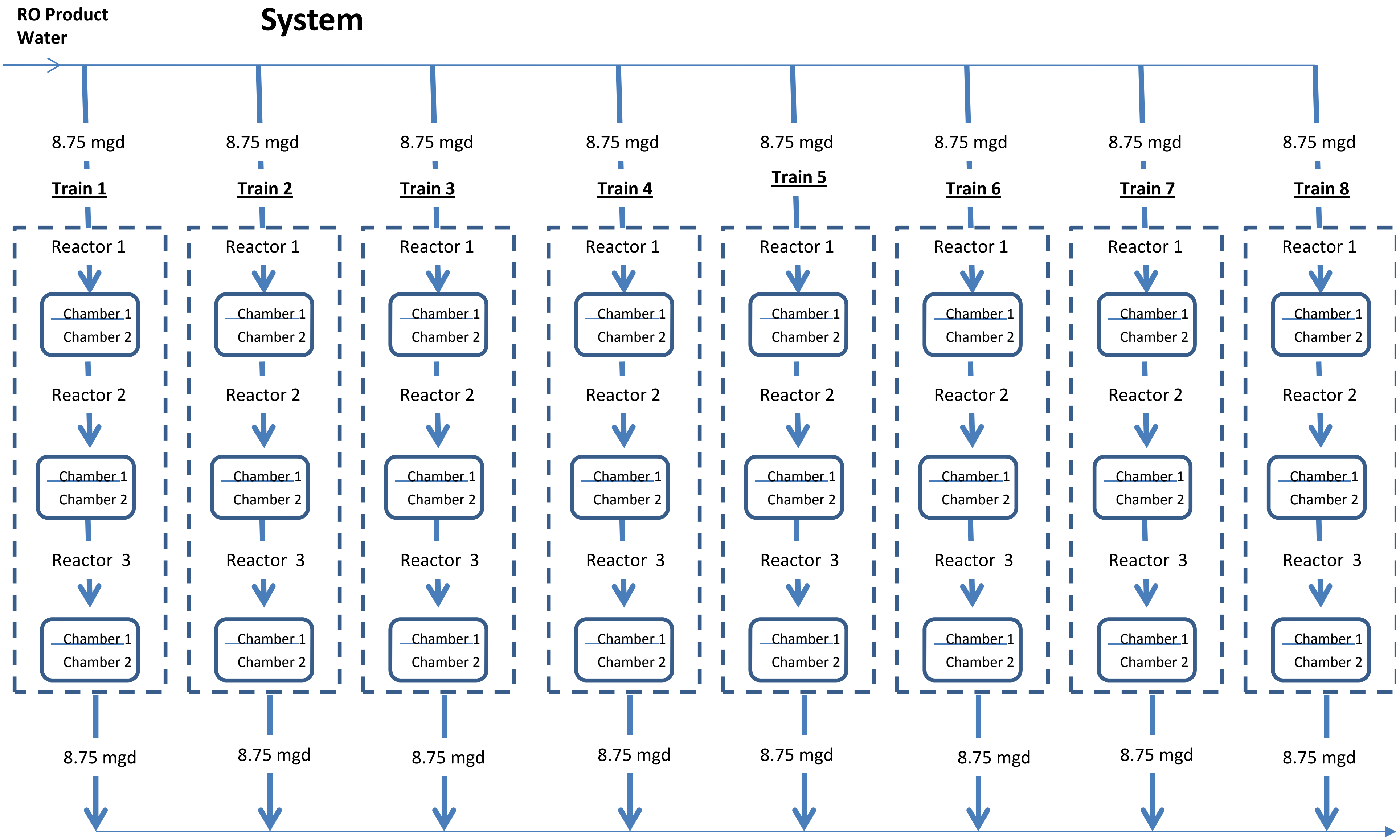
Testing Recommendations

Based on review of OCWD's UV configuration and discussion with Trojan, the project team recommends testing the Trojan UVPhox Model 72AL75 reactor for the San Diego AWT demonstration plant. During the initial phase of the demonstration operation the project team will verify the UV unit can meet 1.2 log removal of NDMA at 1 mgd flow rate by conducting spiking experiments, allowing the team to determine the exact power setting the unit requires for 1.2 log NDMA removal. The unit will then be operated under these settings for the remainder of the demonstration period during all routine and quarterly water quality sampling events.

Should CDPH require, the project team will perform UV collimated beam studies to assess the delivered dose required to reach the 1.2 log NDMA removal. This will include the development of standard curves for log removal by exposing RO product spiked with NDMA to UV light under different intensity settings and exposure time periods using a bench scale collimated beam unit. CDPH may also request that MS2 phage spiking be done to demonstrate 4-log virus removal; however, testing done at OCWD and West Basin has demonstrated that the dose required to achieve NDMA destruction is more than sufficient for achieving 4-log virus reduction.

Because the UV system proposed for the demonstration plant would not be completely identical to the full scale (slightly different reactors and different train configuration) the energy efficiency obtained from the demonstration plant would not be directly comparable to that of the full scale system. Accordingly, for the full scale plant the City would have the option to either use the exact reactor and train configuration as OCWD or another operational advanced treatment facility or to selected a different system and conduct validation testing of the full-scale unit during plant commissioning, similar to the approach taken by the existing advanced treatment facilities operating in southern California.

Figure 1 -Basic Configuration of OCWD's GWR UV / AOP System

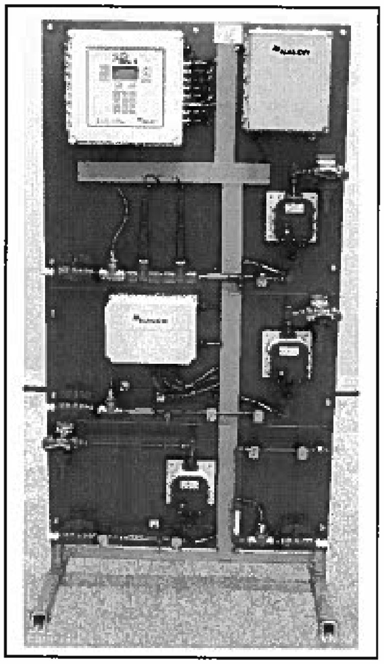


APPENDIX D – TECHNICAL SPECIFICATIONS: 3D TRASAR® AUTOMATION SYSTEM FOR RO SYSTEMS , NALCO INC.

Nalco SPECIFICATION # TBA

3D TRASAR® Automation for Reverse Osmosis Systems

- Optimize performance of Reverse Osmosis systems through data collection, trending and interpretation
- Improve control of antiscalant treatment programs even as operating conditions and water quality change
- Continuously monitors the system and alerts operators to "out of desired range" conditions permitting corrective action before performance is affected
- Availability of treatment program data, operational data and reports via the web simplifies process assurance compliance and troubleshooting.
- Modular design enables the system to be customized to meet customer needs.
- User-friendly interface makes the system easy to install, configure and operate



Description

3D TRASAR Automation for Reverse Osmosis Systems is a modular control platform designed to provide advanced control of antiscalant treatment programs and enable operational data collection for performance analysis. The system uses an updated version of the tried-and-true 3D TRASAR controller coupled with Nalco patented fluorescence technology to optimize control of antiscalant programs and enhance monitoring of pH adjustment and oxidant destruction programs. The expanded capabilities of this new 3D TRASAR controller permit continuous measurement of the key reverse osmosis system parameters.

- Feedwater: Fluorescence (treatment and background), conductivity, temperature, pH, ORP, and flow
- Permeate: Conductivity, temperature, flow and pressure
- Concentrate: Fluorescence, conductivity, temperature, flow and pressure
- Membrane/Interstage: Pressure

The data, along with operating data from the customer's DCS can be wirelessly transmitted back to Nalco for analysis, trending and interpretation. This web capability provides easy access to data, system reporting and enables alerting of key personnel to conditions outside of "best practices".

The 3D TRASAR Automation for Reverse Osmosis Systems is a modular system. It can be customized to handle a variety of reverse osmosis system configurations and upgraded as changes are made to operating conditions or process equipment. Quick-connectors simply installation, sensor calibration/maintenance and in-field upgrades.

3D TRASAR Automation for Reverse Osmosis Systems is just one more example of how Nalco innovation protects your reverse osmosis system, saves water and energy and increases efficiency. 3D TRASAR technology detects, determines and delivers the next dimension in reverse osmosis water management.

Modular Design

The heart of the 3D TRASAR for Reverse Osmosis Systems is the Feedwater System. It provides the sensors, controller and communications interface needed to automate antiscalant treatment programs. They are available as either frame-mount or panel-mount (to mount on the wall) versions.

Feedwater System

Standard Features:

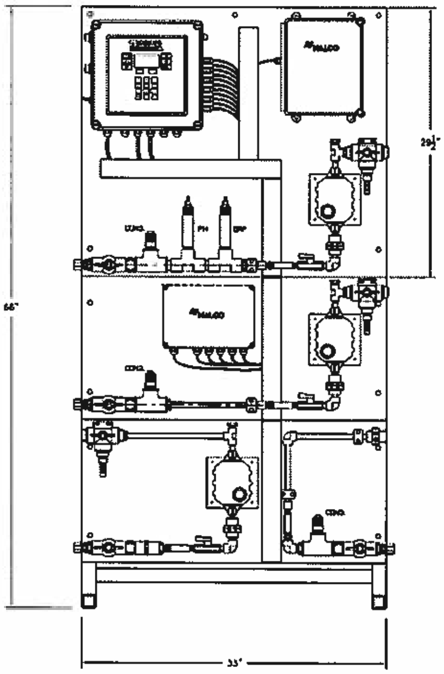
- 3D TRASAR Controller
- Fluorometer
- Conductivity & Temperature
- Sample Flow Switch
- Nalco Global Gateway (Regional Standards)

Options:

- pH & ORP Probes
- Analog Input Modules (provides 6 inputs prewired to accept pressure transmitters and 2 user-wireable inputs)

Mounting

Panels should be mounted on a flat wall so that the controller is at eye level. Add-On Module panels are mounted on the frame below the mains system panel. Wall mounted Add-On Modules must be close enough to the main panel for the probe cables to be connected.



060-RO6011.88 System with 060-RO1000.88 and 060-RO1120.88 Add-On Modules mounted on frame

Add-On Modules

There are 4 Add-On Modules for the 3D TRASAR for Reverse Osmosis Systems. They are all supplied as panel that con be mounted on the frame of the Feedwater System or on the wall.

Fluorometer/Conductivity Add-On Module

- Fluorometer
- Fluorometer Splitter Box (permits up to 4 fluorometers to be connected to the 3D TRASAR Controller)
- Conductivity (5-10,000 µS) & Temperature
- Sample Flow Switch

Fluorometer Add-On Module*

- Fluorometer
- Sample Flow Switch

Note: Requires temperature input from another module.

Permeate Conductivity Add-On Module

- Conductivity (1-500 µS) & Temperature
- Sample Flow Switch

Fluorometer & Permeate Conductivity Add-On Module

- Fluorometer
- Conductivity (1-500 µS) & Temperature
- Sample Flow Switch

To Order

Systems & Add-On Modules

Part No.	Description
060-RO4000.88	Fluorometer/Conductivity System, Wall Mount (No pH, ORP, or Analog Input Module)
060-RO4001.88	Fluorometer/Conductivity System, Frame Mount (No pH, ORP or Analog Input Module)
060-RO6000.88	Fluorometer/Conductivity System, Wall Mount (No Analog Input Module)
060-RO6001.88	Fluorometer/Conductivity System, Frame Mount (No Analog Input Module)
060-RO6010.88	Fluorometer/Conductivity System, Wall Mount, Analog Input Module
060-RO6011.88	Fluorometer/Conductivity System, Frame Mount, Analog Input Module
060-RO1000.88	Fluorometer/Conductivity Add-On Module
060-RO1100.88	Fluorometer Add-On Module
060-RO1120.88	Fluorometer + Permeate Conductivity Add-On Module
060-RO1110.88	Permeate Conductivity Add-On Module

Accessories

Part No.	Description
060-ROFSB100.88	Fluorometer Splitter Box
060-ROAIM100.88	Analog Input Module
060-ROSRB100.88	4-20mA Signal Repeater (split/repeat up to 4 signals)
060-ROHP500.88	Pressure Transducer, 500 psi, 1/4" MNPT
060-ROLP145.88	Pressure Transducer, 150 psi, 1/4" MNPT
060-ROEXC005.88	Cable, Extension, 5 m, (for Pressure Transducer)
060-ROEXC010.88	Cable, Extension, 10 m, (for Pressure Transducer)
060-ROEXC030.88	Cable, Extension, 30 m, (for Pressure Transducer)

Spare & Replacement Parts

Part No.	Description
060-TR3220.88	Fluorometer
TBA	Cable, Fluorometer, 4 ft, with quick-connect
6041271	Conductivity Sensor,1.0K (5-10,000 µS), with quick-connect
6041272	Conductivity Sensor,0.1K (1-500 µS)), with quick-connect
6042175	Flow Switch, with quick-connect
060-TR5411.88	pH Replacement probe
060-TR5412.88	Cable, 6 ft, pH
060-TR5421.88	ORP Replacement probe
060-TR5422.88	Cable, 6 ft, ORP
060-TR5222.88 *	Desiccant canister (fluorometer)
060-TR5223.88 *	Desiccant indicator (fluorometer)
991-19432523.88 *	Fuse, 10 A, 250V SLO-BLO (main fuse)
991-05047661.88	Ethernet crossover cable, 6' (2m), orange

Calibration Solutions & Supplies

460-S0940.75 *	TRASAR Calibration solution, 1L bottle
460-S0800.75	10% Sulfuric Acid, 1:1, 1L bottle
500-P2817.88	Flow cell brush, 16"
500-P0116.88	Beaker, 800 ml, plastic (3 each required)
500-P2147.88 *	Syringe, 60cc, plastic (2 each required)
001-H07641.88 **	Conductivity standard solution, 10,000 S/cm, 500 mL
001-H07642.88 **	Conductivity standard solution, 5000 S/cm, 500 mL
460-S0297.75 **	Conductivity standard solution, 3000 S/cm, 1L
460-S0298.75 **	Conductivity standard solution, 600 S/cm, 1L
460-S0743.75 **	Conductivity standard solution, 200 S/cm, 1L
460-S0299.75 **	Conductivity standard solution, 40 S/cm, 1L
460-S0408.75 **	pH standard solution, pH 10 buffer, 1L
460-S0407.75 **	pH standard solution, pH 7 buffer, 1L

APPENDIX E – MEMBRANE CLEANING PROTOCOLS

'TORAY'
Innovation by Chemistry

Issued in June 2008

TORAY MEMBRANE MODULE
Instruction Manual

Model: Pressured Type PVDF Hollow Fiber Membrane Module "HFU Series"

issued by Toray Industries, Inc.

Water Treatment & Environment Division

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Content

I. Introduction

Toray PVDF Hollow Fiber Membrane Module “HFU series” is the pressured type hollow fiber UF (ultra filtration) membrane module developed with the polymer science and the membrane fabrication technologies accumulated for a long time in Toray Industries, Inc.

The membrane material is Poly-vinylidene Fluoride (PVDF). The nominal molecular weight cut off of the membrane is 150,000 daltons. Testing has confirmed that more than 90% of 150,000 daltons model polymers is consistently removed.

The module, with Polyvinylchloride (PVC) casing, is pressure-driven which products much purified water than siphon-driven. The maximum operating pressure is 300 kPa (43.5 PSI). The flow direction is outside-to-inside which is suitable for high turbidity water treatment because the air-scrubbing can be adopted to remove suspended solid effectively.

1. Characteristics of Toray "HFU series" Membrane Modules

(1) High Filtration Flux

HFU series provides high filtration flux and stable operation for the filtration of various raw water sources. The membrane is made with a special spinning method, which enables high permeability and high fouling resistance.

(2) Excellent Water Quality

HFU series provides very good water quality for the filtrate, extremely low turbidity since the membrane has 150,000 dalton nominal molecular weight cut off. HFU series is recommended to be applied to tertiary treatment of sewage water and RO pretreatment in seawater desalination.

(3) High Mechanical Strength

The membrane of HFU series has very high mechanical strength because it is made of PVDF with the special spinning method developed by Toray. HFU series provides high integrity and durability under recommended operating conditions.

(4) High Chemical Durability

The membrane material of HFU series is PVDF, which allows you to clean the membrane with high concentrations of chlorine and with high concentrations of acid resulting in better cleaning and longer sustainable membrane flux rates.

2. Applications of Toray "HFU series" Membrane Modules

- Tertiary Treatment of Sewage Water
- RO Pretreatment in Seawater Desalination
- Industrial Water Production
- Reuse of Industrial Waste Water

II. For Your Safety

- Please be sure to read and follow the instructions below before using HFU series. This manual should be retained for future reference.

- Follow the safety precautions as they are intended to protect operators and equipment from various risks such as physical harm and/or property damage. The following table shows a level of potential risk for each indicated symbol.

⚠ **DANGER**	This symbol indicates an imminent hazardous situation which will result in serious injury or death when the instruction is not observed.
⚠ **WARNING**	This symbol indicates a potentially hazardous situation which will result in serious injury or death when the instruction is not observed.
⚠ **CAUTION**	This symbol indicates a potentially hazardous situation which might result in injury or property damage when the instruction is not observed.

- The following table explains the information to be noted.

🛇 Prohibited	“Prohibited” This symbol indicates a prohibited action or procedure.
❗ Instruction	“Instruction” This symbol indicates an important action or procedure which has to be taken without fail.

1. Safety Instruction for Unpacking and Installation

⚠ DANGER

Instruction

Be sure to wear safety gear such as rubber gloves and safety glasses for unpacking. The membrane is packaged in sodium hypochlorite solution (100mg/l). If the solution happens to splash onto the skin, wash the affected part with running water. If the solution happens to get in the eyes or mouth, wash the affected part with sufficient amounts of clean running water for more than 15 minutes and see a doctor immediately.

⚠ WARNING

Instruction

Be sure to wear safety gear such as a helmet and safety shoes to avoid injury.

⚠ CAUTION

Prohibited

The preservative solution should be drained out before using the modules. After that, keep clean water in the modules to prevent the hollow fiber membrane from drying out. Do not allow the modules to dry out even for a few hours.

Prohibited

The membrane modules should not be frozen.

Prohibited

Be careful not to damage or dent the modules during handling.

Instruction

Victaulic clamps are applied for connecting the modules of HFU-2020 or HFU-1020 to the piping. Follow the instruction of the G-type Victaulic Joint Set-up Guide at the connection point. Wrong connections may damage the modules.

Instruction

IDF/ISO Clamp Union Fittings 1.5 are applied for connecting the modules of HFU-2008 or HFU-1010 to the piping. Do not over-tighten the clamp as damage to the module may occur.

Prohibited

Keep the connection surface free of any dirt or oils.

Instruction

Be sure to install the modules vertically for effective air scrubbing.

2. Safety Instruction for Filtration Operation

⚠ DANGER

Instruction

Flush all the piping out with clean water and make sure no debris is remaining in the piping prior to connecting the modules.

Instruction

Confirm that the preservative chemical in the modules is completely drained out before starting the filtration operation. The preservative chemical is harmful to humans.

Flush the modules at low pressure, filling from the bottom, and vent to remove any air from the modules. Air left in the modules may cause water hammer and may result in damage to the membrane. Prior to use, make certain modules are flushed and filtrate water meets the required quality.

WARNING

Instruction

Always monitor filtrate water quality such as turbidity and/or the number of particles during filtration, and stop the operation if abnormal water quality is detected.

Prohibited

Do not exceed the maximum applicable pressure of 300 kPa (43.5 PSI). Higher pressures can damage the modules. Do not exceed the maximum temperature of 40 degree C (104 degree F). The higher temperature damages the modules.

Prohibited

Do not freeze the membrane modules.

Instruction

The operating conditions, including the filtration flux and the periodical physical cleaning, must be properly set-up otherwise the trans-membrane pressure may rise too quickly. The operation range is described in the latter section of this manual.

Instruction

Do not overfeed air to the modules. Excessive scrubbing air damages the membranes and/or shortens the membrane life.

The air flow rate should be within the range below for each module type.

HFU-2020: 4.8 – 9.0 Nm^3/h (2.8 – 5.3 scfm)
HFU-2008: 0.7 – 1.2 Nm^3/h (0.4 – 0.7 scfm)
HFU-1020: 4.8 – 9.0 Nm^3/h (2.8 – 5.3 scfm)
HFU-1010: 1.2 – 2.2 Nm^3/h (0.7 – 1.3 scfm)

Instruction

Integrity tests, such as Pressure Decay Test (PDT) or Diffusive Air Flow (DAF) Test, must not exceed an air pressure of 100kPa (14.5 PSI). Keep the source air pressure lower than 200 kPa (29 PSI), to prevent module damage.

3. Safety Instruction for Chemical Cleaning

⚠ DANGER

Instruction

Take special precautions when handling chemicals during chemical cleaning. Wear the safety gear such as safety glasses and protective gloves. If chemicals come in direct contact with your skin or your clothes, treat appropriately based on the MSDS.

Prohibited

Do not mix sodium hypochlorite with acid. Such mixture generates toxic chlorine gas.

Instruction

Stop operation whenever any anomaly occurs with the equipment or any signs of an anomaly are observed.

⚠ CAUTION

Instruction

In the chemical cleaning, strictly follow the procedure described in the latter section of this manual. Otherwise you may damage the modules or negatively affect the membrane performance.

4. Safety Instruction for Disposal

⚠WARNING

! Instruction

When dispose modules, please apply a service of a qualified waste disposing company. When modules are to incinerate, please dispose by appropriate facilities which can neutralize hydrogen fluoride (HF) gas. HF gas is generaterd at membrane incineration.

III.

Specifications of Toray "HFU series" Membrane Modules

Table 1.　Specifications of membrane *1)

Membrane Material		PVDF (Polyvinylidene fluoride)
Nominal Molecular Weight Cut Off		150,000 *2)
Trans-Membrane Pressure	Maximum *3)	300 kPa (43.5 PSI)
	Normal Operation	Lower than 200 kPa (29.0 PSI)
Operating Temperature Range		0 – 40 degree C (32 – 104 degree F)
Operating pH Range		1 – 10

*1): Please note that the specifications are subject to changes from time to time.

*2): The nominal molecular weight cut off is determined with the model test of dextran.

*3): TMP should be below 300 kPa (43.5 PSI) at any time even when the feed pump is not stable.

Table 2.　Feed water limits *1)

Turbidity	Intermittent Peak *4)	100 NTU
	Continuous Maximum	30 NTU
TSS	Intermittent Peak *4)	100 mg/L
	Continuous Maximum	30 mg/L
Pretreatment Filter Mesh Size		smaller than 200 micron meter
Temperature Range		0 – 40 degree C (32 – 104 degree F)
pH Range		1 – 10
Maximum Feed Pressure		300 kPa (43.5 PSI)

*1): Please note that the specifications are subject to changes from time to time.

*4): The duration time should be less than 48 hours and the occurrence frequency should not exceed more than once a month.

Table 3. Cleaning limits *1)

Cleaning pH Range	0 – 12
Cleaning Temperature Range	0 – 40 degree C (32 – 104 degree F)
Maximum concentration of NaClO as Cl_2	3,000 mg/L
Maximum NaClO exposure (lifetime contact time) as Cl_2	1,000,000 mg/L hours
Maximum acid contact time	1,000 hours (pH≥0)

*1): Please note that the specifications are subject to changes from time to time.

Table 4. Specifications of modules *1)

Module Type		HFU-2020	HFU-1020	HFU-1010 (small module for pilot test)	HFU-2008 (small module for pilot test)
Membrane Surface Area (Outer Surface)		72 m^2 (775 ft^2)	29 m^2 (312 ft^2)	7.0 m^2 (75 ft^2)	11.5 m^2 (124 ft^2)
Dimensions	Diameter	216 mm (8.50 inches)	216 mm (8.50 inches)	114 mm (4.49 inches)	89 mm (3.50 inches)
	Length	2,160 mm (7.087 ft.)	1,120 mm (3.675 ft.)	1,078 mm (3.537 ft.)	2,000 mm (6.562 ft.)
Weight	Full of water	110 kg (243 lbs)	60 kg (132 lbs)	15 kg (33 lbs)	18 kg (40 lbs)
	Drained	67 kg (148 lbs)	40 kg (88 lbs)	9 kg (20 lbs)	11 kg (24 lbs)
Materials	Housing	Polyvinylchloride			
	Potting	Epoxy Resin			
Connections	Top	Victaulic joints 80A	Victaulic joints 80A	IDF/ISO Clamp Union Fittings 1.5s	IDF/ISO Clamp Union Fittings 1.5s
	Bottom	Victaulic joints 80A	Victaulic joints 80A	IDF/ISO Clamp Union Fittings 1.5s	IDF/ISO Clamp Union Fittings 1.5s
	Side	Victaulic joints 65A	Victaulic joints 65A	IDF/ISO Clamp Union Fittings 1.5s	IDF/ISO Clamp Union Fittings 1.5s
Operating Conditions	Max. Feed Water Flow	12 m^3/h (53 gpm)	4.8 m^3/h (21 gpm)	1.2 m^3/h (5.1 gpm)	2.0 m^3/h (8.4 gpm)
	Max. Backwash Flow	13.5m^3/h (59 gpm)	5.4 m^3/h (23 gpm)	1.3 m^3/h (5.7 gpm)	2.1 m^3/h (9.4 gpm)
	Max. Air Flow	9.0 Nm^3/h (5.3 scfm)	9.0 Nm^3/h (5.3 scfm)	2.2 Nm^3/h (1.3 scfm)	1.2 Nm^3/h (0.7 scfm)
	Filtration Method	Outside-to-inside, Dead End or Cross Flow			
	Max. Inlet Pressure	300 kPa (43.5 psi)			
	Maximum Temperature	40 degree C (104 degree F)			

*1): Please note that the specifications are subject to changes from time to time.

CAUTION

Handle and operate the modules within the ranges and the limits indicated in Table 1 to 4. Operation outside these ranges or limits may damage the modules, may affect filtration performance, and will void the warranty.

IV.

Configuration of Toray "HFU Series" Membrane Modules

(1): Filtrate Outlet / Inlet of Backwash Water

(2): Air Outlet / Backwash Water Outlet

(3): Feed Water Inlet / Air Inlet / Drain Outlet

Connections

	Pipe fitting outer diameter mm (in)	Connectors
(1)	89.1 (3 1/2”)	Victaulic joints 80A
(2)	76.3 (3”)	Victaulic joints 65A
(3)	89.1 (3 1/2”)	Victaulic joints 80A

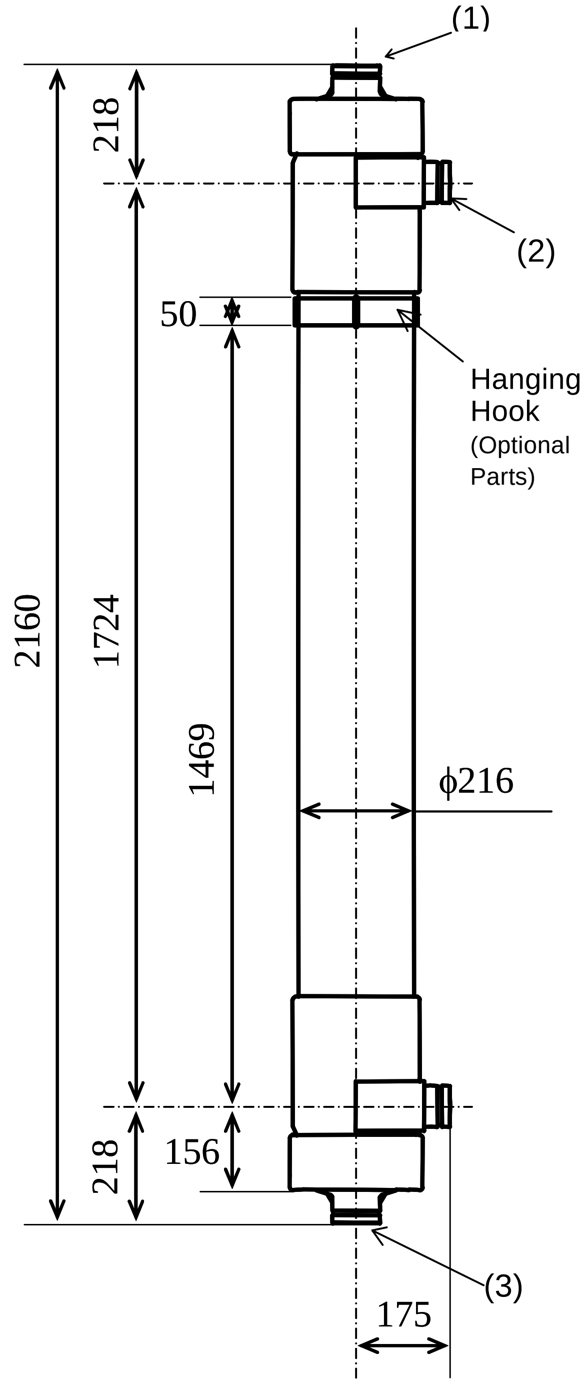


Fig. 1 Type: HFU-2020

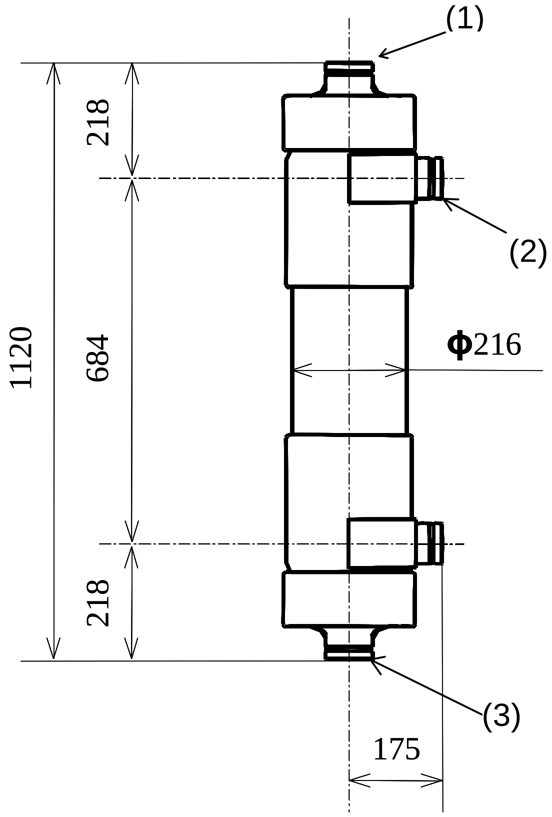


Fig. 2 Type: HFU-1020

(1): Filtrate Outlet / Inlet of Backwash Water

(2): Air Outlet / Backwash Water Outlet

(3): Feed Water Inlet / Air Inlet / Drain Outlet

Connections

	Pipe fitting outer diameter mm (in)	Connectors
(1)	50.5 (2”)	IDF/ISO Clamp Union Fittings 1.5s
(2)	50.5 (2”)	IDF/ISO Clamp Union Fittings 1.5s
(3)	50.5 (2”)	IDF/ISO Clamp Union Fittings 1.5s

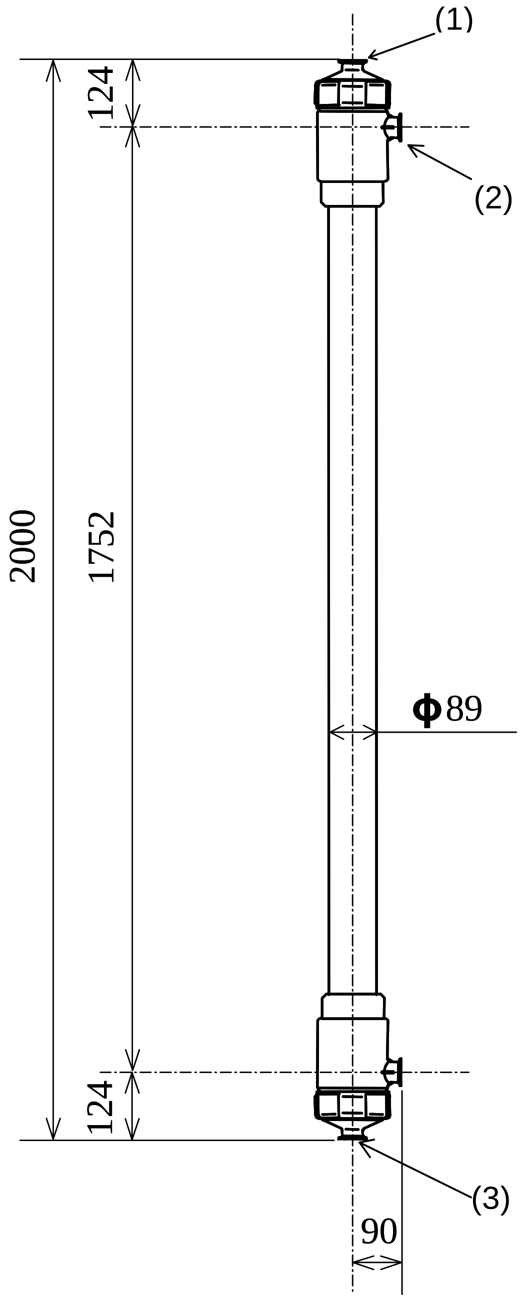


Fig. 3 Type: HFU-2008

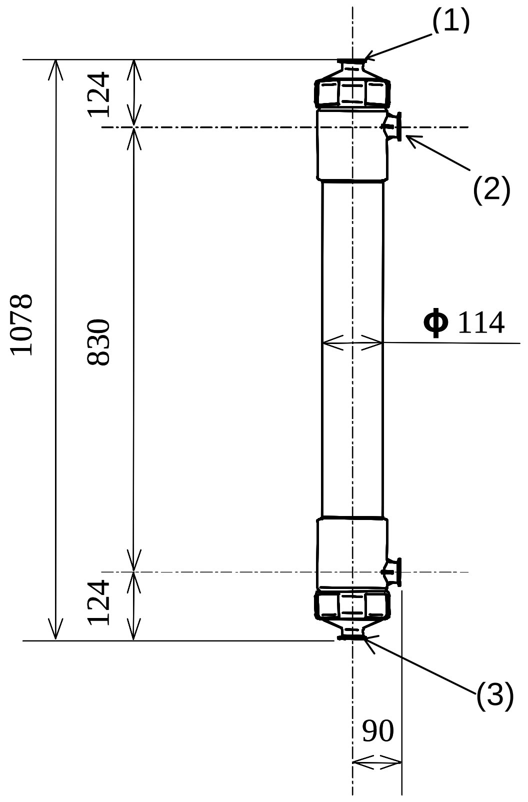


Fig. 4 Type: HFU-1010

Installation

The standard method to install the membrane modules is described below.

1. Unpack the membrane module from wooden box or corrugated box.
2. Remove plugging plate from each nozzle of the module.
3. Drain out the preservative solution from the module.

DANGER

- Wear rubber gloves and safety glasses when you drain the preservative chemical. Note that the preserving chemical is sodium hypochlorite solution (100 mg/l of chlorine). If this solution splashes onto your skin, wash the affected part with running water. If the solution gets in your eyes or mouth, wash the affected part with enough amounts of running water for over 15 minutes and see a doctor immediately.

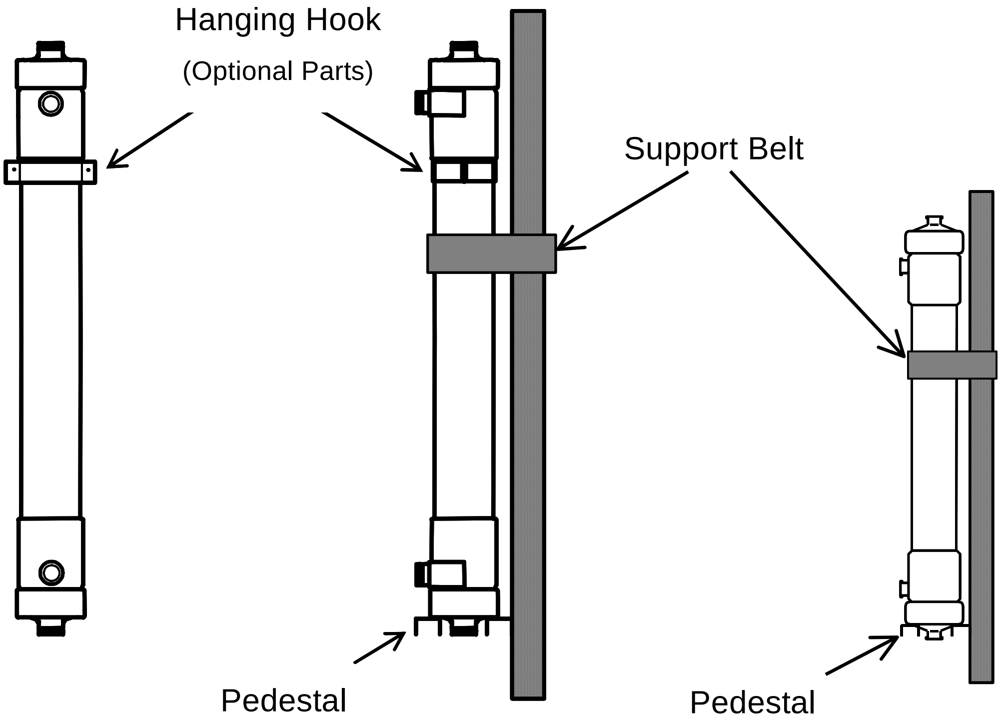
4. Put the module vertically on the pedestal in the module rack. Fix the module upright with the hanging hook and/or the supporting belt. (see Fig. 5)

WARNING

- Don't drop the module.
- Use equipment such as chain blocks, a crane, or a forklift truck when you handle the module. The HFU-2020 module is too heavy to handle by hand.

CAUTION

- Be careful not to install the module upside down. Confirm the module is installed in the right direction.
- Don't over-tighten the module with the hanging hook and/or the supporting belt, or you may damage the module.
- Don't allow the hollow fiber membrane to dry out even for a few hours, especially in summer.
- Don't freeze the module.



(1) HFU-2020, HFU-1020

(2) HFU-2008, HFU-1010

Fig. 5 Installation of the membrane module

5. Connect the piping to each connection point of the module with Victaulic clamps (HFU-2020, HFU-1020) or ferrule joints (HFU-2008, HFU-1010). (see Fig. 6)

⚠ **CAUTION**	- Keep the connection surface free of any dirt or oils. - Follow the instruction of the G-type Victaulic Joint Set-up Guide when using Victaulic Joint. A wrong use may cause the damage to the module. - Do not overtighten the clamp when using ferrule joint (IDF/ISO Clamp Union Fittings 1.5s), or you may damage the module.

6. Make sure that the module is installed vertically.

⚠ **CAUTION**	- If the module is not installed vertically, the effect of the air scrubbing would be reduced and effective filtration will be impaired.

VI. Operation

1. Filtration

(1) Check that all piping is connected appropriately and flushed out prior to the operation. Fig. 6 shows a typical example of piping.

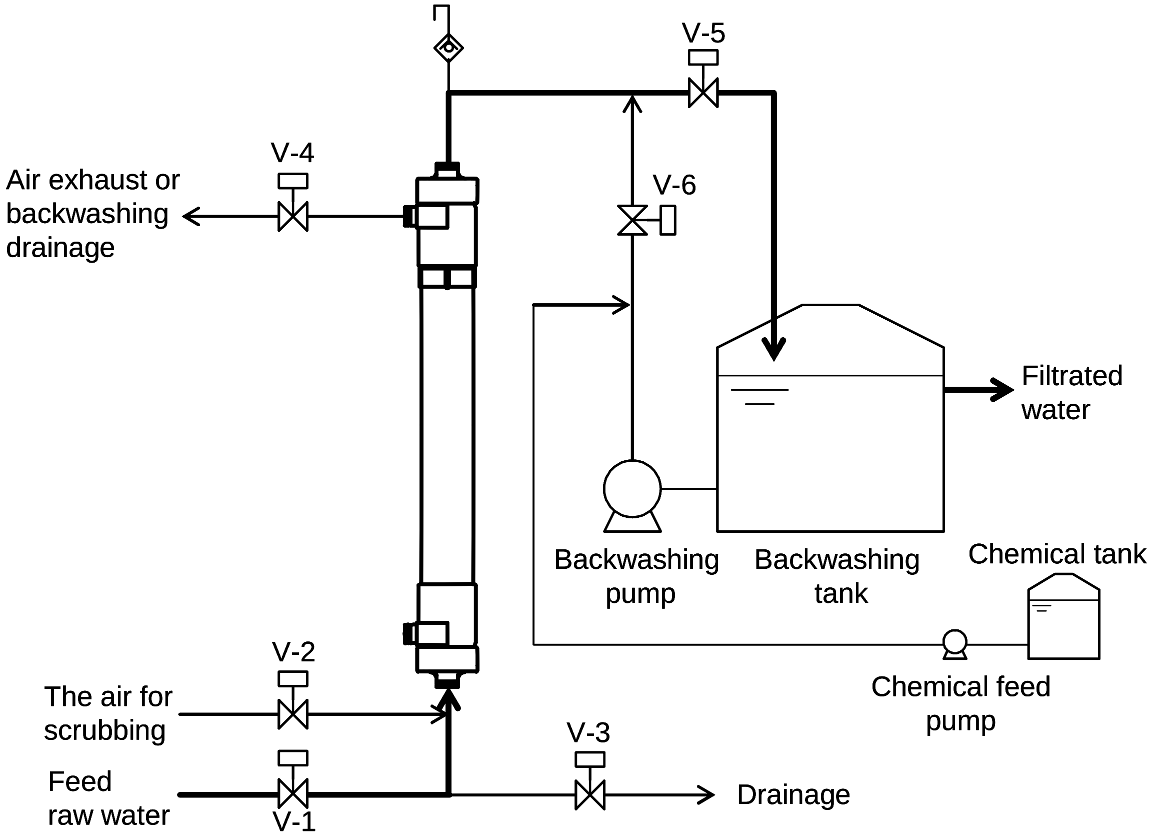


Fig. 6 Typical example of piping

(2) Make sure the feed water valve (V-1), the drainage valve (V-3), and the valve for the scrubbing air (V-2) are "closed".

(3) Make sure the filtrate water line is open. Open the air exhaust valve (V-4).

(4) Gradually open the feed water valve (V-1) and charge the feed water to the module to purge any air out.

⚠ **CAUTION**	- Don't open the feed water valve (V-1) quickly, or water-hammer may occur and the module could be damaged.

(5) Confirm that the air is out of the module, and then close the air exhaust valve (V-4).

(6) Set appropriate volume of filtrate water flow.

⚠ **CAUTION**	- Don't exceed 300 kPa (43.5 PSI) to avoid damage to the module. - Operating conditions including the filtration flux and the physical cleaning should be properly set up, observing the rise of trans-membrane pressure. (Details are described in the next session.) Please contact us if you need technical support.

(7) When stopping operation, gradually close the feed water valve (V-1).

2. Backwash and Air-scrubbing

The physical cleaning with backwash followed by air-scrubbing should be carried out periodically and automatically for the continuous filtration. The frequency of the physical cleaning mainly depends on the raw water quality. (Typical frequency is once every 30 minutes normally for surface water filtration. Please contact us if you need technical support.) Fig. 7 shows a typical example of the flow diagram for backwash and air-scrubbing. Don't carry out the backwash and the air-scrubbing simultaneously since it may damage the membrane.

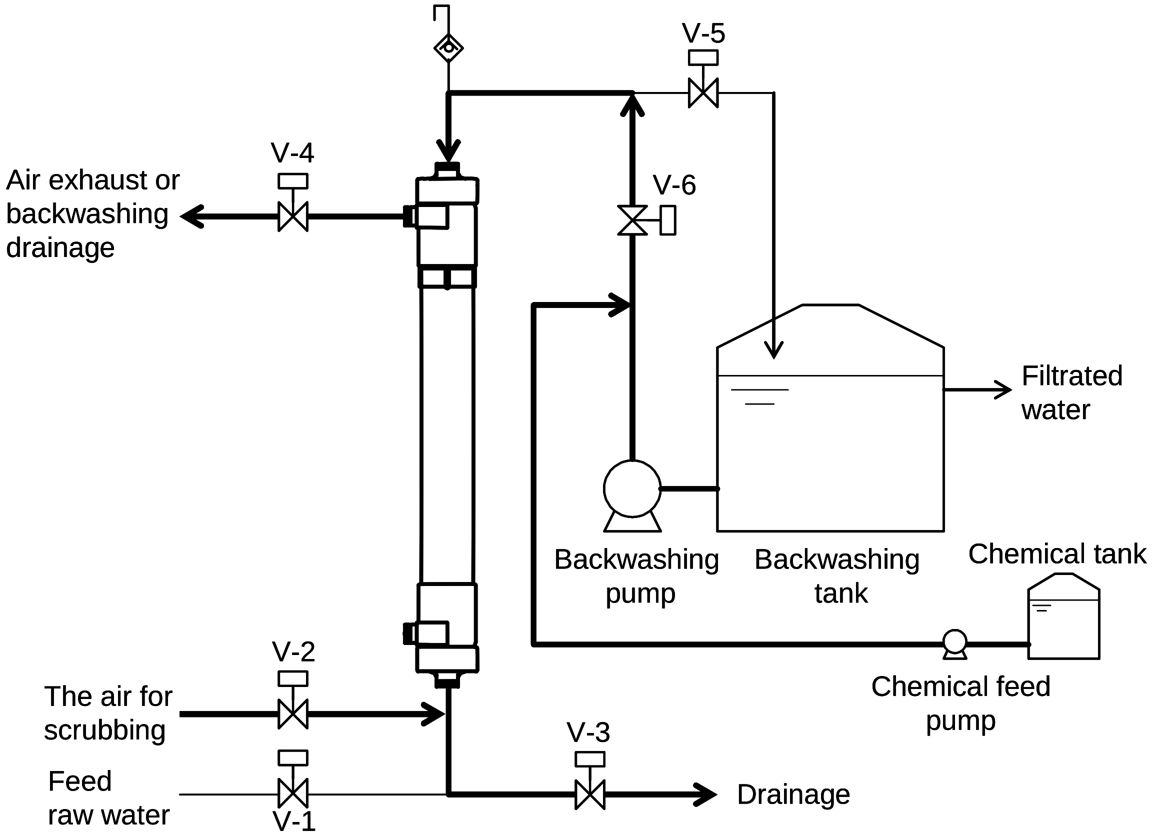


Fig. 7 Flow diagram for backwash and air-scrubbing

(1) Close the feed water valve (V-1) and stop the feed water pump.

(2) Open the air exhaust valve (V-4).

(3) Close the filtrate water valve (V-5) and open the backwashing valve (V-6) to feed back the filtrate water from the backwashing tank to the membrane module. During backwash, chemical feed pump can be operated to dose chemical to the backwash water. The dosing chemical is usually sodium

hypochlorite and the dosing ratio should be up to 50 mg/L as Cl_2.

The flow rate of backwash water is set up in advance for 1.0 to 1.5 times filtrate water flow rate (don't exceed Max. Backwash Flow described in Table 4).

(4) After backwashing for a fixed time (normally 30 seconds, up to 60 seconds), close the backwashing valve (V-6) and stop the backwashing pump.

(5) Open the air exhaust valve (V-4) and the air-scrubbing valve (V-2) for air-scrubbing for a fixed time (normally 30 seconds, up to 60 seconds).

⚠ **CAUTION**	- The air flow rate for air-scrubbing should be within the range below. Excessive air flow rate may damage the hollow fiber membrane. HFU-2020: 4.8 – 9.0 Nm^3/h, normally 6.0 Nm^3/h (2.8 – 5.3 scfm, normally 3.5 scfm) HFU-2008: 0.7 – 1.2 Nm^3/h, normally 0.8 Nm^3/h (0.4 – 0.7 scfm, normally 0.5 scfm) HFU-1020: 4.8 – 9.0 Nm^3/h, normally 6.0 Nm^3/h (2.8 – 5.3 scfm, normally 3.5 scfm) HFU-1010: 1.2 – 2.2 Nm^3/h, normally 1.5 Nm^3/h (0.7 – 1.3 scfm, normally 0.9 scfm)

(6) Close the air-scrubbing valve (V-2) and open the drainage valve (V-3).
(7) Close the drainage valve (V-3) after the water is all drained out.
(8) Run the feed water pump and open the feed water valve (V-1).
(9) Close the air exhaust valve (V-4) after the air is purged from the module.

⚠ **CAUTION**	- Always monitor filtrate water quality during filtration, and stop the operation if abnormal water quality is detected. If abnormal water quality is detected, check the integrity of the module with PDT (Pressure Decay Test) or DAF (Diffusive Air Flow Test). The recommended test procedure is provided as the technical information by Toray.

3. Toray Maintenance Cleaning

Instead of chemical dosing for every backwash, soaking the membrane to chemical solution several tens of minutes a day is also effective for membrane performance retention. This process is called Toray Maintenance Cleaning (TMC). The TMC is usually held following the backwash and air-scrubbing which does not contain the chemical dosing. The frequency and soaking time of the TMC mainly depends on the raw water quality. (Normally once a day and each soaking time are 20 minutes. Please contact us if you need technical support.) Fig. 8 shows a typical example of flow diagram for the TMC.

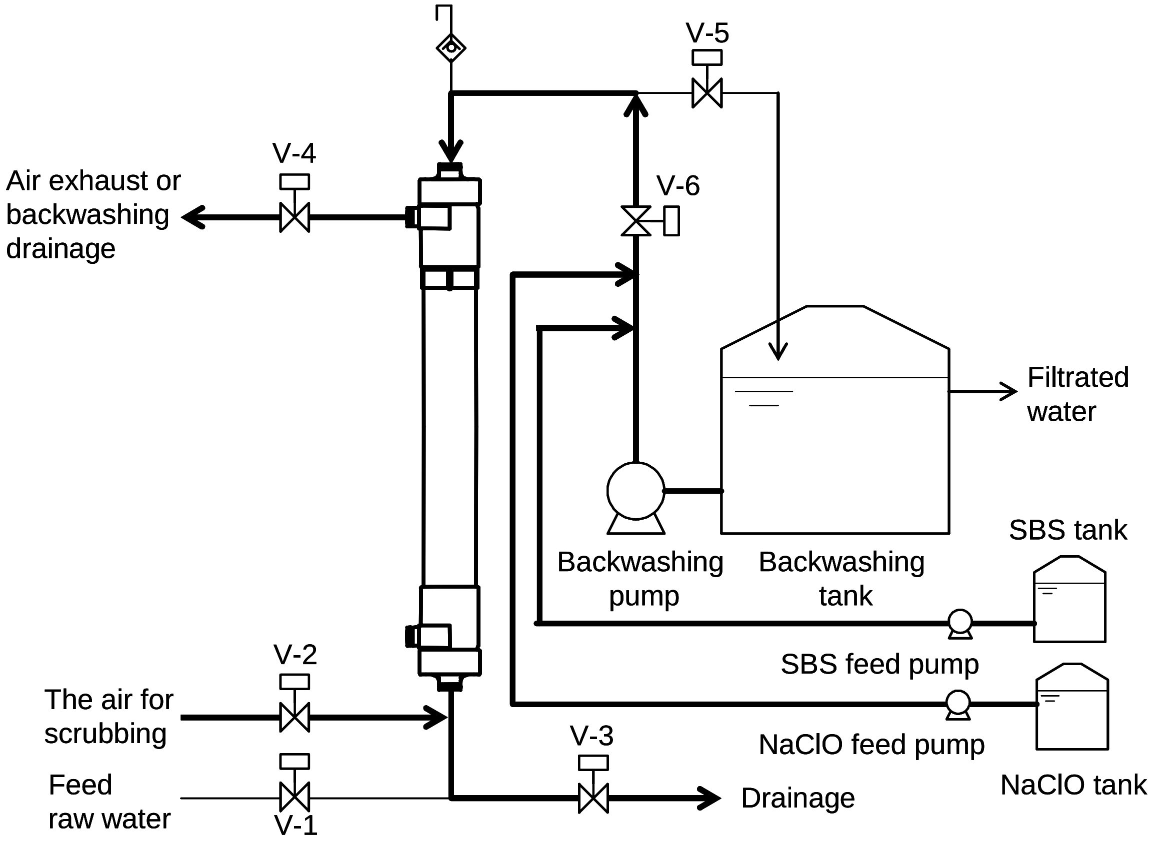


Fig. 8　Flow diagram for the TMC

(1) Open the air exhaust valve (V-4) and the drainage valve (V-3).

(2) Open the backwashing valve (V-6), run the NaClO feed pump and the backwashing pump to feed the chemical enhanced backwash water to the membrane module.

The flow rate of backwash water is set up in advance for 1.0 to 1.5 times filtrate water flow rate (don't exceed Max. Backwash Flow described in Table 4).

(3) As soon as the NaClO is detected in the drainage water, close the drainage valve (V-3).

(4) After making sure water comes out from upper part of the side nozzle of the membrane module, stop the NaClO feed pump, close the backwashing valve (V-6) and stop the backwashing pump.

(5) Soak the membrane in the chemical for a fixed time (normally 20minutes). During the soak, open the air-scrubbing valve (V-2) a few times (normally every 5 minutes and each scrubbing time are 30 seconds).

(6) Open the backwashing valve (V-6), run the sodium bi-sulfite (SBS) feed pump and the backwashing pump to deactivate the chlorine residue for a fixed time (normally 30 seconds).

(7) Stop the SBS feed pump and the backwashing pump and close the backwashing valve (V-6), and then open the air-scrubbing valve for a fixed time (normally 30 seconds).

CAUTION

- The air flow rate for air-scrubbing should be within the range below. Excessive air flow rate may damage the hollow fiber membrane.

  HFU-2020: 4.8 – 9.0 Nm^3/h, normally 6.0 Nm^3/h
  (2.8 – 5.3 scfm, normally 3.5 scfm)

  HFU-2008: 0.7 – 1.2 Nm^3/h, normally 0.8 Nm^3/h
  (0.4 – 0.7 scfm, normally 0.5 scfm)

  HFU-1020: 4.8 – 9.0 Nm^3/h, normally 6.0 Nm^3/h
  (2.8 – 5.3 scfm, normally 3.5 scfm)

  HFU-1010: 1.2 – 2.2 Nm^3/h, normally 1.5 Nm^3/h
  (0.7 – 1.3 scfm, normally 0.9 scfm)

(8) Close the air-scrubbing valve (V-2), open the drainage valve (V-3) to drain the chemical from the membrane module.

(9) Close the drainage valve (V-3), and then open the backwashing valve (V-6) and run the backwashing pump (normally 30 seconds). Stop the backwashing pump and close the backwashing valve (V-6), and then open the air-scrubbing valve (V-2) (normally 30 seconds). Repeat this procedure until the overflow water meets the required water quality.

(10) Make sure the air-scrubbing valve (V-2) and the backwashing valve (V-6) are "closed" and the backwashing pump is "stopped".

⚠ **CAUTION**	- Always monitor filtrate water quality during filtration, and stop the operation if abnormal water quality is detected. If abnormal water quality is detected, check the integrity of the element with PDT (Pressure Decay Test) or DAF (Diffusive Air Flow) Test. The test procedure is provided as the technical information by Toray.

4. Temperature Correction Factor

The permeability of the membrane is influenced by temperature mainly because the water viscosity changes with temperature. When you evaluate the permeability correctly, you need to eliminate the temperature effect with the temperature correction factor (TCF) shown in Fig. 9.

A Trans-Membrane Pressure (TMP) measured at some real temperature can be converted to 25 degree C corrected TMP with multiplying by TCF at real temperature shown in Fig. 9.

A filtrate flow rate measured at some real temperature can be converted to 25 degree C corrected filtrate flow rate with divided by TCF at real temperature shown in Fig. 9.

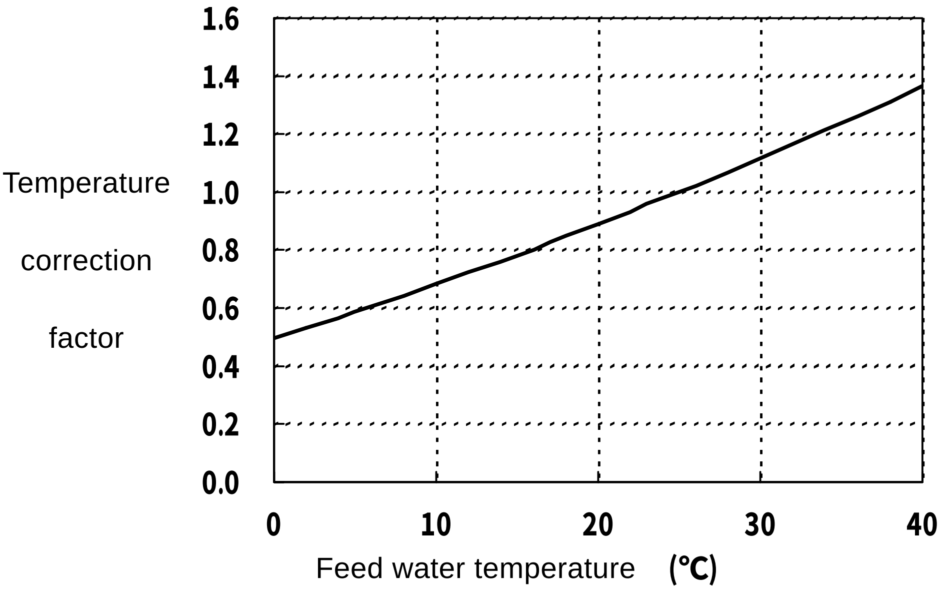


Fig. 9 Temperature correction factor (TCF) for HFU series

The equation for calculating TCF at a temperature (T degree C) is as follows.

$$\mathrm{TCF}$$

$$= 0.0008902 / (0.01257187 \times \mathrm{EXP}((1 - 0.005806436 \times (273.15 + T)) / (0.001130911 \times (273.15 + T) - 0.000005723952 \times (273.15 + T) \times (273.15 + T))) / 1000)$$

VII. Chemical Cleaning

The chemical cleaning should be carried out to remove foulants accumulated in the membrane pores or sticking to the membrane surface.

⚠ CAUTION	- Carry out the chemical cleaning before the trans-membrane pressure rises up to 200 kPa (29.0 PSI), or the module filtration performance could be reduced significantly. - Follow the instruction described in this manual when you carry out the chemical cleaning. If you use the unacceptable chemicals or perform the cleaning altered from the recommended procedure, the membrane could be seriously damaged.

⚠ DANGER	- Pay full attention when handling chemicals and be sure to wear the safety gear such as glasses and gloves. The chemicals used for the chemical cleaning are harmful to people. If chemicals directly contact your skin, your eyes or other body parts, take the appropriate treatment as stated in its MSDS. - Do not mix sodium hypochlorite with acid. Such mixture generates toxic chlorine gas. - Stop operations when any instrumental anomalies occur or any sign of anomalies are observed.

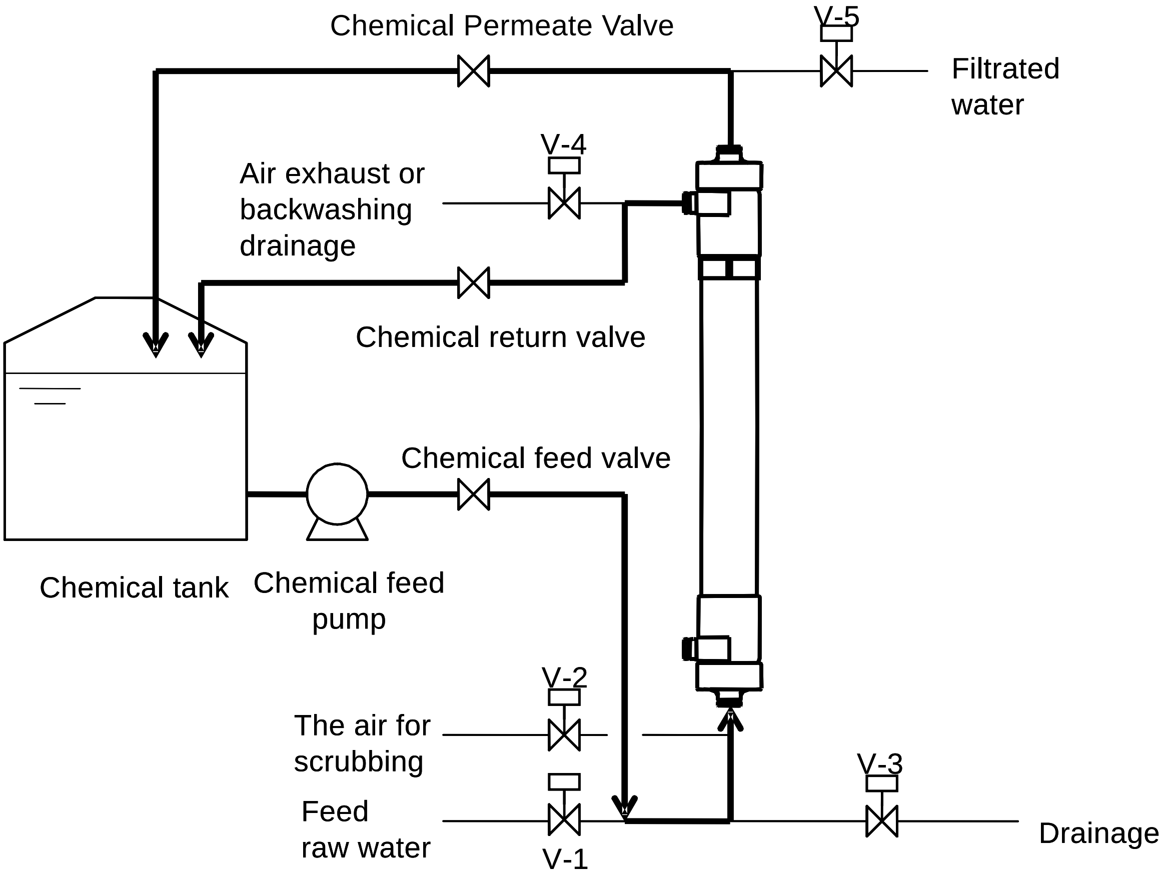


Fig. 10 Flow diagram for chemical cleaning

(1) The flow diagram for cleaning simultaneously both outer surface and inside of hollow fiber membranes is shown in Fig. 10. The flow diagram can be changed case by case. Please contact us if you need the information in detail.

(2) Open the chemical return valve and then open the chemical feed valve.

(3) Run the chemical feed pump to start the circulation of chemical and then open the chemical permeate valve to have the chemical permeate through the membrane.

(4) Circulate the chemical for a fixed time.

(5) Stop the chemical feed pump.

(6) Drain the chemical and rinse the cleaning line and the module thoroughly with product water.

⚠ CAUTION	- Take appropriate measures to prevent the mis-operation or accidents that could cause the chemicals to get into the product water. Check the piping and correctly position of each valve before starting the chemical cleaning.

(7) The standard conditions for chemical cleaning are shown in Table 5.

- The concentration and the circulation time shown in Table 5 should be observed. Otherwise the membrane module may get damaged and/or the life of membrane may be shortened.
- To get enough cleaning effect, the cleaning temperature should be higher than 20 degree C.
- The circulation flow rate for each type of the module is as follows.

HFU-2020:	50 L/min (13 gpm)
HFU-2008:	8 L/min (2.1 gpm)
HFU-1020:	20 L/min (5.3 gpm)
HFU-1010:	5 L/min (1.3 gpm)

Table 5. Standard conditions for chemical cleaning

Pollutants	Chemicals	Maximum Concentration	Circulation Time (hr)
Inorganic substances	Citric acid *1	3.0 wt%	1 - 3
Organic substances	Sodium hypochlorite	3,000 mg/l as chlorine	1 - 3

*1: Besides citric acid, hydrochloric acid (with the maximum concentration of 1.0 mol/l), oxalic acid (with 1.0 wt%), sulfuric acid (with 0.05 mol/l) and nitric acid (with 0.1 mol/l) are acceptable.

⚠ CAUTION	- In the case of cleaning with acid and with sodium hypochlorite alternately, rinse the cleaning line and the module with clean water thoroughly after each cleaning. Use product water for rinsing and make sure that pH of the water in the module is in the range between pH 6.5 and 7.5 after rinsing.

⚠ DANGER	- Do not use any other chemicals than those indicated above. - Do not mix sodium hypochlorite with acid. Such mixture generates toxic chlorine gas.

VIII. Storage of Membrane Module

Follow the instruction below when you store the modules.

⚠ **CAUTION**

- Be careful not to freeze the modules.

1. Storage of New Membrane Modules

Keep the modules in the original packing in a dark and cool place.
Avoid direct sunlight and moisture.

2. Storage of Membrane Modules after use

(1) Short term, or temporary, shutdown or storage

In the case of the suspension of operation for less than four days, stop the feed water and keep modules full of water.
If the suspension lasts for four days to less than eight days, fill the module with the chemical described in Table 6. Use filtrate quality water.

Table 6. Conditions for storing membrane modules for less than eight days

Maximum Storage period	Chemical	Concentration of the chemical
7 days	sodium hypochlorite	20 mg/l as chlorine

(2) Long term storage

First carry out a chemical cleaning with sodium hypochlorite. Fill the module with the chemical described in Table 7. Use filtrate quality water. Follow the instructions shown in the table 7.

Keep the modules sealed with the aqueous chemical solution shown in Table 6 or Table 7. If removing modules from the system, seal them and store out of direct sunlight.

Table 7. Conditions for storing membrane modules for more than seven days

Storage period	Preservative Chemical	Concentration of the chemical
more than 7 days	sodium bisulfite	1,000 mg/l

DANGER

- Rinse the module thoroughly with clean water after the chemical cleaning with sodium hypochlorite, and fill the module with sodium bisulfite solution. Toxic chlorine gas is generated in the case of mixing sodium hypochlorite with sodium bisulfite without first flushing with water.

3. Replace Preservative Chemical

Check the pH value of sodium bisulfite solution as the preservative and replace the chemical if the pH is below three (3.0). Sodium bisulfite solution with a pH of 3 - 6 is active for the preservation. Sodium bisulfite reacts with oxygen and forms sulfuric acid which results in a lower pH.

'TORAY'

Toray Membrane USA, Inc.
Cleaning Procedures for Composite Polyamide RO Membrane Elements

This bulletin provides general information about the most typical foulants which may affect the performance of Composite Polyamide Reverse Osmosis (RO) membrane elements, and procedures for the removal of these foulants. The information in this bulletin applies to both 4-inch and 8-inch diameter RO membrane elements.

The surface of the RO membrane is subject to fouling by foreign materials which may be present in the feed water. Examples are:

- Calcium carbonate scale
- Sulfate scale of calcium, barium or strontium
- hydrates of metal oxides (iron, manganese, copper, nickel, aluminum, etc.)
- Polymerized silica scale
- Inorganic colloidal deposits
- Mixed inorganic/organic colloidal deposits
- NOM organic material (Natural Organic Matter)
- Man-made organic compounds (e.g. antiscalant/dispersants, cationic polyelectrolytes)
- Biological (bacterial bioslime, algae, mold, or fungi)

The term fouling used here includes the build up/ deposition of all kinds of layers on the surface of the membrane, including scale formation.

Note: The Composite Polyamide type of RO membrane elements may not be exposed to chlorinated water under any circumstances. Any such exposure may cause irreparable damage to the membrane. Absolute care must be taken following any disinfection of piping or equipment or the preparation of cleaning or storage solutions to ensure that no trace of chlorine is present in the feedwater to the RO membrane elements. If there is any doubt about the presence of chlorine, perform chemical testing. Neutralize any chlorine residual with a sodium bisulfite solution, and ensure adequate mixing and contact time to accomplish complete dechlorination. Dosing rate is 1.8 to 3.0 ppm sodium bisulfite per 1.0 ppm of free chlorine.

Note: It is recommended that all RO membrane cleaning operations should be closely coordinated with Toray Membrane USA during the RO membrane element warranty period. TMUS field service personnel are available to be on site for cleaning assistance, should the need arise. Please contact TMUS for current charges for this service.

Note: The use of cationic surfactant should be avoided in cleaning solutions, since irreversible fouling of the membrane elements may occur.

The nature and rapidity of fouling depends on a number of factors, including:

- quality of the feedwater
- system recovery rate
- element flux

Type of Foulant/ Problem	**Probable** Location	**Pressure** Drop	**Feed** Pressure	**Salt** Passage
Metal Oxide Fouling (e.g. Fe,Mn,Cu,Ni,Zn)	1st stage lead elements	Rapid increase	Rapid increase	Rapid Increase
Colloidal Fouling (organic and/or inorganic complexes)	1st stage/ lead elements	Gradual increase	Gradual increase	Slight increase
Mineral Scaling (e.g. Ca, Mg, Ba, Sr)	Last stage/ tail elements	Moderate increase	Slight increase	Marked increase
Polymerized Silica	Last stage/ tail elements	Normal to increased	Increased	Normal to increased
Biological Fouling	Any stage, usually lead	Marked increase	Marked increase	Normal to increased
Organic Fouling (dissolved NOM)	All stages	Gradual Increase	Increased	Decreased
Antiscalant Fouling	2nd stage most severe	Normal to increased	Increased	Normal to increased
Oxidant damage (e.g Cl2, Ozone,KmnO4)	1st stage most severe	Normal to decreased	Decreased	Increased
Hydrolysis damage (out of range pH)	All stages	Normal to decreased	Decreased	Increased
Abrasion damage (carbon fines, etc)	1st stage most severe	Normal to decreased	Decreased	Increased
O-ring leaks (at interconnectors or adapters)	Random (typically at feed adapter)	Normal to decreased	Normal to decreased	Increased
Glue line leaks (due to perm pressure > feed pressure in service or standby)	1st stage most severe	Normal to decreased	Normal to decreased	Increassed
Glue line leaks (due to closed permeate valve while cleaning or flushing)	Tail element of a stage	Increased (based on prior fouling and high delta P	Increased (based on prior fouling and high delta P	Increased

Note: Pressure Drop is defined as the Feed pressure minus the Concentrate pressure

Table 1 Types of foulant, and their usual symptoms

Foulant types and effective cleaners

Calcium Carbonate Scale: Calcium carbonate is a mineral scale that may be deposited from almost any feedwater if there is a failure in the antiscalant/dispersant addition system or in the acid injection pH control system. An early detection of calcium carbonate scaling is essential to prevent damage caused by the crystals on the active membrane layers. Calcium carbonate scale detected early can be removed by lowering the feedwater pH to between 3.0 and 5.0 for one or two hours. Longer resident accumulations of calcium carbonate scale can be removed by a low pH cleaning with a citric acid solution.

Calcium, Barium & Strontium Sulfate Scale: Sulfate scale is a much "harder" mineral scale than calcium carbonate and is therefore more difficult to remove. Sulfate scale may be deposited if there is a failure in the antiscalant/dispersant feed system or if there is an over feed of sulfuric acid in pH adjustment. Early detection of the resulting sulfate scaling is essential to prevent damage caused by the crystals on the active membrane layers. Barium and strontium sulfate scales are particularly difficult to remove as they are insoluble in almost all cleaning solutions. Special care should be taken to prevent their formation.

Calcium Phosphate Scale: This scale is particularly common in municipal wastewaters and water supplies which may contain high levels of phosphate. This scale can generally be removed with acidic pH cleaners.

Metal Oxide/Hydroxide Foulants: Typical metal oxide and metal hydroxide foulants are iron, zinc, manganese, copper, aluminum, etc. They can be the result of corrosion products from unlined pipes and tanks; from oxidation of the soluble metal ion with air, chlorine, ozone, potassium permanganate; or from a pretreatment filter system upset that utilizes iron or aluminum based coagulant aids. Can generally be removed with low pH cleaners

Polymerized Silica Coating: A silica gel coating resulting from the super-saturation and polymerization of soluble silica can be very difficult to remove. It should be noted that this type of silica fouling is different from silica-based colloidal foulants, which may be associated with either metal hydroxides or organic matter. Polymerized silica scale can be very difficult to remove by traditional chemical cleaning methods.

Colloidal Foulants: Colloids are inorganic or mixed inorganic/organic based particles that are suspended in water and will not settle out due to gravity. Colloidal matter typically contains one or more of the following major components: iron, aluminum, silica, sulfur, or organic matter. High pH cleaners are generally more effective against this type of foulant

Dissolved NOM/ Organic Foulants: The sources of dissolved NOM (Natural Organic Matter) foulants are typically derived from the decomposition of vegetative material into surface waters or shallow wells. The chemistry of organic foulants is very complex, with the major organic components being either humic acid or fulvic acid. Dissolved NOMs can quickly foul RO membranes by being absorbed onto the membrane surface. Once absorption has occurred, then a slower fouling process of gel or cake formation begins. It should be noted that the mechanism of fouling with dissolved NOM should not be confused with the mechanism of fouling created by NOM organic material that is bound with colloidal particles. High pH cleaners are generally more effective against this type of foulant. Please note that wastewaters may contain a range of naturally occurring and man-made organic compounds. Should any of these compounds chemically bond to the membrane, cleaning regimes may be ineffective in removing the foulant.

Microbiological Deposits: Organic-based deposits resulting from bacterial slimes, fungi, molds, etc. can be difficult to remove, particularly if the feed path is plugged. Plugging of the feed path makes it difficult to introduce and distribute the cleaning solutions. To inhibit additional growth, it is important to clean and sanitize not only the RO system, but also the pretreatment, piping, dead-legs, etc. High pH cleaners in association with biocide treatments are most effective against this type of problem.

Selection and Use of Cleaning Chemicals

There are a number of factors involved in the selection of a suitable cleaning chemical (or chemicals) and proper cleaning protocol. At the time of the first cleaning, it is recommended to contact:

- Manufacturer of the equipment,
- RO element manufacturer,
- RO specialty chemical and service supplier.

Proper identification of the foulant is essential to prescibe the correct cleaners to most effectively remove the foulant.

Once the suspected foulant(s) are identified, one or more cleaning chemicals will be recommended.
These cleaning chemical(s) can be:

- Generic (typically technical grade, available from local chemical supply companies)
- Private-labeled proprietary chemicals.

Independent RO service companies are available who can determine the proper chemicals and cleaning protocol for your situation by testing a fouled element at their facility. For difficult situations, this is a recommended option.

It is not unusual to use a number of different cleaning chemicals in a specific sequence to achieve the optimum cleaning. As foulants may be laid down in discrete “layers”, the sequence of cleaning can be important.

Typically, a low pH cleaning is first used to remove foulants (such as mineral scale), followed by a high pH cleaning to remove organic material. This is not always the case - there are instances where a high pH cleaning may used first to remove foulants like oil or biological matter, followed by a low pH cleaning. The optimum sequence can usually only be determined by conducting tests.

Some cleaning solutions are “combination” agents, and may have detergents added to aid in the removal of heavy biological and organic debris, while others have a chelating agent like EDTA added to aid in the removal of colloidal, organic and biological material, as well as sulfate scale. Advice on the best use of such cleaners is best obtained directly from the manufacturer of the speciality cleaners.

TMUS has no objection to the use of speciality cleaners, providing it has been adequately demonstrated that the cleaner will not damage the Toray membrane.

General Precautions in Cleaning Chemical Selection and Usage

- If using a proprietary chemical, be sure the chemical has been qualified for use with the membrane by the chemical supplier. The chemical supplier’s instructions should not be in conflict with TMUS’s recommended cleaning parameters and limits.
- Use the mildest cleaning regimen. This includes the cleaning parameters of pH, temperature, and contact time. This will optimize the useful life of the membrane.
- Clean at the recommended target temperatures to optimize cleaning efficiency and membrane life.
- Use the minimal amount of chemical contact time to optimize membrane life.

- Be prudent in the adjustment of pH at the low and high pH range to extend the useful life of the membrane. A “gentle” pH range is 4 to 10, while the harshest is 2 to 12.
- Typically, the most effective cleaning sequence is low pH followed by high pH solutions. One known exception is oil-fouled membranes should not use a low pH clean first as the oil will coagulate.
- Cleaning and flushing flows should be in the same direction as the normal feed flow to avoid potential telescoping and element damage.
- When cleaning a multi-stage RO, the most effective cleaning plan is to clean one bank/stage at a time so cleaning flow velocities can be optimized and foulants from upstream stages will not pass through to downstream stages.
- Flushing detergents with higher pH permeate can reduce any foaming problems.
- Verify that proper disposal requirements for the cleaning solution are followed.
- If the system has been fouled biologically, consider the extra step of introducing a sanitizing biocide chemical after a successful cleaning. Biocides can be introduced
    - immediately after cleaning,
    - periodically (e.g. once a week),
    - continuously during service.
- Ensure that the biocide is compatible with the membrane, does not create any health risks, is effective in controlling biological activity, and is not cost prohibitive before going this route.
- Safety Considerations
    - Be sure all hoses and piping can handle the temperatures, pressures and pH which will be encountered during a cleaning.
    - Always add chemicals slowly to an agitated batch of make-up water.
    - Always wear safety glasses and appropriate protective gear when working with chemicals.
    - Don’t mix concentrated acids with caustic solutions.
    - Thoroughly rinse the 1st cleaning solution from the RO system before introducing the next solution.

pH and Temperature Limits for Cleaning Toray

Membrane Type	**45 C (113 F)**	**35 C (95 F)**	**30 C (86 F)**
Brackish (“7 “and “L”)	2-10	2-11.5	2-12
Low Pressure Brackish (“G” And “H”)	2-10	2-11.5	2-12
Seawater	2-10	2-11	2-12

Note: The above cleaning parameters denote the maximum temperature limits for a corresponding range of pH. Cleaning operations performed at the extremes may result in a more effective cleaning, but can shorten the useful life of the membrane due to hydrolysis.effects. To optimize the useful life of a membrane, it is recommended to use the least harsh cleaning solutions necessary and to minimize the contact time whenever possible.

Cleaning and Flushing Flow Rates per RO Pressure Tube
(differential Pressures are not to exceed 60 psi (4 bar) across any tube.)

Element Diameter	**GPM**	**LPM**
4-inches	6 to 10	23 to 38
8-inches	24 to 40	91 to 151

Elements should be cleaned at the highest flow rate possible without exceeding 60 psi differential pressure limit. Exceeding the limit can result in mechanical damage to the elements.

Cleaning Solution Volume Requirement per RO Element
(This volume does not include additional volumes required for piping, filters, etc. or the initial 20% of volume dumped to drain.)

Element Size	**Normal Fouling** (Gallons)	**Heavy Fouling** (Gallons)	**Normal Fouling** (Liters)	**Heavy Fouling** (Liters)
4 x 40 inches	2.5	5	9.5	19
8 x 40 inches	9	18	34	68

Cleaning Tank sizing

Required volume of cleaning solution can be estimated as follows:

1. Cleaning solution requirement per element (see above) x number of elements to be cleaned

Plus

2. Swept volume of connecting pipework to and from cleaning skid

Plus

3. Extra 20% of (1+2) above for first part of cleaning solution sent to drain

RO Cleaning Skid

The successful cleaning of an RO on-site requires a well designed RO cleaning skid. See Figure 1 for a typical arrangement. The skid may or may not be hard piped to the RO skid and may use flexible hose for connections to the RO skid.
For a multi-stage RO, it is recommended that each bank/array be cleaned one stage at a time to optimize cross-flow cleaning velocity.
The source water for chemical solution make-up and rinsing should be clean RO permeate or DI water and be free of hardness, transition metals (e.g. iron), and chlorine..

RO Cleaning Tank:
This tank needs to be sized properly to accommodate the displacement of water in the hose, piping, and RO elements. (see above).The tank should be designed to:

- Allow 100 % drainage
- easy access for chemical introduction and mixing
- recirculation line from the RO Cleaning Pump,
- proper venting,
- overflow,
- return line located near the bottom to minimize foam formation when using a surfactant.

RO Cleaning Pump:
This pump needs to be sized to develop the proper cross-flow velocity to scrub the membrane clean. The maximum recommended pressure is 60 psi (4 bar) at the inlet to the pressure vessels to minimize the production of permeate during cleaning and so reduce the convective re-deposition of foulant back on the membrane surface. The table above gives the recommended flow rate ranges for each pressure tube.

RO Cleaning Cartridge Filter:

Normally 5 to 10-micron and is designed to remove foulants that have been displaced from the cleaning process. Filter must be located upstream of the RO elements.

RO Tank Heater or Cooler:
The maximum design temperature for cleaning is 113° F (45° C). It should be noted that heat is generated and imparted by the RO Cleaning Pump during recirculation which can act as a heater,

RO Tank Mixer: This component is recommended for optimal mixing of chemical, though some designers rely solely on the slow introduction of chemical while maintaining a recirculation through the RO Cleaning Pump back to the tank.

Instrumentation: Cleaning system instrumentation should be included to monitor flow, temperature, pressure, and tank level.

Sample Points:
Sample valves should be located to allow pH and TDS measurements off the RO Cleaning Pump discharge and the concentrate side recirculation return line.

Permeate Return Line:
A small amount of the cleaning solution can permeate through the membranes, therefore a permeate-side return line back to the RO Cleaning Tank is required.
Important: The permeate line and any permeate valves must always be open to atmospheric pressure during the cleaning and flushing steps or damage to RO elements can occur. If the permeate line is closed, the permeate pressure can build up and become higher than the feed-side pressure of the tail elements. This can result in excessive permeate back-pressure which can damage the membrane glue lines in the tail elements.

RO Membrane Element Cleaning and Flushing Procedures

The RO membrane elements can be cleaned in place in the pressure tubes by recirculating the cleaning solution across the high-pressure side of the membrane at low pressure and relatively high flow. A cleaning unit is needed to accomplish this task. See fig 1 for general arrangement.

RO cleaning procedures may vary dependent on the situation. The time required to clean a stage is from 4 to 8 hours. A general procedure for cleaning the RO membrane elements is as follows:

1. Perform a low pressure flush at 60 psi (4 bar) or less of the pressure tubes by pumping clean water from the cleaning tank (or equivalent source) through the pressure tubes to drain for several minutes. Flush water should be clean water of RO permeate or DI quality and be free of hardness, transition metals, and chlorine.
2. Mix a fresh batch of the selected cleaning solution in the cleaning tank. The dilution water should be clean water of RO permeate or DI quality and be free of hardness, transition metals, and chlorine. The temperature and pH should be adjusted to their target levels.
3. Start recirculation. Initially send the displaced water from the system to drain so y cleaning chemical is not diluted. Then divert the first 20%of the returned cleaning solution (the most highly fouled cleaning solution) to drain before allowing the remaining cleaning solution to recirculate back into the RO Cleaning Tank. For the first 5 minutes, slowly throttle the flow rate to 1/3 of the maximum design flow rate. This is to minimize the potential plugging of the feed path with a large amount of dislodged foulant. For the second 5 minutes, increase the flow rate to 2/3 of the maximum design flow rate, and then increase the flow rate to the maximum design flow rate. If required, readjust the pH back to the target when it changes more than 0.5 pH units. Circulate the cleaning solution through the pressure tubes for approximately one hour or as required.
4. An optional soak and recirculation sequence can be used, if required. The soak time can be from 1 to 8 hours depending on the manufacturer’s recommendations. Caution should be used to maintain the proper temperature and pH.
5. Upon completion of the chemical cleaning step, a low pressure cleaning rinse with clean water (RO permeate or DI quality and free of hardness, transition metals, and chlorine) is required to remove all traces of chemical from the Cleaning Skid and the RO Skid. Drain and flush the cleaning tank; then completely refill the Cleaning Tank with clean water for the Cleaning Rinse. Rinse the pressure tubes by pumping all of the rinse water from the Cleaning Tank through the pressure tubes to drain. A second cleaning can be started at this point, if required.
6. Once the RO system is fully rinsed of cleaning chemical with clean water from the Cleaning Tank, a final low pressure clean-up flush can be performed using pretreated feedwater.The permeate line should remain open to drain. Feed pressure should be less than 60 psi (4bar). This final flush continues until the flush water flows clean and is free of any foam or residues of cleaning agents. This usually takes 15 to 60 minutes. The operator should sample the flush water going to the drain for detergent removal and lack of foaming by using a clear flask and shaking it. A conductivity meter can be used to test for removal of cleaning chemicals. The flush water to drain should be within 10-20% of the feedwater conductivity.A pH meter can also be used to compare the flush water to drain to the feed pH.

7. Once all the stages of a train are cleaned and the chemicals flushed out, the RO can be restarted and placed into a Service Rinse. The RO permeate should be diverted to drain until it meets the quality requirements of the process (e.g. conductivity, pH, etc.). It is not unusual to take a period from a few hours to a few days for the RO permeate quality to fully stabilize, especially after high pH or very low pH cleanings..

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Technical Service Bulletin

July 2010 TSB107.20

Foulants and Cleaning Procedures for composite polyamide RO Membrane Elements (ESPA, ESNA, CPA, LFC, NANO and SWC)

This bulletin provides general information about the usual foulants affecting the performance of Hydranautics' Composite Polyamide Reverse Osmosis (RO) membrane elements and the removal of these foulants. The information in this bulletin applies to 4-inch, 6-inch, 8-inch, 8.5-inch, and 16-inch diameter RO membrane elements.

Note: The Composite Polyamide type of RO membrane elements may not be exposed to chlorinated water under any circumstances. Any such exposure will cause irreparable damage to the membrane. Absolute care must be taken following any disinfection of piping or equipment or the preparation of cleaning or storage solutions to ensure that no trace of chlorine is present in the feedwater to the RO membrane elements. If there is any doubt about the presence of chlorine, perform chemical testing to make sure. Neutralize any chlorine residual with a sodium bisulfite solution, and ensure adequate mixing and contact time to accomplish complete dechlorination. Dosing rate is 1.8 to 3.0 ppm sodium bisulfite per 1.0 ppm of free chlorine.

Note: It is recommended that all RO membrane cleaning operations should be closely coordinated with Hydranautics during the RO membrane element warranty period. Hydranautics field service personnel are available to be on site for cleaning assistance, should the need arise. Please contact Hydranautics for current charges for this service.

Note: The use of cationic surfactant should be avoided in cleaning solutions, since irreversible fouling of the membrane elements may occur.

If additional information is needed, please contact the Technical Services Department at:

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RO Membrane Fouling and Cleaning

During normal operation over a period of time, RO membrane elements are subject to fouling by suspended or sparingly soluble materials that may be present in the feedwater. Common examples of foulants are:

- Calcium carbonate scale
- Sulfate scale of calcium, barium or strontium
- Metal oxides (iron, manganese, copper, nickel, aluminum, etc.)
- Polymerized silica scale
- Inorganic colloidal deposits
- Mixed inorganic/organic colloidal deposits
- NOM organic material (Natural Organic Matter)
- Man-made organic material (e.g. antiscalant/dispersants, cationic polyelectrolytes)
- Biological (bacterial bioslime, algae, mold, or fungi)

The nature and rapidity of fouling depends on a number of factors, such as the quality of the feedwater and the system recovery rate. Typically, fouling is progressive, and if not controlled early, will impair the RO membrane element performance in a relatively short time. Cleaning is should accur when the RO shows evidence of fouling, just prior to a long-term shutdown, or as a matter of scheduled routine maintenance. The elements shall be maintained in a clean or “nearly clean” condition to prevent excessive fouling by the foulants listed above. Some fouling is allowed as long as:

- normalized permeate flow decrease is less than 10%

- normalized permeate quality decrease is less than 10%
.
- normalized pressure drop, as measured between the feed and concentrate headers, increase is less than 15%.

Cleaning should be carried out before these values are exceeded to maintain the elements in a clean or “nearly clean” condition. Effective cleaning is evidenced by the return of the normalized parameters to their initial, Start-up, value. In the event you do not normalize your operating data, the above values still apply if you do not have major changes in critical operating parameters. The operating parameters that have to stay constant are permeate flow, permeate back-pressure, recovery, temperature, and feed TDS. If these operating parameters fluctuate, then it is highly recommended that you normalize the data to determine if fouling is occurring or if the RO is actually operating normally based on the change in a critical operating parameter. Hydranautics offers a free normalization software program called ROData, which can be downloaded from our web site at www.membranes.com.

Monitoring overall plant performance on a regular basis is an essential step in recognizing when membrane elements are becoming fouled. Performance is affected progressively and in varying degrees, depending on the nature of the foulants. Table 1 “RO Troubleshooting Matrix” provides a summary of the expected effects that common foulants have on performance.

RO cleaning frequency due to fouling will vary by site. A rough rule of thumb as to an acceptable cleaning frequency is once every 3 to 12 months. If you have to clean more than once a month, you should be able to justify further capital expenditures for improved RO pretreatment or a re-design of the RO operation. If the cleaning frequency is every one to three months, you may want to focus on improving the operation of your existing equipment but further capital expenditure may be harder to justify.

It is important to clean the membranes when they are only lightly fouled, not heavily fouled. Heavy fouling can impair the effectiveness of the cleaning chemical by impeding the penetration of the chemical deep into the foulant and in the flushing of the foulant out of the elements. If normalized membrane performance drops 30 to 50%, it may be impossible to fully restore the performance back to baseline conditions.

When inorganic or polyelectrolyte coagulants are used in the pretreatment process, there can often be incomplete reaction of the coagulant and thus insufficient formation of a filterable floc. The user should ensure that excessive amounts of coagulant are not fed to the RO system, as it can lead to fouling. Polyelectrolyte fouling can often be very difficult to remove and result in higher than expected feed pressure. Excessive amounts of inorganic coagulant can be measured by using SDI filter equipment. In the case of iron, the iron on the SDI filter pad should typically be 3 µg/pad and never above 5 µg/pad. In regards to polymer coagulants, the user should discuss the concern with their chemical supplier and have them ensure that the chemical will not adversely affect the membrane.

In addition to the use of turbidity and SDI, particle counters are also very effective to accurately measure the suitability of the feedwater for NF/RO elements. The measure of particles greater than 2 microns in size should be < 100 particles per millilitre.

One RO design feature that is commonly over-looked in reducing RO cleaning frequency is the use of RO permeate water for flushing foulants from the system. Soaking the RO elements during standby with permeate can help dissolve scale and loosen precipitates, reducing the frequency of chemical cleaning.

What you clean for can vary site by site depending on the foulant. Complicating the situation frequently is that more than one foulant can be present, which explains why cleanings frequently require a low pH and high pH cleaning regiment.

Note: The membrane elements shall not be exposed to feed water containing oil, grease, or other foreign matter which proves to chemically or physically damage the integrity of the membrane.

Table 1: RO Troubleshooting Matrix

(Pressure Drop is defined as the Feed pressure minus the Concentrate pressure)

Possible Cause	Possible Location	Pressure Drop	Feed Pressure	Salt Passage
Metal Oxide Fouling (e.g. Fe,Mn,Cu,Ni,Zn)	1st stage lead elements	Rapid increase	Rapid increase	Rapid increase
Colloidal Fouling (organic and/or inorganic complexes)	1st stage lead elements	Gradual increase	Gradual increase	Slight increase
Mineral Scaling (e.g. Ca, Mg, Ba, Sr)	Last stage tail elements	Moderate Increase	Slight increase	Marked increase
Polymerized Silica	Last stage tail elements	Normal to increased	Increased	Normal to increased
Biological Fouling	Any stage, usually lead elements	Marked increase	Marked increase	Normal to increased
Organic Fouling (dissolved NOM)	All stages	Gradual increase	Increased	Decreased
Antiscalant Fouling	2nd stage most severe	Normal to increased	Increased	Normal to increased
Oxidant damage (e.g Cl_2, ozone,$KMnO_4$)	1st stage most severe	Normal to decreased	Decreased	Increased
Hydrolysis damage (out of range pH)	All stages	Normal to decreased	Decreased	Increased
Abrasion damage (carbon fines, etc)	1st stage most severe	Normal to decreased	Decreased	Increased
O-ring leaks (at interconnectors or adapters)	Random (typically at feed adapter)	Normal to decreased	Normal to decreased	Increased
Glue line leaks (due to permeate back-pressure in service or standby)	1st stage most severe	Normal to decreased	Normal to decreased	Increased
Glue line leaks (due to closed permeate valve while cleaning or flushing)	Tail element of a stage	Increased (based on prior fouling & high delta P)	Increased (based on prior fouling & and high delta P)	Increased

Discussion on Foulants

Calcium Carbonate Scale: Calcium carbonate is a mineral scale and may be deposited from almost any feedwater if there is a failure in the antiscalant/dispersant addition system or in the acid injection pH control system that results in a high feedwater pH. An early detection of the resulting calcium carbonate scaling is absolutely essential to prevent the damage that crystals can cause on the active membrane layers. Calcium carbonate scale that has been detected early can be removed by lowering the feedwater pH to between 3.0 and 5.0 for one or two hours. Longer resident accumulations of calcium carbonate scale can be removed by a low pH cleaning with a citric acid solution.

Calcium, Barium & Strontium Sulfate Scale: Sulfate scale is a much “harder” mineral scale than calcium carbonate and is harder to remove. Sulfate scale may be deposited if there is a failure in the antiscalant/dispersant feed system or if there is an over feed of sulfuric acid in pH adjustment. Early detection of the resulting sulfate scaling is absolutely essential to prevent the damage that crystals can cause on the active membrane layers. Barium and strontium sulfate scales are particularly difficult to remove as they are insoluble in almost all cleaning solutions, so special care should be taken to prevent their formation.

Calcium Phosphate Scale: This scale is particularly common in municipal waste waters and polluted water supplies which may contain high levels of phosphate. This scale can generally be removed with acidic pH cleaners. At this time, phosphate scaling calculations are not performed by the Hydranautics RO Design software. As a rule of thumb, contact Hydranautics technical department if phosphate levels in the feed are 5 ppm or higher.

Metal Oxide/Hydroxide Foulants: Typical metal oxide and metal hydroxide foulants are iron, zinc, manganese, copper, aluminum, etc. They can be the result of corrosion products from unlined pipes and tanks, or result from the oxidation of the soluble metal ion with air, chlorine, ozone, potassium permanganate, or they can be the result of a pretreatment filter system upset that utilizes iron or aluminum-based coagulant aids.

Polymerized Silica Coating: A silica gel coating resulting from the super-saturation and polymerization of soluble silica can be very difficult to remove. It should be noted that this type of silica fouling is different from silica-based colloidal foulants, which may be associated with either metal hydroxides or organic matter. Silica scale can be very difficult to remove by traditional chemical cleaning methods. Contact Hydranautics technical department if the traditional methods are unsuccessful. There does exist harsher cleaning chemicals, like ammonium biflouride, that have been used successfully at some sites but are considered rather hazardous to handle and can damage equipment.

Colloidal Foulants: Colloids are inorganic or mixed inorganic/organic based particles that are suspended in water and will not settle out due to gravity. Colloidal matter typically contains one or more of the following major components: iron, aluminum, silica, sulfur, or organic matter.

Dissolved NOM Organic Foulants: The sources of dissolved NOM (Natural Organic Matter) foulants are typically derived from the decomposition of vegetative material into surface waters or shallow wells. The chemistry of organic foulants is very complex, with the major organic components being either humic acid or fulvic acid. Dissolved NOMs can quickly foul RO membranes by being absorbed onto the membrane surface. Once absorption has occurred, then a slower fouling process of gel or cake formation starts. It should be noted that the mechanism of fouling with dissolved NOM should not be confused with the mechanism of fouling created by NOM organic material that is bound up with colloidal particles.

Microbiological Deposits: Organic-based deposits resulting from bacterial slimes, fungi, molds, etc. can be difficult to remove, particularly if the feed path is plugged. Plugging of the feed path makes it difficult to introduce and distribute the cleaning solutions. To inhibit additional growth, it is important to clean and sanitize not only the RO system, but also the pretreatment, piping, dead-legs, etc. The membranes, once chemically cleaned, will require the use of a Hydranautics approved biocide and an extended exposure requirement to be effective. For further information on biocides, refer to Hydranautics Technical Service Bulletin TSB-110 “Biocides for Disinfection and Storage of Hydranautics Membrane Elements”.

Selection and Use of Cleaning Chemicals

There are a number of factors involved in the selection of a suitable cleaning chemical (or chemicals) and proper cleaning protocol. The first time you have to perform a cleaning, it is recommended to contact the manufacturer of the equipment, the RO element manufacturer, or a RO specialty chemical and service supplier. Once the suspected foulant(s) are identified, one or more cleaning chemicals will be recommended. These cleaning chemical(s) can be generic or can be private-labeled proprietary chemicals. Typically, the generic chemicals can be of technical grades and are available from local chemical supply companies. The proprietary RO cleaning chemicals can be more expensive, but may be easier to use and you cannot rule out the advantage of the intellectual knowledge supplied by these companies. Some independent RO service companies can determine the proper chemicals and cleaning protocol for your situation by testing at their facility a fouled element pulled from your system.

It is not unusual to use a number of different cleaning chemicals in a specific sequence to achieve the optimum cleaning. Typically, a high pH cleaning is used first to remove foulants like oil or biological matter, followed by a low pH cleaning to remove foulants like mineral scale or metal oxides/hydroxides fouling. There are times that order of high and low pH cleaning solutions is reversed or one solution only is required to clean the membranes. Some cleaning solutions have detergents added to aid in the removal of heavy biological and organic debris, while others have a chelating agent like EDTA added to aid in the removal of colloidal material, organic and biological material, and sulfate scale. An important thing to remember is that the improper selection of a cleaning chemical, or the sequence of chemical introduction, can make the foulant worse.

Hydranautics recommends that the membrane system operator thoroughly investigate the signs of fouling before they select a cleaning chemical and a cleaning protocol. Some forms of fouling (iron deposits and scaling commonly associated with well waters) may require only a simple low pH cleaning. However, for most complex fouling phenomena, Hydranautics recommends the following sequence:

1. Flushing with permeate with addition of non oxidizing biocide (DBNPA or similar type) at the end of the flushing.
2. High pH CIP – Temperature versus pH as per recommendations in this TSB
3. Flushing with permeate until pH on the brine side is below pH 8.5
4. Low pH CIP
5. Acid flushing with permeate and non oxidizing biocide (DBNPA or similar type)

General Precautions in Cleaning Chemical Selection and Usage

- If you are using a proprietary chemical, make sure the chemical has been qualified for use with your Hydranautics membrane by the chemical supplier. The chemical supplier’s instructions should not be in conflict with Hydranautics recommended cleaning parameters and limits listed in this Technical Service Bulletin.
- If you are using generic chemicals, make sure the chemical has been qualified for use with your Hydranautics membrane in this Technical Service Bulletin.
- Use the least harshest cleaning regiment to get the job done. This includes the cleaning parameters of pH, temperature, and contact time. This will optimize the useful life of the membrane.
- Clean at the recommended target temperatures to optimize cleaning efficiency and membrane life.
- Use the minimal amount of chemical contact time to optimize membrane life.

- Be prudent in the adjustment of pH at the low and high pH range to extend the useful life of the membrane. A "gentle" pH range is 4 to 10, while the harshest is 2 to 12.
- Oil and biologically -fouled membranes should not use a low pH clean-up first as the oil and biological matter will congeal.
- Cleaning and flushing flows should be in the same direction as the normal feed flow to avoid potential telescoping and element damage.
- When cleaning a multi-stage RO, the most effective cleaning is one stage at a time so cleaning flow velocities can be optimized and foulants from upstream stages don't have to pass through down-stream stages.
- Flushing out detergents with higher pH permeate can reduce foaming problems.
- Verify that proper disposal requirements for the cleaning solution are followed.
- If your system has been fouled biologically, you may want to consider the extra step of introducing a sanitizing biocide chemical before and after a successful cleaning. Biocides can be introduced before and immediately after cleaning, periodically (e.g. once a week), or continuously during service. You must be sure that the biocide is compatible with the membrane, does not create any health risks, is effective in controlling biological activity, and is not cost prohibitive.
- For safety reasons, make sure all hoses and piping can handle the temperatures, pressures and pH's encountered during a cleaning.
- For safety reasons, always add chemicals slowly to an agitated batch of make-up water.
- For safety reason, always wear safety glasses and protective gear when working with chemicals.
- For safety reasons, don't mix acids with caustics. Thoroughly rinse the 1st cleaning solution from the RO system before introducing the next solution.

Selecting a Cleaning Solution

Table 2 lists the recommended generic chemical solutions for cleaning an RO membrane element based on the foulant to be removed.

Important: It is recommended that the MSDS of the cleaning chemicals be procured from the chemical supplier and that all safety precautions be utilized in the handling and storage of all chemicals.

Table 2: Hydranautics Recommended Chemical Cleaning Solutions

Foulant	Gentle Cleaning Solution	Harsher Cleaning Solution
Calcium carbonate scale	1	4
Calcium, barium or strontium sulfate scale	2	4
Metal oxides/hydroxides (Fe, Mn, Zn, Cu, Al)	1	5
Inorganic colloidal foulants	1	4
Mixed Inorganic/organic colloidal foulants	2	6
Polymerized silica coating	None	7
Biological matter	2 or 3	6
NOM organic matter (naturally occurring)	2 or 3	6

Table 3 “Hydranautics Recipes for Cleaning Solutions” offers instructions on the volumes of bulk chemical to be added to 100 U.S. gallons (379 liters) of make-up water. Prepare the solutions by proportioning the amount of chemicals to the amount of make-up water to be used. Make-up water quality should be of RO permeate or deionized (DI) quality, and be free of chlorine and hardness. Before forwarding the cleaning solution to the membranes, it is important to thoroughly mix it, adjust the pH according to the target pH, and stabilize the temperature at the target temperature. Unless otherwise instructed, the cleaning design parameters are based on a chemical recirculation flow period of one hour and an optional chemical soak period of one hour.

Table 4 “Hydranautics Maximum pH and Temperature Limits for Cleaning” highlights the maximum pH and temperature limits for specific membranes, after which irreparable membrane damage can occur. A suggested minimum temperature limit is 70 F (21 C), but cleaning effectiveness and the solubility of the cleaning chemical is significantly improved at higher temperatures.

Description of Cleaning Solutions

Note: The notation (w) denotes that the diluted chemical solution strength is based on the actual weight of the 100% pure chemical or active ingredient.

Solution 1: This is a low pH cleaning solution of 2.0% (w) citric acid ($C_6H_8O_7$). It is useful in removing inorganic scale (e.g. calcium carbonate, calcium sulfate, barium sulfate, strontium sulfate) and metal oxides/hydroxides (e.g. iron, manganese, nickel, copper, zinc), and inorganic-based colloidal material. Note: Citric acid is available as a powder.

Solution 2: This is a high pH cleaning solution (target pH of 10.0) of 2.0% (w) of STPP (sodium tripolyphosphate) ($Na_5P_3O_{10}$) and 0.8% (w) of Na-EDTA (sodium salt of ethylaminediaminetetraacetic acid). It is specifically recommended for removing calcium sulfate scale and light to moderate levels of organic foulants of natural origin. STPP functions as an inorganic-based chelating agent and detergent. Na-EDTA is an organic-based chelating cleaning agent that aids in the sequestering and removal of divalent and trivalent cations and metal ions. STPP and Na-EDTA are available as powders.

Solution 3: This is a high pH cleaning solution (target pH of 10.0) of 2.0% % (w) of STPP (sodium tripolyphosphate) ($Na_5P_3O_{10}$) and 0.025% (w) Na-DDBS ($C_6H_5(CH_2)_{12}$-SO_3Na) (sodium salt of dodecylbenzene sulfonate). It is specifically recommended for removing heavier levels of organic foulants of natural origin. STPP functions as an inorganic-based chelating agent and detergent. Na-DDBS functions as an anionic detergent.

Solution 4: This is a low pH cleaning solution (target pH of 2.5) of 0.5% (w) of HCL (hydrochloric) acid. It is useful in removing inorganic scale (e.g. calcium carbonate, calcium sulfate, barium sulfate, strontium sulfate and metal oxides/hydroxides (e.g. iron, manganese, nickel, copper, zinc) and inorganic-based colloidal material. This cleaning solution is considered to be harsher than Solution 1. HCL acid, a strong mineral acid, is also known as muriatic acid. HCL acid is available in a number of concentrations: (18 ^{0} Baume = 27.9%), (20 ^{0} Baume = 31.4%), (22 ^{0} Baume = 36.0%).

Solution 5: This is a lower pH cleaning solution (natural pH is between pH 4 and 6. No pH adjustment is required) 1.0% (w) of $Na_2S_2O_4$ (sodium hydrosulfite). It is useful in the removal of metal oxides and hydroxides (especially iron fouling), and to a lesser extent calcium sulfate, barium sulfate and strontium sulfate. Sodium hydrosulfite is strong reducing agent and is also known as sodium dithionite. The solution will have a very strong odor so proper ventilation is required. Sodium hydrosulfite is available as a powder.

Solution 6: This is a high pH cleaning solution (target pH of 11.5) of 0.1% (w) of NaOH (sodium hydroxide) and 0.03% (w) of SDS (sodium dodecylsulfate). It is useful in the removal of organic foulants of natural origin, colloidal foulants of mixed organic/inorganic origin, and biological material (fungi, mold, slimes and biofilm). SDS is a detergent that is an anionic surfactant that will cause some foaming. This is considered to be a harsh cleaning regiment. ***Note: Do not exceed maximum pH and temp limits for specific elements. See Table4.***

Solution 7: This is a high pH cleaning solution (target pH of 11.5) of 0.1% (w) of NaOH (sodium hydroxide). It is useful in the removal of polymerized silica. This is considered to be a harsh cleaning regiment. *Note: Do not exceed maximum pH and temp limits for specific elements. See Table4.*

> **Important: It is recommended that the MSDS of the cleaning chemicals be procured from the chemical supplier and that all safety precautions be utilized in the handling and storage of all chemicals.**

Table 3: Hydranautics Recipes for Cleaning Solutions

The quantities listed below are to be added to 100 U.S.gallons (379 liters) of dilution water.

Cleaning Solution	Bulk Ingredients	Quantity	Target [1] pH Adjustment	Target [1] Temp.
1	**Citric acid** (as 100% powder)	17.0 pounds (7.7 kg)	No pH adjustment is Required.	104 F (40 C)
2	**STPP** (sodium tripolyphosphate) (as 100% powder) **Na-EDTA** (Versene 220 or equal) (as 100% powder)	17.0 pounds (7.7 kg) 7.0 pounds (3.18 kg)	Adjust to pH 10.0 with sulfuric or hydrochloric acid.	104 F (40 C)
3	**STPP** (sodium tripolyphosphate) (as 100% powder) **Na-DDBS** Na-dodecylbenzene sulfonate	17 pounds (7.7 kg) 0.21 pounds (0.1 kg)	Adjust down to pH 10.0 with sulfuric or hydrochloric acid.	104 F (40 C)
4	**HCl acid** (hydrochloric acid (as 22^0 Baume or 36% HCL)	0.47 gallons (1.78 liters)	Slowly adjust pH down to 2.5 with HCL acid. Adjust pH up with sodium hydroxide.	95 F (35 C)
5	**Sodium hydrosulfite** (as 100% powder)	8.5 pounds (3.86 kg)	No pH adjustment is required.	95 F (35 C)
6	**NaOH** (sodium hydroxide) (as 100% powder) (or as 50% liquid) **SDS** (sodium dodecylsulfate)	0.83 pounds (0.38 kg) 0.13 gallons (0.49 liters) 0.25 pounds (0.11 kg)	Slowly adjust pH up to 11.5 with sodium hydroxide. Adjust pH down to 11.5 by adding HCL acid.	86 F (30 C)
7	**NaOH** (sodium hydroxide) (as 100% powder) (or as 50% liquid)	0.83 pounds (0.38 kg) 0.13 gallons (0.49 liters)	Slowly adjust pH up to 11.5 with sodium hydroxide. Adjust pH down to 11.5 by adding HCL acid.	86 F (30 C)

[1] *- Note: These pH and temperature targets are recommendations only. For maximum pH and temperature limits for specific elements. See Table 4.*

Table 4: Hydranautics pH and Temperature Limits for Cleaning

(See Table 3 for target pH and temperatures)

	Continuous Operation		Maximum Cleaning Temp			
Membrane	**<45 C**	**≤ 36 C**	**50 C**	**≤45 C**	**≤35 C**	**≤25 C**
NANO-SW, NANO-BW	3 to 8.5	3 to 9	Contact Hydranautics Technical Department	Contact Hyd Tech Dept	1 to 10.5	1 to 11.5
ESNA1-LF, ESNA1-LF2, ESNA1-K1	3 to 9.5	2 to 10	Contact Hydranautics Technical Department	2 to 10.5	1 to 11	1 to 12
ESPA1, ESPA3, ESPA4	3 to 9.5	2 to 10	Contact Hydranautics Technical Department	2 to 10.5	1 to 11	1 to 12
ESPA2	3 to 10	2 to 10.6	Contact Hydranautics Technical Department	2 to 10.5	1 to 11	1 to 12
ESPAB	3 to 10.5	2 to 11	Contact Hydranautics Technical Department	2 to 11	1 to 11.5	1 to 12.5
LFC3, LFC3-LD	3 to 9.5	2 to 10	Contact Hydranautics Technical Department	2 to 10.5	1 to 11	1 to 12
CPA3	3 to 10	2 to 10.8	Contact Hydranautics Technical Department	2 to 11	1 to 11.5	1 to 12.5
CPA5-LD, ESPA2-LD	3 to 10.5	2 to 11	Contact Hydranautics Technical Department	2 to 11.5	1 to 12	1 to 13
SWC4+, SWC5, SWC5-LD, SWC6	3 to 10.5	2 to 11	Contact Hydranautics Technical Department	2 to 11	1 to 12	1 to 13

Note: The above cleaning parameters denote the maximum temperature limits for a corresponding range of pH. Cleaning operations performed at the extremes may result in a more effective cleaning, but can shorten the useful life of the membrane due to hydrolysis. To optimize the useful life of a membrane, it is recommended to use the least harsh cleaning solutions and minimize the contact time whenever possible. The pH of the feed stream or cleaning solution should be closely monitored and controlled. The pH meters used to measure and control pH should be regularly calibrated to ensure accuracy. It is typical to re-circulate cleaning chemicals through the RO for 1 hour. At the pH limits shown above, cleaning exposure at temperatures less than 40 C is limited to 60 minutes, at temperatures greater than 40 C exposure is limited to 30 minutes. Extended soaking is possible, but at less aggressive pH levels. See page 14 for more information on cleaning and flushing procedures.

Table 5: Cleaning and Flushing Flow Rates per RO Pressure Tube

(Pressures are not to exceed 60 psi (4 bar) at inlet to tubes.)

Element Diameter	**GPM**	**LPM**
4-inches	6 to 10	23 to 38
6-inches	12 to 20	46 to 76
8-inches	24 to 40	91 to 151
8.5-inches	27 to 45	102 to 170
16-inches	96 to 160	360 to 600

Table 6: Cleaning Solution Volume Requirement per RO Element

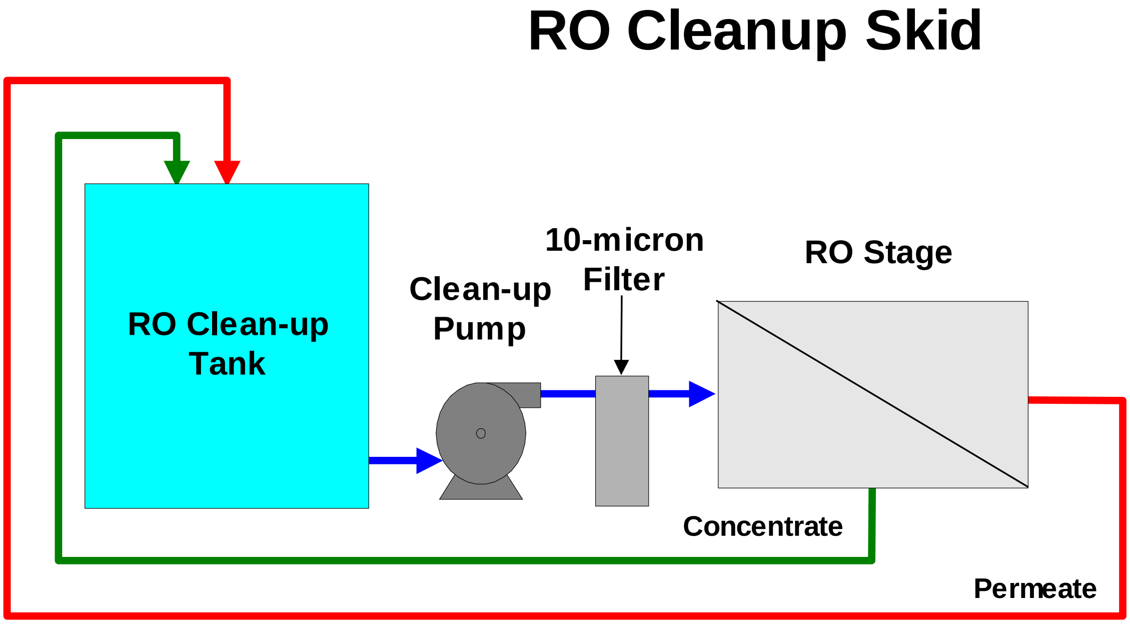
(these volumes do not include volumes required for piping, filters, etc)

(these volumes do not include initial 20% of volume dumped to drain)

Element Size	**Normal Fouling** (Gallons)	**Heavy Fouling** (Gallons)	**Normal Fouling** (Liters)	**Heavy Fouling** (Liters)
4 x 40 inches	2.5	5	9.5	19
6 x 40 inches	5	10	19	38
8 x 40 inches	9	18	34	68
8.5 x 40 inches	10	20	38	76
16 x 40 inches	36	72	136	272

RO Cleaning Skid

The successful cleaning of an RO on-site requires a well designed RO cleaning skid. Normally this skid is not hard piped to the RO skid and uses temporary hosing for connections. It is recommended to clean a multi-stage RO one stage at a time to optimize cross-flow cleaning velocity. The source water for chemical solution make-up and rinsing should be clean RO permeate or DI water and be free of hardness, transition metals (e.g. iron), and chlorine. Components must be corrosion proof. Major cleaning system components are:



- RO Cleaning Tank: This tank needs to be sized properly to accommodate the displacement of water in the hose, piping, and RO elements. The table below denotes the amount of chemical solution that needs to be made for a single RO element. The tank should be designed to allow 100 % drainage, easy access for chemical introduction and mixing, a recirculation line from the RO Cleaning Pump, proper venting, overflow, and a return line located near the bottom to minimize foam formation when using a surfactant.
- RO Cleaning Pump: This pump needs to be sized to develop the proper cross-flow velocity to scrub the membrane clean. The maximum recommended pressure is 60 psi (4 bar) at the inlet to the pressure vessels to minimize the production of permeate during cleaning and reduce the convective redeposition of foulant back on to the membrane surface. The table below denotes the flow rate ranges for each pressure tube.
- RO Cleaning Cartridge Filter: Normally 5 to 10-micron and is designed to remove foulants that have been displaced from the cleaning process.
- RO Tank Heater or Cooler: The maximum design temperature for cleaning is 113^0 F (45^0 C). It should be noted that heat is generated and imparted by the RO Cleaning Pump during recirculation.
- RO Tank Mixer: This is recommended to get optimal mixing of chemical, though some designers rely solely on the slow introduction of chemical while maintaining a recirculation through the RO Cleaning Pump back to the tank.
- Instrumentation: Cleaning system instrumentation should be included to monitor flow, temperature, pressure, and tank level.
- Sample Points: Sample valves should be located to allow pH and TDS measurements off the RO Cleaning Pump discharge and the concentrate side recirculation return line.

- Permeate Return Line: A small amount of the cleaning solution can permeate through the membranes and so a permeate-side return line back to the RO Cleaning Tank is required.

  Important: The permeate line and any permeate valves must always be open to atmospheric pressure during the cleaning and flushing steps or damage to RO elements can occur. If the permeate line is closed, the permeate pressure can build up and become higher than the feed-side pressure of the tail elements. This can result in excessive permeate back-pressure which can damage the membrane glue lines in the tail elements.

RO Membrane Element Cleaning and Flushing Procedures

The RO membrane elements can be cleaned in place in the pressure tubes by recirculating the cleaning solution across the high-pressure side of the membrane at low pressure and relatively high flow. A cleaning unit is needed to do this. RO cleaning procedures may vary dependent on the situation. The time required to clean a stage can take from 4 to 8 hours.

A general procedure for cleaning the RO membrane elements is as follows:

1. Perform a low pressure flush at 60 psi (4 bar) or less of the pressure tubes by pumping clean water from the cleaning tank (or equivalent source) through the pressure tubes to drain for several minutes. Flush water should be clean water of RO permeate or DI quality and be free of hardness, transition metals, and chlorine.

2. Mix a fresh batch of the selected cleaning solution in the cleaning tank. The dilution water should be clean water of RO permeate or DI quality and be free of hardness, transition metals, and chlorine. The temperature and pH should be adjusted to their target levels.

3. Circulate the cleaning solution through the pressure tubes for approximately one hour or the desired period of time. At the start, send the displaced water to drain so you don't dilute the cleaning chemical and then divert up to 20% of the most highly fouled cleaning solution to drain before returning the cleaning solution back to the RO Cleaning Tank. For the first 5 minutes, slowly throttle the flow rate to 1/3 of the maximum design flow rate. This is to minimize the potential plugging of the feed path with a large amount of dislodged foulant.. For the second 5 minutes, increase the flow rate to 2/3 of the maximum design flow rate, and then increase the flow rate to the maximum design flow rate. If required, readjust the pH back to the target when it changes more than 0.5 pH units.

4. An optional soak and recirculation sequence can be used, if required. The soak time can be from 1 to 8 hours depending on the manufacturer's recommendations. Caution should be used to maintain the proper temperature and pH. *Do not exceed maximum pH and temperature limits for specific elements. See Table 4.* Also note that this does increase the chemical exposure time of the membrane.

5. Upon completion of the chemical cleaning steps, a low pressure Cleaning Rinse with clean water (RO permeate or DI quality and free of hardness, transition metals, and chlorine) is required to remove all traces of chemical from the Cleaning Skid and the RO Skid. Drain and flush the cleaning tank; then completely refill the Cleaning Tank with clean water for the Cleaning Rinse. Rinse the pressure tubes by pumping all of the rinse water from the Cleaning Tank through the pressure tubes to drain. A second cleaning can be started at this point, if required.

5. Once the RO system is fully rinsed of cleaning chemical with clean water from the Cleaning Tank, a Final Low Pressure Clean-up Flush can be performed using pretreated feed water. The permeate line should remain open to drain. Feed pressure should be less than 60 psi (4 bar). This final flush continues until the flush water flows clean and is free of any foam or residues of cleaning agents. This usually takes 15 to 60 minutes. The operator can sample the flush water going to the drain for detergent removal and lack of foaming by using a clear flask and shaking it. A conductivity meter can be used to test for removal of cleaning chemicals, such that the flush water to drain is within 10-20% of the feed water conductivity. A pH meter can also be used to compare the flush water to drain to the feed pH.

7. Once all the stages of a train are cleaned, and the chemicals flushed out, the RO can be restarted and placed into a Service Rinse. The RO permeate should be diverted to drain until it meets the quality requirements of the process (e.g. conductivity, pH, etc.). It is not unusual for it to take from a few hours to a few days for the RO permeate quality to stabilize, especially after high pH cleanings.

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APPENDIX F – EXAMPLE DATA COLLECTION SHEETS

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City of San Diego IPR/RA Demostration Project

MF/UF SYSTEM

DRAFT OPERATIONAL DATA COLLECTION SHEET

un Number: ________________

Date (mm/dd/yy)	Time (hh:mm)	Operator	PLC Temperature (degC)	Filtrate Flow		Pressure					Time since Backwash (min)	Backwash Flow (gpm)	Turbidity (NTU)		Notes
				PLC Screen (gpm)	Rotameter (gpm)	PLC Feed (psi)		PLC Filtrate (psi)		TMP (psi)			Online Feed (NTU)	Online Filtrate (NTU)	
						Left	Right	Left	Right						

Note: Minimum of two readings per day

Comments: ____

____

____

____

City of San Diego IPR/RA Demostration Project

MF/UF SYSTEM

DRAFT EVALUATION OF CLEANING EFFICIENCY

Run Number: ___________

Date (mm/dd/yy)	Time (hh:mm)	Operator	Feed Temp-erature (degC)	Filtrate Flow (gpm)		Feed Pressure (psi)	Filtrate Pressure (psi)	TMP (psi)	

BEFORE CLEANING

Chemical 1: ____________ pH ___________ Turbidity ___________ TDS ____________________

Visual Color: ____________ Flow (gpm): ___________ Residual (before): ___________ Residual (after): ___________

Pressure (psi): ___________ Temperature (before): ___________ Temperature (after): ___________

Describe Chemical Cleaning Procedure (including flows and pressures during cleaning if possible):

AFTER CHEMICAL 1

Chemical 2: ____________ pH ___________ Turbidity ___________ TDS ____________________

Visual Color: ____________ Flow (gpm): ___________ Residual (before): ___________ Residual (after): ___________

Pressure (psi): ___________ Temperature (before): ___________ Temperature (after): ___________

Describe Chemical Cleaning Procedure (including flows and pressures during cleaning if possible):

AFTER CHEMICAL 2

Chemical 3: ____________ pH ___________ Turbidity ___________ TDS ____________________

Visual Color: ____________ Flow (gpm): ___________ Residual (before): ___________ Residual (after): ___________

Pressure (psi): ___________ Temperature (before): ___________ Temperature (after): ___________

Describe Chemical Cleaning Procedure (including flows and pressures during cleaning if possible):

AFTER CHEMICAL 3

Comments:

City of San Diego IPR/RA Demonstration Project
On-Site Lab
DRAFT pH Data Log Sheet

Date	Time	Sampler	NC Tert Feed	RO Feed	Combined Permeate

City of San Diego IPR/RA Demonstration Project
On-Site Lab
DRAFT Conductivity/Temperature Data Log Sheet

Date	Time	Sampler	NC Tert Feed		RO Feed		Combined Permeate	
			Temperature (C)	Conductivity (S)	Temperature (C)	Conductivity (S)	Temperature (C)	Conductivity (S)

City of San Diego IPR/RA Demonstration Project
On-Site Lab
DRAFT UV Data Log Sheet

Date	Time	Sampler	NC Tert Feed (S1)	RO Feed (S2)	Combined Permeate

City of San Diego IPR/RA Demonstration Project

DRAFT Long Term RO Performance Testing

DRAFT Operational Data Collection Sheet

Date (mm:dd:yy)	***Time*** (hh:mm)	***Run Hours***	***Operator Initials***	***Feed Chlorine*** Free/Total	***Feed pH***	***Feed Temp.*** (deg F)	***Pressure***						***Flow***				***Conductivity***				
							Feed (psi)	Stage 1 Interstage (psi)	Stage 2 Interstage (psi)	Conc. (psi)	Stage 1 Permeate (psi)	Stage 2 Permeate (psi)	Stage 1 Permeate (gpm)	Stage 2 Permeate (gpm)	[1]Conc. (gpm)	Recycle (gpm)	Feed (µmhos)	Feed (on line) (µmhos)	Combined Permeate (on line) (µmhos)	Stage 1 Permeate (µmhos)	Stage 2 Permeate (µmhos)

Comments: [1] Measured before recycle, actual concentrate flow leaving the system = "Conc." - "Recycle".

City of San Diego IPR/RA Demonstration Project

RO system

Shutdown Log

Operator Initials	***Begin***		***End***		***Shutdown Reason***
	Date (mm:dd:yy)	***Time*** (hh:mm)	***Date*** (mm:dd:yy)	***Time*** (hh:mm)	

Comments:

City of San Diego IPR/RA Demonstration Project

DRAFT UV Performance Testing

DRAFT UV Operational Data Collection Sheet

Date (mm:dd:yy)	Time (hh:mm)	Run Hours	Operator Initials	Flow		H_2O_2 dose (mg/l)	Power Setting (%)	UV Adsorbance cm^{-1}	UVT (%)	Intensity (mW/cm^2)	EEO
				PLC readout (gpm)	Flow meter (gpm)						

Comments: [1] Measured before recycle, actual concentrate flow leaving the system = "Conc." - "Recycle".

APPENDIX G – WATER QUALITY REGULATORY REQUIREMENTS AND GUIDANCE

Table G-1

Primary Drinking Water Standards for Measured Organic Parameters

Parameter	Units	Primary Drinking Water Standard, MCL	
		Federal	CA
Volatile Organic Compounds			
Benzene	mg/L	0.005	0.001
Carbon tetrachloride	mg/L	0.005	0.0005
1,2 Dichlorobenzene	mg/L	0.6	0.6
1,4 Dichlorobenzene	mg/L	0.075	0.005
1,1 Dichloroethane	mg/L	0	0.005
1,2 Dichloroethane	mg/L	0.005	0.0005
1,1 Dichloroethylene	mg/L	0.007	0.006
cis-1,2 Dichloroethylene	mg/L	0.07	0.006
trans-1,2 Dichloroethylene	mg/L	0.1	0.01
Dichloromethane	mg/L	0.005	0.005
1,3 Dichloropropene	mg/L	NR	0.0005
1,2 Dichloropropane	mg/L	0.005	0.005
Ethylbenzene	mg/L	0.7	0.3
Methyl-tert-butyl ether (MTBE)	mg/L	0	0.013
Monochlorobenzene	mg/L	0.1	0.07
Styrene	mg/L	0.1	0.1
1,1,2,2 Tetrachloroethane	mg/L	0	0.001
Tetrachloroethylene	mg/L	0.005	0.005
Toluene	mg/L	1	0.15
1,2,4 Trichlorobenzene	mg/L	0.07	0.07
1,1,1-Trichloroethane	mg/L	0.2	0.2
1,1,2-Trichloroethane	mg/L	0.005	0.005
Trichloroethylene	mg/L	0.005	0.005
Trichlorofluoromethane	mg/L	0	0.15
1,12Trichloro1,2,2Trifluoroethane	mg/L	0	1.2
Vinyl chloride	mg/L	0.002	0.0005
Xylenes	mg/L	10	1.75
SOCs			
Alachlor	mg/L	0.002	0.002
Atrazine	mg/L	0.003	0.001
Bentazon	mg/L	0	0.018
Benzo(a)pyrene	mg/L	0.0002	0.0002
Carbofuran	mg/L	0.04	0.018
Chlordane	mg/L	0.002	0.0001
Dalapon	mg/L	0.2	0.2
Dibromochloropropane	mg/L	0.0002	0.0002
Di(2ethylhexyl)adipate	mg/L	0.4	0.4
Di(2ethylhexyl)phthalate	mg/L	0.006	0.004
2,4-D	mg/L	0.07	0.07
Dinoseb	mg/L	0.007	0.007
Diquat	mg/L	0.02	0.02
Endothall	mg/L	0.1	0.1
Endrin	mg/L	0.002	0.002
Ethylene dibromide	mg/L	0.00005	0.00005
Glyphosate	mg/L	0.7	0.7
Heptachlor	mg/L	0.0004	0.00001
Heptachlor epoxide	mg/L	0.0002	0.00001
Hexachlorobenzene	mg/L	0.001	0.001
Hexachlorocyclopentadiene	mg/L	0.05	0.05
Lindane	mg/L	0.0002	0.0002
Methoxychlor	mg/L	0.04	0.03
Molinate	mg/L	0	0.02
Oxamyl (Vydate)	mg/L	0.2	0.05
Pentachlorophenol	mg/L	0.001	0.001
Picloram	mg/L	0.5	0.5
Polychlorinated Biphenyls	mg/L	0.0005	0.0005
Simazine	mg/L	0.004	0.004
Thiobencarb	mg/L	0	0.07
Toxaphene	mg/L	0.003	0.003
2,3,7,8_TCDD (Dioxin)	mg/L	3.00E-08	3exp-8
2,4,5-TP (Silvex)	mg/L	0.05	0.05
DBPs			
Total Trihalomethanes	mg/L	0.08	0.1
Total haloacetic acids	mg/L	0.06	0.06
Bromate	mg/L	0.01	0.01
Chlorite	mg/L	1	1

Notes:

-Subsequent to the establishment of the above table maximum residual disinfectant levels (MRDLs) for chloramines, chlorine, and chlorine dioxide have been established at 4.0, 4.0, and 0.8 mg/L, respectively.

Table G-2

Primary Drinking Water Standards for Measured Inorganic Parameters

Parameter	Units	Primary Drinking Water Standard, MCL	
		Federal	CA
Inorganics			
Antimony	mg/L	0.006	0.006
Arsenic	mg/L	0.01	0.01
Asbestos	MFL/L	7	7
Barium	mg/L	2	1
Beryllium	mg/L	0.004	0.004
Cadmium	mg/L	0.005	0.005
Chromium	mg/L	0.1	0.05
Copper	mg/L	1.3	1.3
Cyanide	mg/L	0.2	0.2
Fluoride	mg/L	4	2
Lead	mg/L	0.015	0.015
Mercury	mg/L	0.002	0.002
Nickel	mg/L	0	0.1
Nitrate	mg/L	10 (as N)	45 (as NO_3)
Nitrite as N	mg/L	1	1
Selenium	mg/L	0.05	0.05
Thallium	mg/L	0.002	0.002
Microbial			
Total Coliforms	P/A	Absent	Absent
Radionuclides			
Uranium	ug/L	30	0
Uranium	pCi/L	0	20
Radium 226+228	pCi/L	5	5
Gross Alpha Part.	pCi/L	15	15
Gross Beta Part.	mrem/yr	4	0
Gross Beta Part.	pCi/L	0	50
Strontium 90	pCi/L	8	8
Tritium	pCi/L	20000	20000

Notes:

-As of 6/11/2006 the California gross beta MCL is 4 millirem/year annual dose equivalent to the total body or any internal organ.

-Strontium-90 and tritium are now covered under the gross beta MCL; Stronium-90 MCL = 4 millirem/year to bone marrow; tritium MCL = 4 millirem/year to total body.

-As of 10/18/2007, California has established a MCL for perchlorate at 0.006 mg/L.

-The State and Federal established MCL for nitrate-N + nitrite-N is 10 mg/L.

Table G-3

Secondary Drinking Water Standards for Measured Parameters

Parameter	Units	Secondary, MCL	
		Federal	**CA**
Aluminum	mg/L	0.2	0.2
Color	Units	15	15
Copper	mg/L	1	1
Corrosivity		Non Corr.	Non Corr.
Foaming Agents (MBAS)	mg/L	0.5	0.5
Iron	mg/L	0.3	0.3
Manganese	mg/L	0.05	0.05
MTBE	mg/L	NR	0.005
Odor Threshold	TON	3	3
Silver	mg/L	0.1	0.1
Thiobencarb	mg/L	NR	0.001
Turbidity	NTU	5	5
Zinc	mg/L	5	5
pH		6.5-8.5	NR
Specific Conductance	micromhos	NR	900
Sulfate	mg/L	250	250
Fluoride	mg/L	2	NR
Chloride	mg/L	250	250
TDS	mg/L	500	500

Table G-4
CDPH Drinking Water Notification Levels

Chemical	Notification Level(mg/L)
Boron	1
n-Butylbenzene	0.26
sec-Butylbenzene	0.26
tert-Butylbenzene	0.26
Carbon Disulfide	0.16
Chlorate	0.8
2-Chlorotoluene	0.14
4-Chlorotoluene	0.14
Dichlorodifluoromethane (Freon 12)	1
1,4-Dioxane	0.003
Ethylene Glycol	14
Formaldehyde	0.1
HMX	0.35
Isopropylbenzene	0.77
Manganese	0.5
Methyl isobutyl ketone (MIBK)	0.12
Naphthalene	0.017
N-Nitrosodiethylamine (NDEA)	0.00001
N-Nitrosodimethylamine (NDMA)	0.00001
N-Nitrosodi-n-propylamine (NDPA)	0.00001
Propachlor	0.09
n-Propylbenzene	0.26
RDX	0.0003
Tertiary butyl alcohol (TBA)	0.012
1,2,3-Trichloropropane (1,2,3-TCP)	0.000005
1,2,4-Trimethylbenzene	0.33
1,3,5-Trimethylbenzene	0.33
2, 4, 6-Trinitrotoluene (TNT)	0.001
Vanadium	0.05

Information obtained from http://www.cdph.ca.gov/certlic/drinkingwater/Pages/NotificationLevels.aspx
Last Updated Dec 14, 2007, for complete list of current notifications levels visit the CDPH website listed above.

UCMR3 ANALYTES

Entry Point	CAS Registry	MRL
17-b-estradiol	50–28–2	0.0004 µg/L
17-a-ethynylestradiol	57–63–6	0.0009 µg/L
estriol	50–27–1	0.0008 µg/L
equilin	474–86–2	0.004 µg/L
estrone	53–16–7	0.002 µg/L
testosterone	58–22–0	0.0001 µg/L
4-androstene-3,17-dione	63–05–8	0.0003 µg/L
1,2,3-trichloropropane	96–18–4	0.03 µg/L
1,3-butadiene	106–99–0	0.1 µg/L
chloromethane	74–87–3	0.2 µg/L
1,1-dichloroethane	75–34–3	0.03 µg/L
n-propylbenzene	103–65–1	0.03 µg/L
bromomethane	74–83–9	0.2 µg/L
sec-butylbenzene	135–98–8	0.04 µg/L
chlorodifluoromethane (HCFC–22)	75–45–6	0.08 µg/L
bromochloromethane (halon 1011)	74–97–5	0.06 µg/L
1,4-Dioxane	123–91–1	0.07 µg/L
Perfluorooctane sulfonic acid (PFOS)	1763–23–1	0.04 µg/L
Perfluorooctanoic acid (PFOA)	335–67–1	0.02 µg/L
Perfluorononanoic acid (PFNA)	375–95–1	0.02 µg/L
Perfluorohexane sulfonic acid (PFHxS)	355–46–4	0.03 µg/L
Perfluoroheptanoic acid (PFHpA)	375–85–9	0.01 µg/L
Perfluorobutanesulfonic acid (PFBS)	375–73–5	0.09 µg/L

Entry Point and Distribution System Maximum Residence Time		
Vanadium	7440–62–2	0.2 µg/L
Molybdenum	7439–98–7	1.0 µg/L
Cobalt	7440–48–4	1.0 µg/L
Strontium	7440–24–6	0.3 µg/L
Chlorate	14866–68–3	20 µg/L

Analyte	MWH Method	MWH Analytical Mode	MRL ng/L
1,7-Dimethylxanthine	LC-MS-MS	Positive	5
2,4-D	LC-MS-MS	Negative	5
4-nonylphenol - semi quantitative	LC-MS-MS	Negative	100
4-tert-octylphenol	LC-MS-MS	Negative	50
Acesulfame-K	LC-MS-MS	Negative	20
Acetaminophen	LC-MS-MS	Positive	5
Albuterol	LC-MS-MS	Positive	5
Amoxicillin (semi-quantitative)	LC-MS-MS	Positive	20
Andorostenedione	LC-MS-MS	Positive	5
Atenolol	LC-MS-MS	Positive	5
Atrazine	LC-MS-MS	Positive	5
Bendroflumethiazide	LC-MS-MS	Negative	5
Bezafibrate	LC-MS-MS	Positive	5
BPA	LC-MS-MS	Negative	10
Bromacil	LC-MS-MS	Positive	5
Butalbital	LC-MS-MS	Negative	5
Butylparben	LC-MS-MS	Negative	5
Caffeine	LC-MS-MS	Positive	5
Carbadox	LC-MS-MS	Positive	5
Carbamazepine	LC-MS-MS	Positive	5
Carisoprodol	LC-MS-MS	Positive	5
Chloramphenicol	LC-MS-MS	Negative	10
Chloridazon	LC-MS-MS	Positive	5
Chlorotoluron	LC-MS-MS	Positive	5
Cimetidine	LC-MS-MS	Positive	5
Clofibric Acid	LC-MS-MS	Negative	5
Cotinine	LC-MS-MS	Positive	10
Cyanazine	LC-MS-MS	Positive	5
DACT	LC-MS-MS	Positive	5
DEA	LC-MS-MS	Positive	5
DEET	LC-MS-MS	Positive	2
Dehydronifedipine	LC-MS-MS	Positive	5
DIA	LC-MS-MS	Positive	5
Diazepam	LC-MS-MS	Positive	5
Diclofenac	LC-MS-MS	Negative	5
Dilantin	LC-MS-MS	Positive	20
Diuron	LC-MS-MS	Positive	5
Erythromycin	LC-MS-MS	Positive	10
Estradiol	LC-MS-MS	Negative	5
Estrone	LC-MS-MS	Negative	5
Ethinyl Estradiol - 17 alpha	LC-MS-MS	Negative	5
Ethylparaben	LC-MS-MS	Negative	20
Flumeqine	LC-MS-MS	Positive	10
Fluoxetine	LC-MS-MS	Positive	10
Gemfibrozil	LC-MS-MS	Negative	5

Analyte	MWH Method	MWH Analytical Mode	MRL ng/L
Ibuprofen	LC-MS-MS	Negative	10
Iohexal	LC-MS-MS	Negative	10
Iopromide	LC-MS-MS	Negative	5
Isobutylparaben	LC-MS-MS	Negative	5
Isoproturon	LC-MS-MS	Positive	100
Ketoprofen	LC-MS-MS	Positive	5
Ketorolac	LC-MS-MS	Positive	5
Lidocaine	LC-MS-MS	Positive	5
Lincomycin	LC-MS-MS	Positive	10
Linuron	LC-MS-MS	Positive	5
Lopressor	LC-MS-MS	Positive	20
Meclofenamic Acid	LC-MS-MS	Positive	5
Meprobamate	LC-MS-MS	Positive	5
Metazachlor	LC-MS-MS	Positive	5
Methylparaben	LC-MS-MS	Negative	20
Naproxen	LC-MS-MS	Negative	10
Nifedipine	LC-MS-MS	Positive	20
Norethisterone	LC-MS-MS	Positive	5
Oxolinic acid	LC-MS-MS	Positive	5
Pentoxifylline	LC-MS-MS	Positive	5
Phenazone	LC-MS-MS	Positive	5
Primidone	LC-MS-MS	Positive	5
Progesterone	LC-MS-MS	Positive	5
Propazine	LC-MS-MS	Positive	5
Propylparaben	LC-MS-MS	Negative	5
Quinoline	LC-MS-MS	Positive	5
Simazine	LC-MS-MS	Positive	5
Sucralose	LC-MS-MS	Negative	100
Sulfachloropyridazine	LC-MS-MS	Positive	5
Sulfadiazine	LC-MS-MS	Positive	5
Sulfadimethoxine	LC-MS-MS	Positive	5
Sulfamerazine	LC-MS-MS	Positive	5
Sulfamethazine	LC-MS-MS	Positive	5
Sulfamethizole	LC-MS-MS	Positive	5
Sulfamethoxazole	LC-MS-MS	Positive	5
Sulfathiazole	LC-MS-MS	Positive	5
TCEP	LC-MS-MS	Positive	5
TCPP	LC-MS-MS	Positive	5
TDCPP	LC-MS-MS	Positive	5
Testosterone	LC-MS-MS	Positive	10
Theobromine	LC-MS-MS	Positive	5
Theophylline	LC-MS-MS	Positive	10
Triclosan	LC-MS-MS	Negative	10
Trimethoprim	LC-MS-MS	Positive	5
Warfarin	LC-MS-MS	Negative	5

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TABLE G-5

PRIORITY POLLUTANT NUMERIC CRITERIA AND GUIDANCE

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A		B Freshwater		C Saltwater		D Human Health (10^{-6} risk for carcinogens) For consumption of:	
# Compound	CAS Number	Criterion Maximum Conc. [d] B1	Criterion Continuous Conc. [d] B2	Criterion Maximum Conc. [d] C1	Criterion Continuous Conc. [d] C2	Water & Organisms (μg/L) D1	Organisms Only (μg/L) D2
1. Antimony	7440360					14 a,s	4300 a,t
2. Arsenic [b]	7440382	340 i,m,w	150 i,m,w	69 i,m	36 i,m		
3. Beryllium	7440417					n	n
4. Cadmium [b]	7440439	4.3 e,i,m,w,x	2.2 e,i,m,w	42 i,m	9.3 i,m	n	n
5a. Chromium (III)	16065831	550 e,i,m,o	180 e,i,m,o			n	n
5b. Chromium (VI) [b]	18540299	16 i,m,w	11 i,m,w	1100 i,m	50 i,m	n	n
6. Copper [b]	7440508	13 e,i,m,w,x	9.0 e,i,m,w	4.8 i,m	3.1 i,m	1300	
7. Lead [b]	7439921	65 e,i,m	2.5 e,i,m	210 i,m	8.1 i,m	n	n
8. Mercury [b]	7439976	[Reserved]	[Reserved]	[Reserved]	[Reserved]	0.050 a	0.051 a
9. Nickel [b]	7440020	470 e,i,m,w	52 e,i,m,w	74 i,m	8.2 i,m	610 a	4600 a
10. Selenium [b]	7782492	[Reserved] p	5.0 q	290 i,m	71 i,m	n	n
11. Silver [b]	7440224	3.4 e,i,m		1.9 i,m			
12. Thallium	7440280					1.7 a,s	6.3 a,t
13. Zinc [b]	7440666	120 e,i,m,w,x	120 e,i,m,w	90 i,m	81 i,m		
14. Cyanide [b]	57125	22 o	5.2 o	1 r	1 r	700 a	220,000 a,j
15. Asbestos	1332214					7,000,000 fibers/L k,s	
16. 2,3,7,8-TCDD (Dioxin)	1746016					0.000000013 c	0.000000014 c
17. Acrolein	107028					320 s	780 t
18. Acrylonitrile	107131					0.059 a,c,s	0.66 a,c,t
19. Benzene	71432					1.2 a,c	71 a,c
20. Bromoform	75252					4.3 a,c	360 a,c
21. Carbon Tetrachloride	56235					0.25 a,c,s	4.4 a,c,t
22. Chlorobenzene	108907					680 a,s	21,000 a,j,t
23. Chlorodibromomethane	124481					0.401 a,c	34 a,c
24. Chloroethane	75003						
25. 2-Chloroethylvinyl Ether	110758						

26. Chloroform	67663					[Reserved]	[Reserved]
27. Dichlorobromomethane	75274					0.56 a,c	46 a,c
28. 1,1-Dichloroethane	75343						
29. 1,2-Dichloroethane	107062					0.38 a,c,s	99 a,c,t
30. 1,1-Dichloroethylene	75354					0.057 a,c,s	3.2 a,c,t
31. 1,2-Dichloropropane	78875					0.52 a	39 a
32. 1,3-Dichloropropylene	542756					10 a,s	1,700 a,t
33. Ethylbenzene	100414					3,100 a,s	29,000 a,t
34. Methyl Bromide	74839					48 a	4,000 a
35. Methyl Chloride	74873					n	n
36. Methylene Chloride	75092					4.7 a,c	1,600 a,c
37. 1,1,2,2-Tetrachloroethane	79345					0.17 a,c,s	11 a,c,t
38. Tetrachloroethylene	127184					0.8 c,s	8.85 c,t
39. Toluene	108883					6,800 a	200,000 a
40. 1,2-Trans-Dichloroethylene	156605					700 a	140,000 a
41. 1,1,1-Trichloroethane	71556					n	n
42. 1,1,2-Trichloroethane	79005					0.60 a,c,s	42 a,c,t
43. Trichloroethylene	79016					2.7 c,s	81 c,t
44. Vinyl Chloride	75014					2 c,s	525 c,t
45. 2-Chlorophenol	95578					120 a	400 a
46. 2,4-Dichlorophenol	120832					93 a,s	790 a,t
47. 2,4-Dimethylphenol	105679					540 a	2,300 a
48. 2-Methyl-4,6-Dinitrophenol	534521					13.4 s	765 t
49. 2,4-Dinitrophenol	51285					70 a,s	14,000 a,t
50. 2-Nitrophenol	88755						
51. 4-Nitrophenol	100027						
52. 3-Methyl-4-Chlorophenol	59507						
53. Pentachlorophenol	87865	19 f,w	15 f,w	13	7.9	0.28 a,c	8.2 a,c,j
54. Phenol	108952					21,000 a	4,600,000 a,j,t
55. 2,4,6-Trichlorophenol	88062					2.1 a,c	6.5 a,c
56. Acenaphthene	83329					1,200 a	2,700 a
57. Acenaphthylene	208968						
58. Anthracene	120127					9,600 a	110,000 a

59. Benzidine	92875					0.00012 a,c,s	0.00054 a,c,t
60. Benzo(a)Anthracene	56553					0.0044 a,c	0.049 a,c
61. Benzo(a)Pyrene	50328					0.0044 a,c	0.049 a,c
62. Benzo(b)Fluoranthene	205992					0.0044 a,c	0.049 a,c
63. Benzo(ghi)Perylene	191242						
64. Benzo(k)Fluoranthene	207089					0.0044 a,c	0.049 a,c
65. Bis(2-Chloroethoxy)Methane	111911						
66. Bis(2-Chloroethyl)Ether	111444					0.031 a,c,s	1.4 a,c,t
67. Bis(2-Chloroisopropyl)Ether	39638329					1,400 a	170,000 a,t
68. Bis(2-Ethylhexyl)Phthalate	117817					1.8 a,c,s	5.9 a,c,t
69. 4-Bromophenyl Phenyl Ether	101553						
70. Butylbenzyl Phthalate	85687					3,000 a	5,200 a
71. 2-Chloronaphthalene	91587					1,700 a	4,300 a
72. 4-Chlorophenyl Phenyl Ether	7005723						
73. Chrysene	218019					0.0044 a,c	0.049 a,c
74. Dibenzo(a,h)Anthracene	53703					0.0044 a,c	0.049 a,c
75. 1,2 Dichlorobenzene	95501					2,700 a	17,000 a
76. 1,3 Dichlorobenzene	541731					400	2,600
77. 1,4 Dichlorobenzene	106467					400	2,600
78. 3,3'-Dichlorobenzidine	91941					0.04 a,c,s	0.077 a,c,t
79. Diethyl Phthalate	84662					23,000 a,s	120,000 a,t
80. Dimethyl Phthalate	131113					313,000 s	2,900,000 t
81. Di-n-Butyl Phthalate	84742					2,700 a,s	12,000 a,t
82. 2,4-Dinitrotoluene	121142					0.11 c,s	9.1 c,t
83. 2,6-Dinitrotoluene	606202						
84 Di-n-Octyl Phthalate	117840						
85. 1,2-Diphenylhydrazine	122667					0.040 a,c,s	0.54 a,c,t
86. Fluoranthene	206440					300 a	370 a
87. Fluorene	86737					1,300 a	14,000 a
88. Hexachlorobenzene	118741					0.00075 a,c	0.00077 a,c
89. Hexachlorobutadiene	87683					0.44 a,c,s	50 a,c,t
90. Hexachlorocyclopentadiene	77474					240 a,s	17,000 a,j,t
91. Hexachloroethane	67721					1.9 a,c,s	8.9 a,c,t

92. Indeno(1,2,3-cd) Pyrene	193395					0.0044 a,c	0.049 a,c
93. Isophorone	78591					8.4 c,s	600 c,t
94. Naphthalene	91203						
95. Nitrobenzene	98953					17 a,s	1,900 a,j,t
96. N-Nitrosodimethylamine	62759					0.00069 a,c,s	8.1 a,c,t
97. N-Nitrosodi-n-Propylamine	621647					0.005 a	1.4 a
98. N-Nitrosodiphenylamine	86306					5.0 a,c,s	16 a,c,t
99. Phenanthrene	85018						
100. Pyrene	129000					960 a	11,000 a
101. 1,2,4-Trichlorobenzene	120821						
102. Aldrin	309002	3 g		1.3 g		0.00013 a,c	0.00014 a,c
103. alpha-BHC	319846					0.0039 a,c	0.013 a,c
104. beta-BHC	319857					0.014 a,c	0.046 a,c
105. gamma-BHC	58899	0.95 w		0.16 g		0.019 c	0.063 c
106. delta-BHC	319868						
107. Chlordane	57749	2.4 g	0.0043 g	0.09 g	0.004 g	0.00057 a,c	0.00059 a,c
108. 4,4'-DDT	50293	1.1 g	0.001 g	0.13 g	0.001 g	0.00059 a,c	0.00059 a,c
109. 4,4'-DDE	72559					0.00059 a,c	0.00059 a,c
110. 4,4'-DDD	72548					0.00083 a,c	0.00084 a,c
111. Dieldrin	60571	0.24 w	0.056 w	0.71 g	0.0019 g	0.00014 a,c	0.00014 a,c
112. alpha-Endosulfan	959988	0.22 g	0.056 g	0.034 g	0.0087 g	110 a	240 a
113. beta-Endosulfan	33213659	0.22 g	0.056 g	0.034 g	0.0087 g	110 a	240 a
114. Endosulfan Sulfate	1031078					110 a	240 a
115. Endrin	72208	0.086 w	0.036 w	0.037 g	0.0023 g	0.76 a	0.81 a,j
116. Endrin Aldehyde	7421934					0.76 a	0.81 a,j
117. Heptachlor	76448	0.52 g	0.0038 g	0.053 g	0.0036 g	0.00021 a,c	0.00021 a,c
118. Heptachlor Epoxide	1024573	0.52 g	0.0038 g	0.053 g	0.0036 g	0.00010 a,c	0.00011 a,c
119-125. Polychlorinated biphenyls (PCBs)			0.014 u		0.03 u	0.00017 c,v	0.00017 c,v
126. Toxaphene	8001352	0.73	0.0002	0.21	0.0002	0.00073 a,c	0.00075 a,c
Total Number of Criteria [h]		22	21	22	20	92	90

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Footnotes to Table in Parargraph (b)(1):

a. Criteria revised to reflect the Agency q1* or RfD, as contained in the Integrated Risk Information System (IRIS) as of October 1, 1996. The fish tissue bioconcentration factor (BCF) from the 1980 documents was retained in each case.

b. Criteria apply to California waters except for those waters subject to objectives in Tables III–2A and III–2B of the San Francisco Regional Water Quality Control Board's (SFRWQCB) 1986 Basin Plan, that were adopted by the SFRWQCB and the State Water Resources Control Board, approved by EPA, and which continue to apply.

c. Criteria are based on carcinogenicity of 10 (-6) risk.

d. Criteria Maximum Concentration (CMC) equals the highest concentration of a pollutant to which aquatic life can be exposed for a short period of time without deleterious effects. Criteria Continuous Concentration (CCC) equals the highest concentration of a pollutant to which aquatic life can be exposed for an extended period of time (4 days) without deleterious effects. ug/L equals micrograms per liter.

e. Freshwater aquatic life criteria for metals are expressed as a function of total hardness (mg/L) in the water body. The equations are provided in matrix at paragraph (b)(2) of this section. Values displayed above in the matrix correspond to a total hardness of 100 mg/l.

f. Freshwater aquatic life criteria for pentachlorophenol are expressed as a function of pH, and are calculated as follows: Values displayed above in the matrix correspond to a pH of 7.8. CMC = $\exp(1.005(\mathrm{pH}) - 4.869)$. CCC = $\exp(1.005(\mathrm{pH}) - 5.134)$.

g. This criterion is based on 304(a) aquatic life criterion issued in 1980, and was issued in one of the following documents: Aldrin/Dieldrin (EPA 440/5–80–019), Chlordane (EPA 440/5–80–027), DDT (EPA 440/5–80–038), Endosulfan (EPA 440/5–80–046), Endrin (EPA 440/5–80–047), Heptachlor (440/5–80–052), Hexachlorocyclohexane (EPA 440/5–80–054), Silver (EPA 440/5–80–071). The Minimum Data Requirements and derivation procedures were different in the 1980 Guidelines than in the 1985 Guidelines. For example, a ''CMC'' derived using the 1980 Guidelines was derived to be used as an instantaneous maximum. If assessment is to be done using an averaging period, the values given should be divided by 2 to obtain a value that is more comparable to a CMC derived using the 1985 Guidelines.

h. These totals simply sum the criteria in each column. For aquatic life, there are 23 priority toxic pollutants with some type of freshwater or saltwater, acute or chronic criteria. For human health, there are 92 priority toxic pollutants with either ''water + organism'' or ''organism only'' criteria. Note that these totals count chromium as one pollutant even though EPA has developed criteria based on two valence states. In the matrix, EPA has assigned numbers 5a and 5b to the criteria for chromium to reflect the fact that the list of 126 priority pollutants includes only a single listing for chromium.

i. Criteria for these metals are expressed as a function of the water-effect ratio, WER, as defined in paragraph (c) of this section. CMC = column B1 or C1 value x WER; CCC = column B2 or C2 value x WER.

j. No criterion for protection of human health from consumption of aquatic organisms (excluding water) was presented in the 1980 criteria document or in the 1986 Quality Criteria for Water. Nevertheless, sufficient information was presented in the 1980 document to allow a calculation of a criterion, even though the results of such a calculation were not shown in the document.

k. The CWA 304(a) criterion for asbestos is the MCL.

l. [Reserved]

m. These freshwater and saltwater criteria for metals are expressed in terms of the dissolved fraction of the metal in the water column. Criterion values were calculated by using EPA's Clean Water Act 304(a) guidance values (described in the total recoverable fraction) and then applying the conversion factors in § 131.36(b)(1) and (2).

n. EPA is not promulgating human health criteria for these contaminants. However, permit authorities should address these contaminants in NPDES permit actions using the State's existing narrative criteria for toxics.

o. These criteria were promulgated for specific waters in California in the National Toxics Rule (''NTR''), at § 131.36. The specific waters to which the NTR criteria apply include: Waters of the State defined as bays or estuaries and waters of the State defined as inland, i.e., all surface waters of the State not ocean waters. These waters specifically include the San Francisco Bay upstream to and including Suisun Bay and the Sacramento-San Joaquin Delta. This section does not apply instead of the NTR for this criterion.

p. A criterion of 20 ug/l was promulgated for specific waters in California in the NTR and was promulgated in the total recoverable form. The specific waters to which the NTR criterion applies include: Waters of the San Francisco Bay upstream to and including Suisun Bay and the Sacramento-San Joaquin Delta; and waters of Salt Slough, Mud Slough (north) and the San Joaquin River, Sack Dam to the mouth of the Merced River. This section does not apply instead of the NTR for this criterion. The State of California adopted and EPA approved a site specific criterion for the San Joaquin River, mouth of Merced to Vernalis; therefore, this section does not apply to these waters.

q. This criterion is expressed in the total recoverable form. This criterion was promulgated for specific waters in California in the NTR and was promulgated in the total recoverable form. The specific waters to which the NTR criterion applies include: Waters of the San Francisco Bay upstream to and including Suisun Bay and the Sacramento-San Joaquin Delta; and waters of Salt Slough, Mud Slough (north) and the San Joaquin River, Sack Dam to Vernalis. This criterion does not apply instead of the NTR for these waters. This criterion applies to additional waters of the United States in the State of California pursuant to 40 CFR 131.38(c). The State of California adopted and EPA approved a site-specific criterion for the Grassland Water District, San Luis National Wildlife Refuge, and the Los Banos State Wildlife Refuge; therefore, this criterion does not apply to these waters.

r. These criteria were promulgated for specific waters in California in the NTR. The specific waters to which the NTR criteria apply include: Waters of the State defined as bays or estuaries including the San Francisco Bay upstream to and including Suisun Bay and the Sacramento-San Joaquin Delta. This section does not apply instead of the NTR for these criteria.

s. These criteria were promulgated for specific waters in California in the NTR. The specific waters to which the NTR criteria apply include: Waters of the Sacramento-San Joaquin Delta and waters of the State defined as inland (*i.e.,* all surface waters of the State not bays or estuaries or ocean) that include a MUN use designation. This section does not apply instead of the NTR for these criteria.

t. These criteria were promulgated for specific waters in California in the NTR. The specific waters to which the NTR criteria apply include: Waters of the State defined as bays and estuaries including San Francisco Bay upstream to and including Suisun Bay and the Sacramento-San Joaquin Delta; and waters of the State defined as inland (i.e., all surface waters of the State not bays or estuaries or ocean) without a MUN use designation. This section does not apply instead of the NTR for these criteria.

u. PCBs are a class of chemicals which include aroclors 1242, 1254, 1221, 1232, 1248, 1260, and 1016, CAS numbers 53469219, 11097691, 11104282, 11141165, 12672296, 11096825, and 12674112, respectively. The aquatic life criteria apply to the sum of this set of seven aroclors.

v. This criterion applies to total PCBs, e.g., the sum of all congener or isomer or homolog or aroclor analyses.

w. This criterion has been recalculated pursuant to the 1995 Updates: Water Quality Criteria Documents for the Protection of Aquatic Life in Ambient Water, Office of Water, EPA–820-B–96–001, September 1996. See also Great Lakes Water Quality Initiative Criteria Documents for the Protection of Aquatic Life in Ambient Water, Office of Water, EPA–80–B–95–004, March 1995.

x. The State of California has adopted and EPA has approved site specific criteria for the Sacramento River (and tributaries) above Hamilton City; therefore, these criteria do not apply to these waters.

General Notes to Table in Paragraph (b)(1)

1. The table in this paragraph (b)(1) lists all of EPA's priority toxic pollutants whether or not criteria guidance are available. Blank spaces indicate the absence of national section 304(a) criteria guidance. Because of variations in chemical nomenclature systems, this listing of toxic pollutants does not duplicate the listing in Appendix A to 40 CFR Part 423–126 Priority Pollutants. EPA has added the Chemical Abstracts Service (CAS) registry numbers, which provide a unique identification for each chemical.

2. The following chemicals have organoleptic-based criteria recommendations that are not included on this chart: zinc, 3-methyl-4-chlorophenol.

3. Freshwater and saltwater aquatic life criteria apply as specified in paragraph (c)(3) of this section.

(2) Factors for Calculating Metals Criteria. Final CMC and CCC values should be rounded to two significant figures.

(i) *CMC = WER* × (*Acute Conversion Factor*) × (exp{m_A[1n (*hardness*)]+b_A})

(ii) *CCC = WER* × (*Acute Conversion Factor*) × (exp{m_C[1n (*hardness*)]+b_C})

(iii) Table 1 to paragraph (b)(2) of this section:

Metal	m_A	b_A	m_C	b_C
Cadmium	1.128	−3.6867	0.7852	−2.715
Copper	0.9422	−1.700	0.8545	−1.702
Chromium (III)	0.8190	3.688	0.8190	1.561
Lead	1.273	−1.460	1.273	−4.705
Nickel	0.8460	2.255	0.8460	0.0584
Silver	1.72	−6.52		
Zinc	0.8473	0.884	0.8473	0.884

Note to Table 1: The term ''exp'' represents the base e exponential function.

(iv) Table 2 to paragraph (b)(2) of this section:

Metal	Conversion factor (CF) for freshwater acute criteria	CF for freshwater chronic criteria	CF for saltwater acute criteria	CF [a] for saltwater chronic criteria
Antimony	(d)	(d)	(d)	(d)
Arsenic	1.000	1.000	1.000	1.000
Beryllium	(d)	(d)	(d)	(d)
Cadmium	[b] 0.944	[b] 0.909	0.994	0.994
Chromium (III)	0.316	0.860	(d)	(d)
Chromium (VI)	0.982	0.962	0.993	0.993
Copper	0.960	0.960	0.83	0.83
Lead	[b] 0.791	[b] 0.791	0.951	0.951
Mercury	....	....	....	....
Nickel	0.998	0.997	0.990	0.990
Selenium	....	(c)	0.998	0.998
Silver	0.85	(d)	0.85	(d)
Thallium	(d)	(d)	(d)	(d)
Zinc	0.978	0.986	0.946	0.946

Footnotes to Table 2 of Paragraph (b)(2):

[a] Conversion Factors for chronic marine criteria are not currently available. Conversion Factors for acute marine criteria have been used for both acute and chronic marine criteria.

[b] Conversion Factors for these pollutants in freshwater are hardness dependent. CFs are based on a hardness of 100 mg/l as calcium carbonate ($CaCO_3$). Other hardness can be used; CFs should be recalculated using the equations in table 3 to paragraph (b)(2) of this section.

[c] Bioaccumulative compound and inappropriate to adjust to percent dissolved.

[d] EPA has not published an aquatic life criterion value.

Note to Table 2 of Paragraph (b)(2): The term ''Conversion Factor'' represents the recommended conversion factor for converting a metal criterion expressed as the total recoverable fraction in the water column to a criterion expressed as the dissolved fraction in the water column. See ''Office of Water Policy and Technical Guidance on Interpretation and Implementation of Aquatic Life Metals Criteria'', October 1, 1993, by Martha G. Prothro, Acting Assistant Administrator for Water available from Water Resource Center, USEPA, Mailcode RC4100, M Street SW, Washington, DC, 20460 and the note to § 131.36(b)(1).

(v) Table 3 to paragraph (b)(2) of this section:

	Acute	Chronic
Cadmium	CF=1.136672—[(ln {hardness}) (0.041838)]	CF = 1.101672—[(ln {hardness})(0.041838)]
Lead	CF=1.46203—[(ln {hardness})(0.145712)]	CF = 1.46203—[(ln {hardness})(0.145712)]

(c) *Applicability.* (1) The criteria in paragraph (b) of this section apply to the State's designated uses cited in paragraph (d) of this section and apply concurrently with any criteria adopted by the State, except when State regulations contain criteria which are more stringent for a particular parameter and use, or except as provided in footnotes p, q, and x to the table in paragraph (b)(1) of this section.

(2) The criteria established in this section are subject to the State's general rules of applicability in the same way and to the same extent as are other Federally-adopted and State-adopted numeric toxics criteria when applied to the same use classifications including mixing zones, and low flow values below which numeric standards can be exceeded in flowing fresh waters.

(i) For all waters with mixing zone regulations or implementation procedures, the criteria apply at the appropriate locations within or at the boundary of the mixing zones; otherwise the criteria apply throughout the water body including at the point of discharge into the water body.

(ii) The State shall not use a low flow value below which numeric standards can be exceeded that is less stringent than the flows in Table 4 to paragraph (c)(2) of this section for streams and rivers.

(iii) Table 4 to paragraph (c)(2) of this section:

Criteria	Design flow
Aquatic Life Acute Criteria (CMC).	1 Q 10 or 1 B 3
Aquatic Life Chronic Criteria (CCC).	7 Q 10 or 4 B 3
Human Health Criteria.	Harmonic Mean Flow

Note to Table 4 of Paragraph (c)(2): 1. CMC (Criteria Maximum Concentration) is the water quality criteria to protect against acute effects in aquatic life and is the highest instream concentration of a priority toxic pollutant consisting of a short-term average not to be exceeded more than once every three years on the average.

2. CCC (Continuous Criteria Concentration) is the water quality criteria to protect against chronic effects in aquatic life and is the highest in stream concentration of a priority toxic pollutant consisting of a 4-day average not to be exceeded more than once every three years on the average.

3. 1 Q 10 is the lowest one day flow with an average recurrence frequency of once in 10 years determined hydrologically.

4. 1 B 3 is biologically based and indicates an allowable exceedence of once every 3 years. It is determined by EPA's computerized method (DFLOW model).

5. 7 Q 10 is the lowest average 7 consecutive day low flow with an average recurrence frequency of once in 10 years determined hydrologically.

6. 4 B 3 is biologically based and indicates an allowable exceedence for 4 consecutive days once every 3 years. It is determined by EPA's computerized method (DFLOW model).

(iv) If the State does not have such a low flow value below which numeric standards do not apply, then the criteria included in paragraph (d) of this section apply at all flows.

(v) If the CMC short-term averaging period, the CCC four-day averaging period, or once in three-year frequency is inappropriate for a criterion or the site to which a criterion applies, the State may apply to EPA for approval of an alternative averaging period, frequency, and related design flow. The State must submit to EPA the bases for any alternative averaging period, frequency, and related design flow. Before approving any change, EPA will publish for public comment, a document proposing the change.

(3) The freshwater and saltwater aquatic life criteria in the matrix in paragraph (b)(1) of this section apply as follows:

(i) For waters in which the salinity is equal to or less than 1 part per thousand 95% or more of the time, the applicable criteria are the freshwater criteria in Column B;

(ii) For waters in which the salinity is equal to or greater than 10 parts per thousand 95% or more of the time, the applicable criteria are the saltwater criteria in Column C except for selenium in the San Francisco Bay estuary where the applicable criteria are the freshwater criteria in Column B (refer to footnotes p and q to the table in paragraph (b)(1) of this section); and

(iii) For waters in which the salinity is between 1 and 10 parts per thousand as defined in paragraphs (c)(3)(i) and (ii) of this section, the applicable criteria are the more stringent of the freshwater or saltwater criteria. However, the Regional Administrator may approve the use of the alternative freshwater or saltwater criteria if scientifically defensible information and data demonstrate that on a site-specific basis the biology of the water body is dominated by freshwater aquatic life and that freshwater criteria are more appropriate; or conversely, the biology of the water body is dominated by saltwater aquatic life and that saltwater criteria are more appropriate. Before approving any change, EPA will publish for public comment a document proposing the change.

(4) *Application of metals criteria.* (i) For purposes of calculating freshwater aquatic life criteria for metals from the equations in paragraph (b)(2) of this section, for waters with a hardness of 400 mg/l or less as calcium carbonate, the actual ambient hardness of the surface water shall be used in those equations. For waters with a hardness of over 400 mg/l as calcium carbonate, a hardness of 400 mg/l as calcium carbonate shall be used with a default Water-Effect Ratio (WER) of 1, or the actual hardness of the ambient surface water shall be used with a WER. The same provisions apply for calculating the metals criteria for the comparisons provided for in paragraph (c)(3)(iii) of this section.

(ii) The hardness values used shall be consistent with the design discharge conditions established in paragraph (c)(2) of this section for design flows and mixing zones.

(iii) The criteria for metals (compounds #1—#13 in the table in paragraph (b)(1) of this section) are expressed as dissolved except where otherwise noted. For purposes of calculating aquatic life criteria for metals from the equations in footnote i to the table in paragraph (b)(1) of this section and the equations in paragraph (b)(2) of this section, the water effect ratio is generally computed as a specific pollutant's acute or chronic toxicity value measured in water from the site covered by the standard, divided by the respective acute or chronic toxicity value in laboratory dilution water. To use a water effect ratio other than the default of 1, the WER must be determined as set forth in Interim Guidance on Determination and Use of Water Effect Ratios, U.S. EPA Office of Water, EPA–823–B–94–001, February 1994, or alternatively, other scientifically defensible methods adopted by the State as part of its water quality standards program and approved by EPA. For calculation of criteria using site-specific values for both the hardness and the water effect ratio, the hardness used in the equations in paragraph (b)(2) of this section must be determined as required in paragraph (c)(4)(ii) of this section. Water hardness must be calculated from the measured calcium and magnesium ions present, and the ratio of calcium to magnesium should be approximately the same in standard laboratory toxicity testing water as in the site water.

(d)(1) Except as specified in paragraph (d)(3) of this section, all waters assigned any aquatic life or human health use classifications in the Water Quality Control Plans for the various Basins of the State (''Basin Plans'') adopted by the California State Water Resources Control Board (''SWRCB''), except for ocean waters covered by the Water Quality Control Plan for Ocean Waters of California (''Ocean Plan'') adopted by the SWRCB with resolution Number 90–27 on March 22, 1990, are subject to the criteria in paragraph (d)(2) of this section, without exception. These criteria apply to waters identified in the Basin Plans. More particularly, these criteria apply to waters identified in the Basin Plan chapters designating beneficial uses for waters within the region. Although the State has adopted several use designations for each of these waters, for purposes of this action, the specific standards to be applied in paragraph (d)(2) of this section are based on the presence in all waters of some aquatic life designation and the presence or absence of the MUN use designation (municipal and domestic supply). (See Basin Plans for more detailed use definitions.)

(2) The criteria from the table in paragraph (b)(1) of this section apply to the water and use classifications defined in paragraph (d)(1) of this section as follows:

Water and use classification	Applicable criteria
(i) All inland waters of the United States or enclosed bays and estuaries that are waters of the United States that include a MUN use designation.	(A) Columns B1 and B2—all pollutants (B) Columns C1 and C2—all pollutants (C) Column D1—all pollutants
(ii) All inland waters of the United States or enclosed bays and estuaries that are waters of the United States that do not include a MUN use designation.	(A) Columns B1 and B2—all pollutants (B) Columns C1 and C2—all pollutants (C) Column D2—all pollutants

(3) Nothing in this section is intended to apply instead of specific criteria, including specific criteria for the San Francisco Bay estuary, promulgated for California in the National Toxics Rule at § 131.36.

(4) The human health criteria shall be applied at the State-adopted 10 (−6) risk level.

(5) Nothing in this section applies to waters located in Indian Country.

(e)*Schedules of compliance.* (1) It is presumed that new and existing point source dischargers will promptly comply with any new or more restrictive water quality-based effluent limitations (''WQBELs'') based on the water quality criteria set forth in this section.

(2) When a permit issued on or after May 18, 2000 to a new discharger contains a WQBEL based on water quality criteria set forth in paragraph (b) of this section, the permittee shall comply with such WQBEL upon the commencement of the discharge. A new discharger is defined as any building, structure, facility, or installation from which there is or may be a ''discharge of pollutants'' (as defined in 40 CFR 122.2) to the State of California's inland surface waters or enclosed bays and estuaries, the construction of which commences after May 18, 2000.

(3) Where an existing discharger reasonably believes that it will be infeasible to promptly comply with a new or more restrictive WQBEL based on the water quality criteria set forth in this section, the discharger may request approval from the permit issuing authority for a schedule of compliance.

(4) A compliance schedule shall require compliance with WQBELs based on water quality criteria set forth in paragraph (b) of this section as soon as possible, taking into account the dischargers' technical ability to achieve compliance with such WQBEL.

(5) If the schedule of compliance exceeds one year from the date of permit issuance, reissuance or modification, the schedule shall set forth interim requirements and dates for their achievement. The dates of completion between each requirement may not exceed one year. If the time necessary for completion of any requirement is more than one year and is not readily divisible into stages for completion, the permit shall require, at a minimum, specified dates for annual submission of progress reports on the status of interim requirements.

(6) In no event shall the permit issuing authority approve a schedule of compliance for a point source discharge which exceeds five years from the date of permit issuance, reissuance, or modification, whichever is sooner. Where shorter schedules of compliance are prescribed or schedules of compliance are prohibited by law, those provisions shall govern.

(7) If a schedule of compliance exceeds the term of a permit, interim permit limits effective during the permit shall be included in the permit and addressed in the permit's fact sheet or statement of basis. The administrative record for the permit shall reflect final permit limits and final compliance dates. Final compliance dates for final permit limits, which do not occur during the term of the permit, must occur within five years from the date of issuance, reissuance or modification of the permit which initiates the compliance schedule. Where shorter schedules of compliance are prescribed or schedules of compliance are prohibited by law, those provisions shall govern.

(8) The provisions in this paragraph (e), Schedules of compliance, shall expire on May 18, 2005.

[FR Doc. 00–11106 Filed 5–17–00; 8:45 am]

BILLING CODE 6560–50–P

Table G-6
Basin Plan Numeric Water Quality Objectives

Constituent	Water Quality Objective
Total Dissolved Solids	300 mg/L
Chloride	50 mg/L
Sulfate	65 mg/L
Percent Sodium	60%
Iron	0.3 mg/L
Manganese	0.05 mg/L
Boron	1.0 mg/L
Turbidity	20 NTU
Color	20 color units
Fluoride	1.0 mg/L
Nutrients	-Total Phosphorus less than 0.025 mg/L -Natural ratios of total nitrogen to total phosphorus are to be upheld, if no data is available a ratio (N:P) of 10:1 is to be used.
Ammonia (as N)	0.025 mg/L
Fecal Coliform	-Not less than 5 samples every 30 days -Sampling shall not exceed a log mean of 200/100mL -No more than 10% of samples during any 30 day period shall exceed 400/100mL
Dissolved Oxygen	- not less than 6.0 mg/L -annual mean DO shall not be less than 7.0 mg/L more than 10% of the time
pH	-change in pH level shall not exceed 0.5 units -pH shall not be depressed below 6.5 nor raised above 8.5
Phenolic Compounds	1.0 µg/L

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APPENDIX H – COMPARISON OF CEC DATA MEASURED IN NCWRP TERTIARY WATER TO MEC/MTL DATA PRESENTED IN THE SWRCB 2010 FINAL REPORT

Table H-1 Comparison of CEC Concentrations measured in the NCWRP Tertiary Effluent to MEC/MTL Ratio's Established in the SWRCB Final Report

CEC	Units	MDL	MTL [4]	MEC [4]	Average Detected Concentration[1] [2]	MEC/MTL	Average/MTL	Comments	Use
Hydrocodone	ng/L	1	NA	NA	83.0				Pain killer
Trimethoprim	ng/L	1	61,000	112	387.0	0.00	0.01		Anti-biotic
Acetaminophen	ng/L	1	350,000	550	2.2	0.00	0.00		Analgesic
Caffeine	ng/L	10	350	900	20.0	2.57	0.06		Stimulant
Erythromycin-H_2O	ng/L	1	4,900	113	318.3	0.02	0.06		Anti-biotic
Sulfamethoxazole	ng/L	1	35,000	1,400	857.3	0.04	0.02		Anti-biotic
Fluoxetine	ng/L	1	10,000	31	36.7	0.00	0.00		Anti-depressant
Pentoxifylline	ng/L	1	NA	NA	4.3				Blood thinner
Meprobamate	ng/L	1	260,000	430	283.3	0.00	0.00		Anti-anxiety
Dilantin	ng/L	1	NA	217	141.3				Anti-convulsant
TCEP	ng/L	10	2,500	688	300.3	0.28	0.12		Fire retardent
Carbamazepine	ng/L	1	1,000	400	266.3	0.40	0.27		Anti-seizure/analgesic
DEET [5]	ng/L	1	2,500	1,520	250.0	0.61	0.10		Insect repellant
Atrazine	ng/L	1	NA	NA	2.3				Herbicide
Diazepam	ng/L	1	NA	NA	3.6				Anti-anxiety/muscle relaxant
Oxybenzone	ng/L	1	NA	NA	14.3				Sunscreen
Estriol	ng/L	5	350	NA	6.3		0.02		Steroid
Ethynylestradiol	ng/L	1	350	1	0.5	0.00	0.00		Synthetic birth control
Estrone	ng/L	1	350	73	68.8	0.21	0.20		Steroid
Estradiol	ng/L	1	0.9	8.4	6.3	9.33	7.04		Steroid
Testosterone	ng/L	1			0.5				Steroid
Progesterone	ng/L	1	110,000	18	0.5	0.00	0.00		Steroid
Androstenedione	ng/L	1	NA	NA	5.2				Steroid
Iopromide [5]	ng/L	1	750,000	2,174	556.3	0.00	0.00		X-ray contrast reagent
Naproxen	ng/L	1	220,000	851	183.3	0.00	0.00		Analgesic
Ibuprofen	ng/L	1	34,000	500	57.3	0.01	0.00		Pain killer
Diclofenac	ng/L	1	1,800	230	65.7	0.13	0.04		Arthritis treatment
Triclosan	ng/L	1	350	485	199.7	1.39	0.57		Anti-biotic
Gemfibrozil [5]	ng/L	1	45,000	3,550	689.3	0.08	0.02		Anti-cholesterol
NDMA	ng/L	2	10	68	42.3 [3]	6.80	4.23		Industrial (e.g. rocket fuel production)
1,2,3-Trichloropropane	ng/L	5	5	NA	250 [6]			Never detected. 500 ng/L MDL	
Hydrazine	ng/L	1	10						
Quinoline	ng/L	1	10						
3-Hydroxycarbofuran	ng/L	400	420	NA	250 [6]		0.60	Never detected. 500 ng/L MDL	
Sucralose [5]	ng/L	--	NA	26,390	NA				food sweetener

Notes:

[1] Average and high detected concentrations from tertiary treatment effluent samples collected on 3/23/2005, 4/13/2005, and 12/30/2005.

[2] Non-detections calculated in at half the MDL.

[3] Average and high detected concentrations from tertiary treatment effluent samples collected on 3/23/2005, 4/13/2005, and 12/12/2005.

[4] MTL and MEC as developed in SWRCB, 2010. MTL=Monitor triggering limit; MEC=Measured Environmental Concentration. Compounds with MEC/MTL > 1 recommended for monitoring.

[5] Identified for surface spreading and direct injection operations as a viable performance indicator compound along with certain surrogate parameters (SWRCB, 2010).

[6] Average and high detected concentrations from tertiary treatment effluent samples collected on 3/23/2005, 4/13/2005, and 12/12/2005.

Acronyms:

CEC - Chemical of Emerging Concern
DEET - N, N-Diethyl-meta-Toluamide
MDL - method detection limit
MEC - Measured Environmental Concentration
MTL - Monitoring Trigger Level
NA - not available
ND - not detected
NDMA - N-nitrosodimethylamine
SWRCB - State Water Resources Control Board
TCEP - Tris (2-chloroethyl) phosphate

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APPENDIX I – ANALYTICAL TESTING METHODS, MDLS, TATS

Table I-1
Compounds to be Monitored Quarterly (non-CEC)

Analyte/Contaminant Group	Method	Turn Around Time	MDL	Units	Rationale
Volatile Organic Compounds (VOCs)					
Benzene	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
Bromoform	EPA 524.2		0.5	µg/L	Priority pollutant
Bromomethane	EPA 524.2		0.5	µg/L	Priority pollutant
tert-Butyl alcohol	EPA 524.2		2	µg/L	CDPH drinking water notification level
n-Butylbenzene	EPA 524.2		0.5	µg/L	CDPH drinking water notification level
sec-Butylbenzen	EPA 524.2		0.5	µg/L	CDPH drinking water notification level
tert-Butylbenzene	EPA 524.2		0.5	µg/L	CDPH drinking water notification level
Carbon Tetrachloride	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
Chlorobenzene	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
Chlorodibromomethane	EPA 524.2		0.5	µg/L	Priority pollutant
Chloroethane	EPA 524.2		0.5	µg/L	Priority pollutant
Chloromethane	EPA 524.2		0.5	µg/L	Priority pollutant
Chloroform	EPA 524.2		0.5	µg/L	Priority pollutant
2-Chlorotoluene	EPA 524.2		0.5	µg/L	CDPH drinking water notification level
4-Chlorotoluene	EPA 524.2		0.5	µg/L	CDPH drinking water notification level
1, 2-Dichlorobenzene	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
1, 3-Dichlorobenzene	EPA 524.2		0.5	µg/L	Priority pollutant
1, 4-Dichlorobenzene	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
Dichlorobromomethane	EPA 524.2		0.5	µg/L	Priority pollutant
Dichlorodifluoromethane (Freon-12)	EPA 524.2		0.5	µg/L	CDPH drinking water notification level
1, 1-Dichloroethane	EPA 524.2		0.5	µg/L	State primary drinking water standards, priority pollutant
1, 2-Dichloroethane	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
1, 1-Dichloroethylene	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
cis-1, 2-Dichloroethylene	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards
trans-1, 2-Dichloroethylene	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
1, 2-Dichloropropane	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
1, 2-Dichloropropene	EPA 524.2		0.5-5	µg/L	Priority pollutant
1, 3-Dichloropropene	EPA 524.2		0.5	µg/L	State primary drinking water standards
Ethylbenzene	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
Hexachlorobutadiene	EPA 524.2		0.5	µg/L	Priority pollutant
Hexachloroethane	EPA 524.2		0.5-5	µg/L	Priority pollutant
Isopropylbenzene	EPA 524.2		0.5	µg/L	CDPH drinking water notification level
Methyl-tert-butyl ether (MTBE)	EPA 524.2		0.5	µg/L	Federal and state primary and secondary drinking water standards
Methylene Chloride (Dichloromethane)	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
Methyl isobutyl ketone (MIKB)	EPA 524.2		5	µg/L	CDPH drinking water notification level
n-Propylbenzene	EPA 524.2		0.5	µg/L	CDPH drinking water notification level
Styrene	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards
1, 1, 2, 2-Tetrachloroethane	EPA 524.2		0.5	µg/L	State primary drinking water standards, priority pollutant
Tetrachloroethylene (PCE)	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
Toluene	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
1, 2, 4-Trichlorobenzene	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
1, 1, 1-Trichloroethane	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
1, 1, 2-Trichloroethane	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
Trichloroehtylene (TCE)	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
Trichlorofluoromethane (Freon-11)	EPA 524.2		0.5	µg/L	State primary drinking water standards
1, 2, 3-Trichloropropane	EPA 524.2 MOD		0.005	µg/L	CDPH drinking water notification level
1, 1, 2-Trichloro-1, 2, 2-Trifluoroethane (Freon-113)	EPA 524.2		0.5	µg/L	State primary drinking water standards
1, 2, 4-Trimethylbenzene	EPA 524.2		0.5	µg/L	CDPH drinking water notification level
1, 3, 5-Trimethylbenzene	EPA 524.2		0.5	µg/L	CDPH drinking water notification level
Vinyl Chloride	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
Xylenes, total	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards
Synthetic Organic Compounds (SOCs)					
Acenapthene	EPA 525.2		0.5	µg/L	Priority pollutant
Acenapthylene	EPA 525.2		0.5	µg/L	Priority pollutant
Acetochlor	EPA 525.2		0.02-5	µg/L	Unregulated comtaminant monitoring program
Acrolein	EPA 556		1-5	µg/L	Priority pollutant
Acrylonitrile					Priority pollutant
Alachlor	EPA 525.2		0.5	µg/L	Federal and state primary drinking water standards, Unregulated comtaminant monitoring program
Aldrin	EPA 505		0.075	µg/L	Priority pollutant
Anthracene	EPA 525.2		0.5	µg/L	Priority pollutant
Atrazine	EPA 525.2		0.4	µg/L	Federal and state primary drinking water standards, IAP recommended
Bentazon	EPA 555		2	µg/L	State primary drinking water standards
Benzidine	EPA 605			µg/L	Priority pollutant
Benzo(a)anthracene	EPA 525.2		0.5	µg/L	Priority pollutant
Benzo(a)pyrene	EPA 525.2		0.1	µg/L	Federal and state primary drinking water standards, priority pollutant
Benzo(g, h, i)perylene	EPA 525.2		0.5	µg/L	Priority pollutant
Benzo(b)fluoranthene	EPA 525.2		0.5	µg/L	Priority pollutant
Benzo(k)fluoranthene	EPA 525.2		0.5	µg/L	Priority pollutant
alpha-BHC	EPA 505		0.01-0.5	µg/L	Priority pollutant
beta-BHC	EPA 505		0.01-0.5	µg/L	Priority pollutant
delta-BHC	EPA 505		0.01-0.5	µg/L	Priority pollutant
Bis(2-chloroethoxy) methane					Priority pollutant
Bis(2-chloroethyl) ether					Priority pollutant
Bis(2-chloroisopropyl) ether					Priority pollutant
Bis(2-ethylhexyl) adipate	EPA 525.2		2	µg/L	Federal and state primary drinking water standards
Bis(2-ethylhexyl) phthalate (DEHP)	EPA 525.2		3	µg/L	Federal and state primary drinking water standards, priority pollutant
4-Bromophenyl phenyl ether					Priority pollutant
Butyl benzyl phthalate	EPA 525.2		0.02-5	µg/L	Priority pollutant
Carbofuran	EPA 531.2		0.4	µg/L	Federal and state primary drinking water standards
Chlordane	EPA 505		0.1	µg/L	Federal and state primary drinking water standards, priority pollutant
2-Chloroethyl vinyl ethers					Priority pollutant
2-Chloronapthalene					Priority pollutant
4-Chlorophenyl phenyl ether					Priority pollutant
Chrysene	EPA 525.2		0.5	µg/L	Priority pollutant
Dalapon	EPA 549		2	µg/L	Federal and state primary drinking water standards
Di-n-butyl phthalate	EPA 525.2		2	µg/L	Priority pollutant
Di-n-octyl phthalate	EPA 525.2		0.02-5	µg/L	Priority pollutant
Dibenzo(g, h)anthracene	EPA 525.2		0.02-5	µg/L	Priority pollutant
Dibromochloropropane	EPA 524.2		0.5	µg/L	Federal and state primary drinking water standards
3, 3-Dichlorobenzidine	EPA 605			µg/L	Priority pollutant
2, 4-Dichlorophenol	EPA 528		0.1-1	µg/L	Priority pollutant
2, 4-Dichlorophenoxy acetic acid (2, 4-D)	EPA 555		3	µg/L	Federal and state primary drinking water standards
4, 4-DDT	EPA 680			µg/L	Priority pollutant
4, 4-DDE	EPA 680			µg/L	Priority pollutant
4, 4-DDD	EPA 680			µg/L	Priority pollutant
Dieldrin	EPA 505		0.02	µg/L	Priority pollutant
Diethyl phthalate	EPA 525.2		0.5	µg/L	Priority pollutant
Dimethyl phthalate	EPA 525.2		0.5	µg/L	Priority pollutant
Dimethoate	EPA 527		0.025	µg/L	Unregulated comtaminant monitoring program
2, 4-Dimethylphenol	EPA 528		0.1-1	µg/L	Priority pollutant
4, 6-Dinitro-o-cresol	EPA 528		0.1-1	µg/L	Priority pollutant
2, 4-Dinitrophenol	EPA 528		0.1-1	µg/L	Priority pollutant
Dinoseb	EPA 555		2	µg/L	Federal and state primary drinking water standards
Diquat	EPA 549.2		0.4	µg/L	Federal and state primary drinking water standards
alpha-Endosulfan	EPA 608			µg/L	Priority pollutant
beta-Endosulfan	EPA 608			µg/L	Priority pollutant

Table I-1
Compounds to be Monitored Quarterly (non-CEC)

Analyte/Contaminant Group	Method	Turn Around Time	MDL	Units	Rationale
Endosulfan sulfate	EPA 608			µg/L	Priority pollutant
Endothall	EPA 548.1		8	µg/L	Federal and state primary drinking water standards
Endrin	EPA 505		0.1	µg/L	Federal and state primary drinking water standards, priority pollutant
Endrin aldehyde	EPA 505		0.01-0.5	µg/L	Priority pollutant
Ethylene Dibromide	EPA 504.1		0.01	µg/L	Federal and state primary drinking water standards
Fluoranthene	EPA 525.2		0.02-5	µg/L	Priority pollutant
Fluorene	EPA 525.2		0.5	µg/L	Priority pollutant
Glyphosate	EPA 547		6	µg/L	Federal and state primary drinking water standards
Heptachlor	EPA 505		0.01	µg/L	Federal and state primary drinking water standards, priority pollutant
Heptachlor epoxide	EPA 505		0.01	µg/L	Federal and state primary drinking water standards, priority pollutant
Hexachlorobenzene	EPA 525.2		0.4	µg/L	Federal and state primary drinking water standards, priority pollutant
Hexachlorocyclopentadiene	EPA 525.2		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
Indeno(1, 2, 3-cd)pyrene	EPA 525.2		0.5	µg/L	Priority pollutant
Isophorone	EPA 525.2		0.02-5	µg/L	Priority pollutant
Lindane (gamma-BHC)	EPA 505		0.2	µg/L	Federal and state primary drinking water standards, priority pollutant
Methoxychlor	EPA 505		0.5	µg/L	Federal and state primary drinking water standards
Metolachlor	EPA 525.2		0.02-5	µg/L	Unregulated comtaminant monitoring program
Molinate	EPA 525.2		0.5	µg/L	State primary drinking water standards
Napthalene	EPA 524.2		0.5	µg/L	CDPH drinking water notification level, priority pollutant
2-Nitrophenol	EPA 528		0.1-1	µg/L	Priority pollutant
4-Nitrophenol	EPA 528		0.1-1	µg/L	Priority pollutant
n-Nitrosodiethylamine (NDEA)	EPA 521		2	ng/L	Unregulated comtaminant monitoring program
n-Nitrosodimethylamine (NDMA)	EPA 521		2	ng/L	CDPH drinking water notification level, Unregulated comtaminant monitoring program, priority pollutant, process performance, IAP recommended, SWRCB CEC advisory panel
n-Nitrosodiphenylamine	EPA 521		2	ng/L	Other nitrosamine compound (non-UCMR/Notification Limit), priority pollutant
n-Nitroso-di-n-butylamine (NDBA)	EPA 521		2	ng/L	Unregulated comtaminant monitoring program
n-Nitroso-di-n-propylamine (NDPA)	EPA 521		2	ng/L	Unregulated comtaminant monitoring program, priority pollutant
n-Nitrosomethylethylamine (NMEA)	EPA 521		2	ng/L	Unregulated comtaminant monitoring program
n-Nitrosomorpholine	EPA 521		2	ng/L	Other nitrosamine compound (non-UCMR/Notification Limit)
N-nitrosopiperidine (NPIP)	EPA 521		2	ng/L	Other nitrosamine compound (non-UCMR/Notification Limit)
n-Nitrosopyrrolidine (NYPR)	EPA 521		2	ng/L	Unregulated comtaminant monitoring program
Oxamyl (Vydate)	EPA 531.2		0.4	µg/L	Federal and state primary drinking water standards
Parachlorometa Cresol	EPA 528		0.1-1	µg/L	Priority pollutant
Pentachlorophenol (PCP)	EPA 528		0.1-1	µg/L	Federal and state primary drinking water standards, priority pollutant
Phenanthrene	EPA 525.2		0.5	µg/L	Priority pollutant
Phenol	EPA 528		0.1-1	µg/L	Priority pollutant
Picloram	EPA 555		1	µg/L	Federal and state primary drinking water standards
Polychlorinated Biphenyls (PCBs)	EPA 505		0.5	µg/L	Federal and state primary drinking water standards
PCB-1016 (Aroclor 1016)	EPA 505		0.5	µg/L	Priority pollutant
PCB-1221 (Aroclor 1221)	EPA 505		0.5	µg/L	Priority pollutant
PCB-1232 (Aroclor 1232)	EPA 505		0.5	µg/L	Priority pollutant
PCB-1242 (Aroclor 1242)	EPA 505		0.5	µg/L	Priority pollutant
PCB-1248 (Aroclor 1248)	EPA 505		0.5	µg/L	Priority pollutant
PCB-1254 (Aroclor 1254)	EPA 505		0.5	µg/L	Priority pollutant
PCB-1260 (Aroclor 1260)	EPA 505		0.5	µg/L	Priority pollutant
Propachlor	EPA 505		0.5	µg/L	CDPH drinking water notification level
Pyrene	EPA 525.2		0.5	µg/L	Priority pollutant
Simazine	EPA 525.2		0.5	µg/L	Federal and state primary drinking water standards
Surfactants (MBAS)	SM5540C/E425.1		0.05	mg/L	Federal and state secondary drinking water standards
Terbufos Sulfone	EPA 527		0.04	µg/L	Unregulated comtaminant monitoring program
Thiobencarb	EPA 555		1	µg/L	Federal and state primary and secondary drinking water standards
Toxaphene	EPA 505		1	µg/L	Federal and state primary drinking water standards
2, 3, 7, 8-Tetrachlorodibenzo-p-dioxin (2, 3, 7, 8-TCDD)	EPA 1613B		5	pg/L	Federal and state primary drinking water standards, priority pollutant
2, 4, 5-TP (Silvex)	EPA 555		1	µg/L	Federal and state primary drinking water standards
2, 4, 6-Trichlorophenol	EPA 528		0.1-1	µg/L	Priority pollutant
Disinfection by Products (DBPs)					
Total Trihalomethanes	EPA 551.1		0.5	µg/L	Federal and state primary drinking water standards
Total Haloacetic acids	SM6251B		4	µg/L	Federal and state primary drinking water standards
Bromate	EPA 317		1	µg/L	Federal and state primary drinking water standards
Chlorite	EPA 300.1B		10	µg/L	Federal and state primary drinking water standards
Chlorate	EPA 300.1B		20	µg/L	Water treatment disinfection byproduct
Inorganics					
Aluminum	EPA 200.7		25	µg/L	Federal and state secondary drinking water standards
Antimony	EPA 200.7		1	µg/L	Federal and state primary drinking water standards, priority pollutant
Arsenic	EPA 200.7		1	µg/L	Federal and state primary drinking water standards, priority pollutant
Asbestos	EPA 100.2		0.2	MFL	Federal and state primary drinking water standards, priority pollutant
Barium	EPA 200.7		2	µg/L	Federal and state primary drinking water standards
Beryllium	EPA 200.7		1	µg/L	Federal and state primary drinking water standards, priority pollutant
Boron	EPA 200.7		25	µg/L	CDPH drinking water notification level, IAP recommended
Cadmium	EPA 200.7		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
Calcium	EPA 200.7		1	mg/L	San Diego Basin Plan inland surface water monitoring
Chloride	EPA 300.0		10	mg/L	Federal and state secondary drinking water standards
Chromium	EPA 200.7		1	µg/L	Federal and state primary drinking water standards, priority pollutant
Copper	EPA 200.7		2	µg/L	Federal and state primary and secondary drinking water standards, priority pollutant
Cyanide	SM4500CN-F		0.005	mg/L	Federal and state primary drinking water standards, priority pollutant
Fluoride	EPA 300.0		0.05	mg/L	Federal and state primary drinking water standards
Iron	EPA 200.7		0.02	mg/L	Federal and state secondary drinking water standards
Lead	EPA 200.7		0.5	µg/L	Federal and state primary drinking water standards, priority pollutant
Magnesium	EPA 200.7		0.1	mg/L	San Diego Basin Plan inland surface water monitoring
Manganese	EPA 200.7		2	µg/L	Federal and state secondary drinking water standards, CDPH drinking water notification level
Mercury	EPA 245.1		0.2	µg/L	Federal and state primary drinking water standards, priority pollutant
Nickel	EPA 200.7		5	µg/L	State primary drinking water standards, priority pollutant
Perchlorate	EPA 314		2	µg/L	CDPH drinking water notification level
Potassium	EPA 200.7		1	mg/L	San Diego Basin Plan inland surface water monitoring
Selenium	EPA 200.7		5	µg/L	Federal and state primary drinking water standards, priority pollutant
Silver	EPA 200.7		0.5	µg/L	Federal and state secondary drinking water standards, priority pollutant
Sodium	EPA 200.7		1	mg/L	San Diego Basin Plan inland surface water monitoring
Sulfate	EPA 300.0		2	mg/L	Federal and state secondary drinking water standards
Thallium	EPA 200.7		1	µg/L	Federal and state primary drinking water standards, priority pollutant
Vanadium	EPA 200.7		0.5	µg/L	CDPH drinking water notification level
Zinc	EPA 200.7		5	µg/L	Federal and state secondary drinking water standards, priority pollutant
Nutrients					
Ammonia	EPA 350.1		0.05	mg/L	San Diego Basin Plan inland surface water monitoring, process performance
Nitrate-NO3	EPA 300.0		1.8	mg/L	State primary drinking water standards
Nitrate-N	EPA 300.0		0.4	mg/L	Federal primary drinking water standards
Nitrite-N	EPA 300.0		0.4	mg/L	Federal and state primary drinking water standards, process performance
Nitrogen, total	EPA 300.0/351.2		0.5	mg/L	Process performance monitoring
Orthophosphate	SM4500P-E		0.05	mg/L	Process performance monitoring
Phosphorus, total	E365.1/365.2		0.05	mg/L	Process performance monitoring
Microbial					
Total Coliform	SM9223		2	MPL/100mL	Federal and state primary drinking water standards, process performance
Hetertrophic plate count	SM9215		1	CFU/mL	Process performance monitoring

Table I-1
Compounds to be Monitored Quarterly (non-CEC)

Analyte/Contaminant Group	**Method**	**Turn Around Time**	**MDL**	**Units**	**Rationale**
Coliphage	EPA 1601/1602		varies	PFU/mL	Process performance monitoring
Radionuclides					
Uranium	EPA 200.8		1	µg/L	Federal and state primary drinking water standards
Radium-226+228	EPA 903.1 / 904.0		1	pCi/L	Federal and state primary drinking water standards
Gross Alpha particualtes	EPA 900.0		3	pCi/L	Federal and state primary drinking water standards
Gross Beta particulates	EPA 900.0		3	pCi/L	Federal and state primary drinking water standards
Strontium-90	EPA 905.0		1	pCi/L	Federal and state primary drinking water standards
Tritium	EPA 906.0		1,000	pCi/L	Federal and state primary drinking water standards
Explosives					
1, 3-Dinitrobenzene	EPA 529		UCMR	µg/L	Unregulated comtaminant monitoring program
2, 4-Dinitrotoluene	EPA 529		UCMR	µg/L	Priority pollutant
2, 6-Dinitrotoluene	EPA 529		UCMR	µg/L	Priority pollutant
Hexahydro-1, 3, 5-trinitro-1, 3, 5-triazine (RDX)	EPA 529		UCMR	µg/L	Unregulated comtaminant monitoring program
Nitrobenzene	EPA 529		UCMR	µg/L	Priority pollutant
2, 4, 6-Trinitrotoluene	EPA 529		UCMR	µg/L	Unregulated comtaminant monitoring program
Acetanilide Degredates					
Acetochlor ethane sulfonic acid (ESA)	EPA 535		UCMR	µg/L	Unregulated comtaminant monitoring program
Acetochlor oxanilic acid (OA)	EPA 535		UCMR	µg/L	Unregulated comtaminant monitoring program
Alachlor ethane sulfonic acid (ESA)	EPA 535		UCMR	µg/L	Unregulated comtaminant monitoring program
Alachlor oxanilic acid (OA)	EPA 535		UCMR	µg/L	Unregulated comtaminant monitoring program
Metolachlor ethane sulfonic acid(ESA)	EPA 535		UCMR	µg/L	Unregulated comtaminant monitoring program
Metolachlor oxanilic acid (OA)	EPA 535		UCMR	µg/L	Unregulated comtaminant monitoring program
General Water Qualtiy Monitoring Parameters					
Biochemical oxygen demand (BOD)	SM5210B		3	mg/L	Process performance monitoring
Color	S2120B		3	ACU	Federal and state secondary drinking water standards
Corrosivity					Federal and state secondary drinking water standards
Odor threshold	S2150B		1	TON	Federal and state secondary drinking water standards
pH	4500HB/E150		0.001	pH units	Process performance monitoring
Specific conductance	ML/S2510B		2	umho/cm	Federal and state secondary drinking water standards
Temperature					Process performance monitoring
Total anion / cation	SM1030E		0.001	meg/L	Process performance monitoring
Total dissolved solids (TDS)	SM2540C		10	mg/L	Federal and state secondary drinking water standards, Process performance
Total organic carbon (TOC)	SM5310C		0.25	mg/L	Process performance monitoring
Turbidity	EPA 180.1		0.05	NTU	Federal and state secondary drinking water standards, Process performance
Other Compounds					
Acetaminiphen	LC-MS-MS		1	ng/L	Other potential AOP byproduct
n-Acetyl-p-benzoquione					Other potential AOP byproduct
1, 4-Dioxane	EPA 522 MOD		0.5	µg/L	CDPH drinking water notification level, process performance monitoring, IAP recommended
1, 2-dipheylhydrazine					Priority pollutant
Formaldehyde					Other potential AOP byproduct
2, 2', 4, 4', 5, 5'-Hexabromobiphenyl (HBB)	EPA 527		UCMR	µg/L	Unregulated comtaminant monitoring program
2, 2', 4, 4', 5, 5'-Hexabromobiphenyl ether (BDE-153)	EPA 527		UCMR	µg/L	Unregulated comtaminant monitoring program
2, 2', 4, 4', 5-Pentabromodiphenyl ether (BDE-99)	EPA 527		UCMR	µg/L	Unregulated comtaminant monitoring program
2, 2', 4, 4', 6-Pentabromodiphenyl ether (BDE-100)	EPA 527		UCMR	µg/L	Unregulated comtaminant monitoring program
2, 2', 4, 4'-Tetrabromodiphenyl ether (BDE-47)	EPA 527		UCMR	µg/L	Unregulated comtaminant monitoring program

Table I-2

CECs to be Monitored Quarterly

Analyte/Contaminant Group	Method [1]	Turn Around Time	MDL	Units	Rationale
Hormones					
EE2 (17 Alpha-ethynylestradiol)	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
E2 (17 Beta-Estradiol)	API SCIEX 5000 LC-MS-MS		1	ng/L	Identified CEC, SWRCB CEC advisory panel
Andorostenedione	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Estrone	API SCIEX 5000 LC-MS-MS		1	ng/L	Identified CEC, IAP recommended
Norethisterone	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Progesterone	API SCIEX 5000 LC-MS-MS		1	ng/L	Identified CEC
Testosterone	API SCIEX 5000 LC-MS-MS		1	ng/L	Identified CEC
Pesticides / Herbicides					
2,4-D	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Atrazine	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Bromacil	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Chlorotoluron	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Cyanazine	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
DACT (Diaminochlorotriazine)	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
DEA (Deethylatrazine)	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
DIA (Deisopropylatrazine)	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Diuron	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Isoproturon	API SCIEX 5000 LC-MS-MS		20	ng/L	Identified CEC
Linuron	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Metazachlor	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Propazine	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Simazine	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Pharmaceuticals					
Acetaminophen	API SCIEX 5000 LC-MS-MS		1	ng/L	Identified CEC
Albuterol	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Amoxicillin (semi quantitative)	API SCIEX 5000 LC-MS-MS		20	ng/L	Identified CEC
Atenolol	API SCIEX 5000 LC-MS-MS		1	ng/L	Identified CEC
Bendroflumethiazide	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Bezafibrate	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Butalbital	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Carbadox	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Carbamazepine	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC, IAP recommended
Carisoprodol	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Chloramphenicol	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Chloridazon	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Cimetidine	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Dehydronifedipine	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Diazepam	API SCIEX 5000 LC-MS-MS		1	ng/L	Identified CEC
Diclofenac	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Dilantin (Phenytoin)	API SCIEX 5000 LC-MS-MS		20	ng/L	Identified CEC, IAP recommended
Erythromycin (semiquantitative)	API SCIEX 5000 LC-MS-MS		10	ng/L	Identified CEC
Flumeqine	API SCIEX 5000 LC-MS-MS		10	ng/L	Identified CEC
Fluoxetine (semiquantitative)	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Furosemide	API SCIEX 5000 LC-MS-MS		10	ng/L	Identified CEC
Gemfibrozil	API SCIEX 5000 LC-MS-MS		1	ng/L	Identified CEC, IAP recommended, SWRCB CEC advisory panel
Ibuprofen	API SCIEX 5000 LC-MS-MS		1	ng/L	Identified CEC
Ketoprofen	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Ketorolac	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Lidocaine (Semiquantitative)	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Lincomycin	API SCIEX 5000 LC-MS-MS		10	ng/L	Identified CEC
Lopressor	API SCIEX 5000 LC-MS-MS		20	ng/L	Identified CEC
Meclofenamic	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Meprobamate	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC, IAP recommended
Naproxen	API SCIEX 5000 LC-MS-MS		10	ng/L	Identified CEC
Nifedipine	API SCIEX 5000 LC-MS-MS		20	ng/L	Identified CEC
Oxolinic acid	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Pentoxifylline	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Primidone	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Sulfachloropyridazine	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Sulfadiazine	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Sulfadimethoxine	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Sulfamerazine	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Sulfamethazine	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Sulfamethizole	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Sulfamethoxazole	API SCIEX 5000 LC-MS-MS		1	ng/L	Identified CEC, IAP recommended
Sulfathiazole	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Theophylline	API SCIEX 5000 LC-MS-MS		10	ng/L	Identified CEC
Trimethoprim	API SCIEX 5000 LC-MS-MS		1	ng/L	Identified CEC
Warfarin	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Preservative					
Butylparben	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Ethylparaben	API SCIEX 5000 LC-MS-MS		20	ng/L	Identified CEC
Isobuylparaben	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Methylparaben	API SCIEX 5000 LC-MS-MS		20	ng/L	Identified CEC
Propylparaben	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Stimulants					
1,7-dimethylxanthine	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Caffeine	API SCIEX 5000 LC-MS-MS		3	ng/L	Identified CEC, SWRCB CEC advisory panel
Cotinine	API SCIEX 5000 LC-MS-MS		1	ng/L	Identified CEC
Theobromine	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC
Wastewater Indicators					
4-nonylphenol (qualitative)	API SCIEX 5000 LC-MS-MS		100	ng/L	Identified CEC
4-tert-octylphenol	API SCIEX 5000 LC-MS-MS		10	ng/L	Identified CEC
BPA (Bis Phenol A)	API SCIEX 5000 LC-MS-MS		10	ng/L	Identified CEC
Iohexol	API SCIEX 5000 LC-MS-MS		10	ng/L	Identified CEC
Iopromide	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC, IAP recommended, SWRCB CEC advisory panel
PFOS (Perfluoro octanesulfonate)	API SCIEX 5000 LC-MS-MS		0.2	ng/L	Identified CEC
Sucralose	API SCIEX 5000 LC-MS-MS		100	ng/L	Identified CEC, SWRCB CEC advisory panel
TCEP (Tris(2-chloroethyl) phosphate)	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC, IAP recommended
Other Identified CECs					
DEET (N,N-Diethyl-meta-toluamide)	API SCIEX 5000 LC-MS-MS		2	ng/L	Identified CEC, IAP recommended, SWRCB CEC advisory panel
1, 4-Dioxane	EPA 522 MOD		0.5	μg/L	Identified CEC, IAP recommended, process performance
n-Nitrosodimethylamine (NDMA)	EPA 521		2	ng/L	Identified CEC, IAP recommended, process performance, SWRCB CEC advisory panel
Triclosan	API SCIEX 5000 LC-MS-MS		5	ng/L	Identified CEC, SWRCB CEC advisory panel
1, 2, 3-Trichloropropane	EPA 524.2 MOD		0.005	μg/L	IAP recommended
Hydrazine					IAP recommended
Quinoline					IAP recommended

Notes:

1. API SCIEX 5000 LC-MS-MS analytical method represents the most current, peer-reviewed methodology available.

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APPENDIX J – SAMPLING PROCEDURES FOR MICROBIAL PARAMETERS

BIOVIR LABORATORIES, INC.

EXAMPLE PROCEDURE FOR COLLECTING FILTERED WATER SAMPLES (Using HV Envirochek Capsule Filters)
FOR
METHOD 1622/23 ANALYSIS

NOTE! The EPA method 1623: Cryptosporidium and Giardia in Water by Filtration/IMS/FA December 2005
Sample arrival temperature requirement is 0° C to < 20°C *
EPA target arrival temperature <10°C

* Adapted from EPA Document. See http;/www.epa.gov/microbes

Example Procedure for Collecting Filtered Water Samples for Method 1622/1623 Analysis

1.0 Required Materials

Have the following materials available prior to sampling:

- Several pair of new latex gloves*
- Sample Data sheet*
- HV Envirochek capsule Filter and Filer Sampling Equipment w/ 10L cubitainer*
- Small Return cooler w/ 250 mL Temperature blank
- Waterproof Sample label*
- Waterproof Pen
- Cooler / vessel for chilling of sample prior to shipment
- Ice for chilling of sample prior to shipping
- 2 plastic liners (bags)*
- 4-5 Gel Pacs (Frozen)* or
- Ice (cubes or crushed) for shipping
- 5 large ziplocks bags*
- Strapping or duct tape to seal cooler prior to shipping
- Shipping air bill (completed by utilities)

2.0 Collecting the Sample from a Pressurized Source

- Put on a pair of latex gloves.
- Flush the system for 2 to 3 minutes until any accumulated stagnant water or debris has cleared, or temperature and turbidity has become visibly uniform before connecting the sampling unit to the tap.
- While system is flushing record following information on the sample data sheet:
    - Public Water System (PWS)Name and Address
    - Sampler Name
    - PWS ID Number
    - Facility Name and PWS facility ID number
    - Sample collection point name and ID number
    - Sample collection date
    - Source water type (required for E. Coli sample forms)
    - Assay Requested (indicate if Regular or Matrix sample)
- After system has flushed, measure and enter water quality parameters such as temperature, turbidity, pH.
- Connect assembled sampling unit to the sample tap **(without capsule filter)** to sample tap, flush sampling unit for 2-3 minutes and test for leaks, and slowly adjust up an adequate flow. **(maximum** values 100 psi w/ flow restrictor).
- Turn off sample tap, install filter capsule **(retain blue vinyl caps)**, insert three (3) foot length tubing into effluent 10L cubitainer .
- Record start time on sample data sheet. Slowly turn on sample tap. When 10L cubitainer has reached fill mark, turn off sample tap. Record stop time
- **If taking a Matrix spike sample with this sample the two volumes must be the same (within 10%)**
- Hold Capsule filter (inlet pointing up), remove tubing allowing water to drain through the “out port” of the filter. Open bleed valve to speed draining process, and disconnect tubing from capsule filter.
- Seal capsule filter ends with blue caps, close bleed valve, and place into gallon ziplock bag. Seal and place into a second ziplock bag (ie. Double bag)

3.0 Pre-Chilling of Filter

---

*Supplied if Requested

- Place bagged filter and temperature blank into an ice bath. The filter will float semi- submerged in the ice water.
- A 25˚C filter and temperature blank will chill to approximately 6˚C in 1.5 hours
- Filter and temperature blank should be stored between 0 - 8˚C from time of filtration**.**
- Sample testing must be completed within 96 hours of sample collection**.**

4.0 Packing and Shipping the Sample Using Ice Cubes/Crushed Ice

- Create a double liner by inserting one plastic liner into the other. Line the cooler with the liners
- Divide 8-lbs of ice(cubes or crushed) into the ziplock bags, expel as much air as possible then seal. Secure the ends with tape.˚
- Place the chilled filter and temperature blank into the sample cooler, cover with a layer of bubble wrap or similar material. Place an ice pack on top of the insulating material.
- Seal each liner by twisting the top of each bag, and secure with tape.
- Place the completed sample data sheet (chain of custody) into a ziplock bag, seal and tape to the inside cooler lid.
- Close and seal the cooler lid.
- Attach your completed air bill to the cooler, retain sender copy. Send to processing lab
- Alert BioVir at least 24 hours prior to sample shipment date. Indicate courier used and request BioVir contact client if sample not received.
- If problems are encountered with the shipment, communicate with the shipping company and BioVir to resolve.

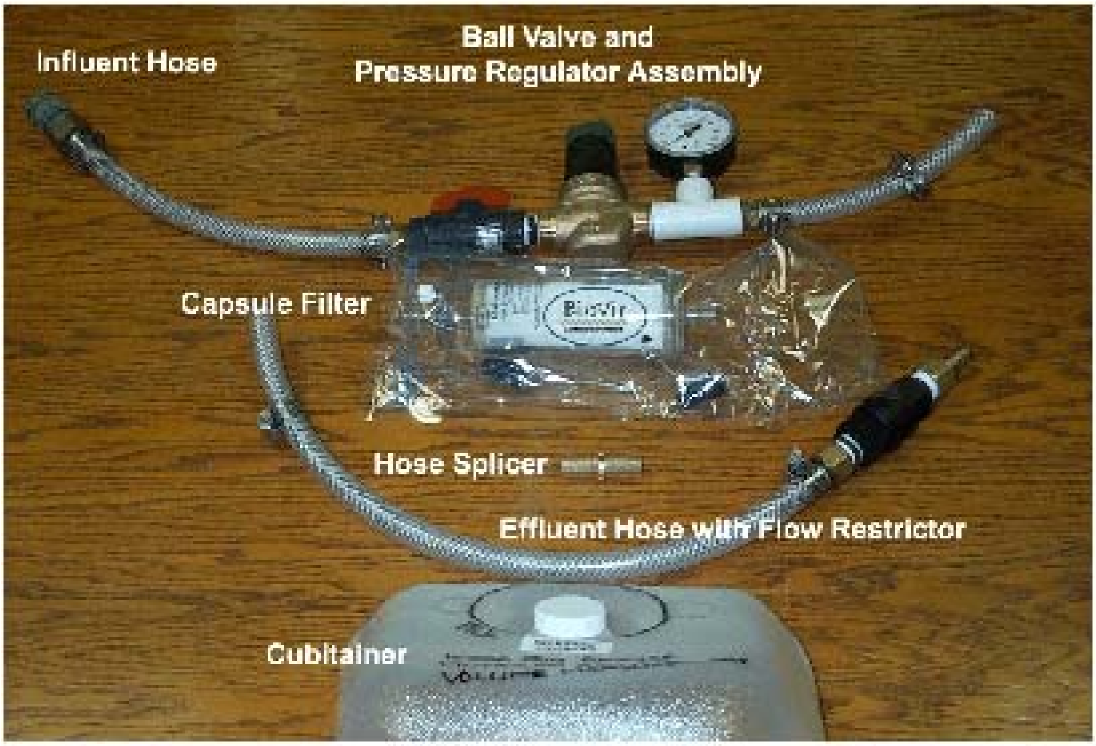
5.0 Packing and Shipping Sample Using Frozen Gel Pacs

- Create a double liner by inserting one bag liner into the other. Line cooler with the liners.
- Place each **FROZEN** gel pac into a ziplock.
- Place the pre-chilled filter and temperature blank into cooler, cover with a layer of bubble wrap or similar material. Place a frozen gel pac on each side and on top of the filter and temperature blank.
- Seal each liner by twisting the top of each bag, and securing with tape.
- Place the completed sample data sheet (chain of custody) into a ziplock, seal and tape to the inside cooler lid.
- Close and seal the cooler lid.
- Attach your completed air bill to the cooler, retain sender copy. Send to processing lab
- Alert BioVir at least 24 hours prior to sample shipment date. Indicate courier used and request BioVir contact client if sample not received.
- If problems are encountered with the shipment, communicate with the shipping company and BioVir to resolve.

NOTE ! It is very important to use the double liners and ziplocks to prevent leakage from the sample cooler. Shipping companies may delay shipment if leakage occurs.

*Supplied if Requested

EPA Method 1623 Field Concentrating Apparatus



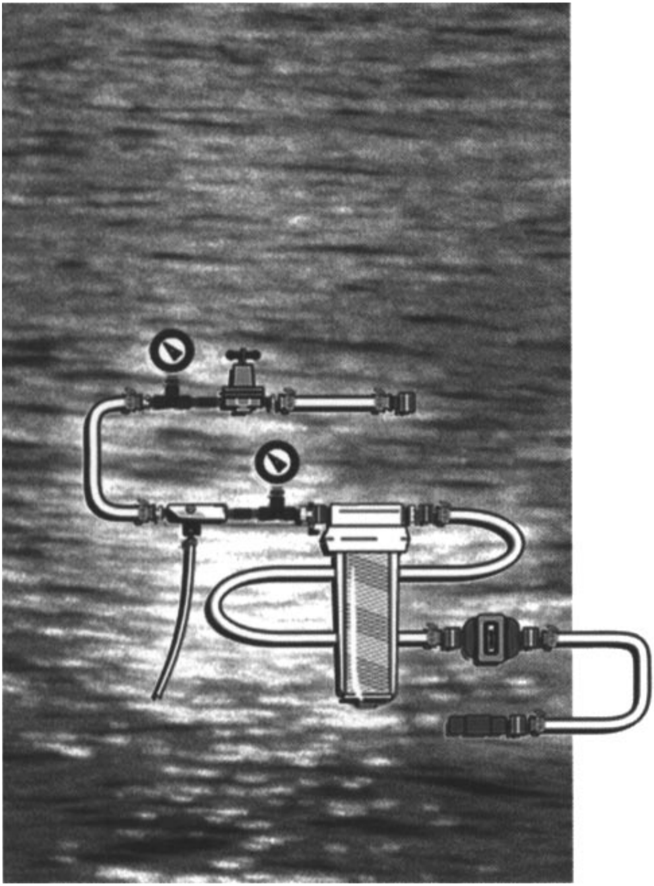
United States
Environmental
Protection Agency

Office of Ground Water
and Drinking Water
Washington, DC 20460

EPA/814-B-95-001
June 1995

EPA

Information Collection Requirements Rule— Protozoa and Enteric Virus Sample Collection Procedures



ABOUT THIS MANUAL

This manual is designed to be brought into the field by drinking water utility personnel when collecting source and finished water samples for protozoa and viruses. The sample collection steps in this manual are consistent with those demonstrated in the accompanying video. To further associate the steps in this manual with the sampling demonstration on the video, the photos for each step are taken directly from the video.

Several graphic conventions are used throughout the manual to differentiate steps or denote special actions:

2 A step icon is used at the beginning of each step. These steps are parallel to those in the accompanying video.

! Actions denoted by this icon are critical to ensuring that the sample will be valid and uncontaminated, such as putting on fresh latex gloves before handling the filter.

Text denoted by this icon provides additional information to the samplers, but may not be part of the actual collection procedure.

Collecting protozoan and virus samples correctly under the Information Collection Requirements Rule can be challenging. Please watch the demonstration video before collecting the samples, and be sure to follow each step in this manual when in the field.

CONTENTS

Protozoan and Enteric Virus Sample Collection Procedures as Defined by the Information Collection Requirements Rule

This manual describes the procedures for collecting source water and finished water samples for protozoan and enteric virus monitoring under the Information Collection Requirements (ICR) rule. This manual and the accompanying video comprise a two-part set of instructional materials that provide public water supply systems with the information needed to properly collect samples for protozoan and virus monitoring. All water utility personnel involved with ICR monitoring should watch the video and review this manual before collecting any samples.

The protozoan collection procedures described in this manual and in the video are based on the procedures in the ICR Protozoan Method for Detecting *Giardia* cysts and *Cryptosporidium* Oocysts in Water by a Fluorescent Antibody Procedure. The total culturable virus collection procedures described in this manual and in the video are based on the procedures in the Virus Monitoring Protocol for the Information Collection Rule. Both of these methods can be requested by calling the Safe Drinking Water Hotline, at (800) 426-4791.

QUESTIONS COMMONLY ASKED BY DRINKING WATER UTILITIES

What is the purpose of the ICR rule?

The ICR rule was developed by EPA to collect occurrence, exposure, and treatment data on drinking water pathogens and disinfectant by-products. The pathogen data are needed to determine whether current Surface Water Treatment Regulations should be revised to include new or more stringent treatment levels for some microbes. The disinfectant by-product data are needed to determine whether to regulate the chemical by-products that form when disinfectants react with organic chemicals in source water.

Although drinking water utilities will be involved in collecting both disinfectant by-product and waterborne pathogen data under the ICR rule, this manual describes the utility's role in collecting data on drinking water pathogen occurrence.

What pathogens are monitored under the ICR rule?

The ICR rule requires public water supply systems to monitor source water (and finished water in some cases) for the following pathogens:

- *Giardia* cysts
- *Cryptosporidium* oocysts
- Total culturable viruses
- Fecal coliform or *Escherichia coli* bacteria
- Total coliform bacteria

EPA is considering revising the current Surface Water Treatment Regulations because existing treatment levels for *Giardia* and viruses may not be adequate to protect public health for systems supplied by poor-quality source water and because of the new threat posed by *Cryptosporidium.*

Giardia cysts in drinking water cause more reported waterborne disease outbreaks than any other single known pathogen. They also are more resistant to environmental stresses and disinfection than almost all other known waterborne pathogens.

Cryptosporidium oocysts in drinking water have caused major waterborne disease outbreaks in the U.S. and other countries and are even more resistant to disinfection than *Giardia.*

Several enteric viruses have caused waterborne disease and may be responsible for many, if not most, of the outbreaks where a causative agent was not identified (about half of all reported outbreaks). Adequate analytical methodology is not yet available for routine analysis for many enteric viruses, so EPA has required monitoring of total culturable viruses. Total culturable viruses are a group of enteric viruses commonly found in poor-quality waters and which EPA believes are at least somewhat representative of other pathogenic viruses. Monitoring for total culturable viruses is useful because this group contains pathogens and is a potential indicator of other viral pathogens.

Fecal coliforms, *E. coli,* and total coliforms have been used for decades to assess source water quality. Coliform bacteria are much more susceptible to environmental stress and disinfection than protozoa and viruses, and would be eliminated by any system that eliminated more resistant pathogens. However, the ICR rule requires drinking water utilities to submit coliform monitoring data as general indicators of water quality. Monitoring procedures for fecal coliform, *E. coli*, and total coliform densities have been established and are not addressed by this manual.

Which drinking water utilities have to collect protozoan and virus samples?

Public water supply systems that serve between 10,000 and 100,000 people and use surface water (or groundwater under the influence of surface water) are required to monitor their source water for *Giardia* cysts and *Cryptosporidium* oocysts.

Public water supply systems that serve more than 100,000 people and use surface water (or groundwater under the influence of surface water) are required to monitor their source water for *Giardia* cysts, *Cryptosporidium* oocysts, and total culturable viruses. If pathogen densities in the source water exceed 1 pathogen per liter during the first 12 months of monitoring, then public water supply systems also must sample finished water for the remaining months.

How often must samples be taken?

Public water supply systems that serve between 10,000 and 100,000 people must collect samples every two months for 12 months.

Systems that serve more than 100,000 people must take samples every month for 18 months.

However, these systems may discontinue monitoring if:

- Viruses are not detected in the source water during the first 12 months of monitoring, or
- Source water has been tested for either total coliforms or fecal coliforms at least five times per week for four months before and two months after the effective date of the ICR and the total coliform density is less than 100 colonies/100 mL or the fecal coliform density in 90 percent of all samples is less than 20 colonies/100 mL.

Where should samples be collected?

Samples must be taken at the intake of each treatment plant. If a plant has several sources of water, the system must sample the blended water from all sources. If this is not possible, the source with the highest expected pathogen concentration should be sampled.

Who will analyze the samples?

EPA has approved several laboratories to analyze the protozoan and virus samples. Before collecting samples, you must arrange to have them analyzed by an EPA-approved laboratory.

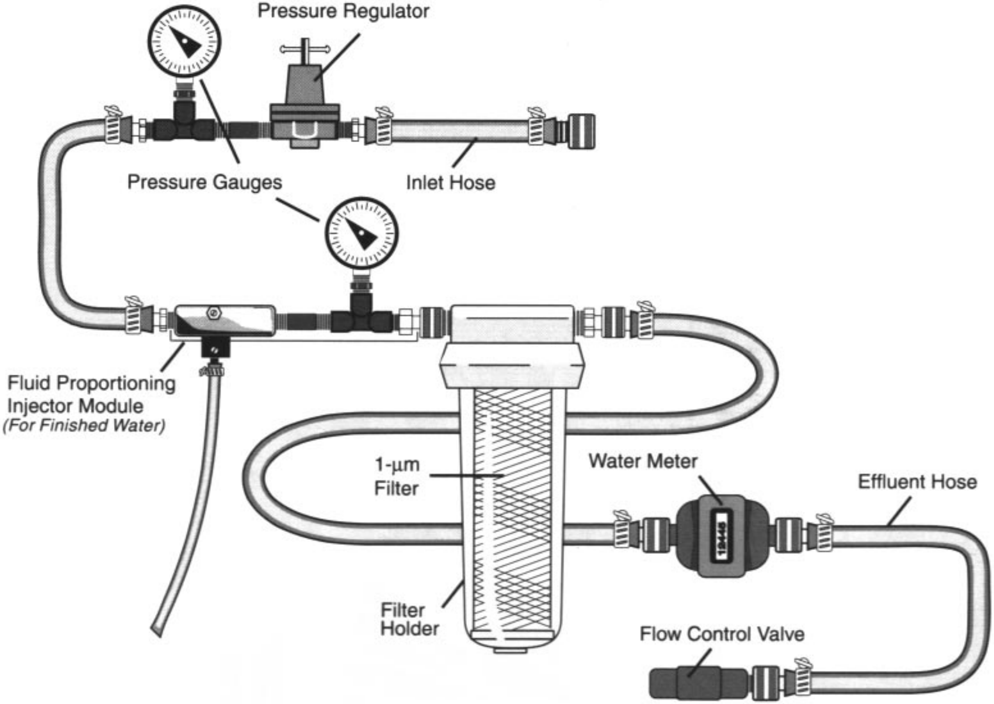
If you have not already located an approved laboratory, notify:

ICR Laboratory Coordinator
EPA Office of Ground Water & Drinking Water
26 West Martin Luther King Drive
Cincinnati, Ohio 45268.

EPA will provide you with a list of approved laboratories or other appropriate guidance.

SAMPLE COLLECTION PROCEDURES FOR DETECTING PROTOZOA IN WATER

Sampling Train for Collecting Protozoa



STEP 1 Each month, your laboratory will send you all of the equipment needed to collect samples for *Giardia* cyst and *Cryptosporidium* oocyst analyses. When you receive the sampling kit, check the contents of the carton. The sampling kit should contain the following items:

☐ Sampling train for collecting protozoa (left):

- Inlet hose
- Pressure regulator with pressure gauge
- Fluid proportioning injector module, including an injector and pressure gauge*
- 1-μm nominal porosity filter and holder made by Parker Hannifan or Filterite
- Water meter
- Effluent hose and flow control valve

---

*Needed for finished water sample collection only

- ☐ Plastic sample bags
- ☐ Ice packs for shipping the collected samples
- ☐ Sample labels

If you are missing any items, contact your laboratory immediately. Do not attempt to collect the samples without a complete sampling kit.

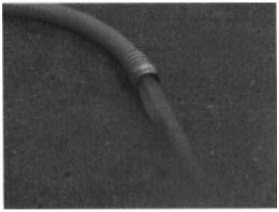
STEP 2 Once you have verified the contents of the sampling kit, place the ice packs in the freezer and repack the box for later use.

COLLECTING SOURCE WATER SAMPLES

When you are ready to collect your protozoa sample, bring the following items with you to the sampling location:

- ☐ Shipping container sent by the laboratory
- ☐ Sampling apparatus
- ☐ Plastic sample bags
- ☐ Sample labels
- ☐ Frozen ice packs
- ☐ Several pairs of new latex gloves
- ☐ pH meter
- ☐ Thermometer
- ☐ Turbidimeter

! If you will be collecting samples from both source water and finished water on the same day, perform the finished water sampling first. Using the sampling apparatus on source water first may cause false positives for finished water sample analyses.

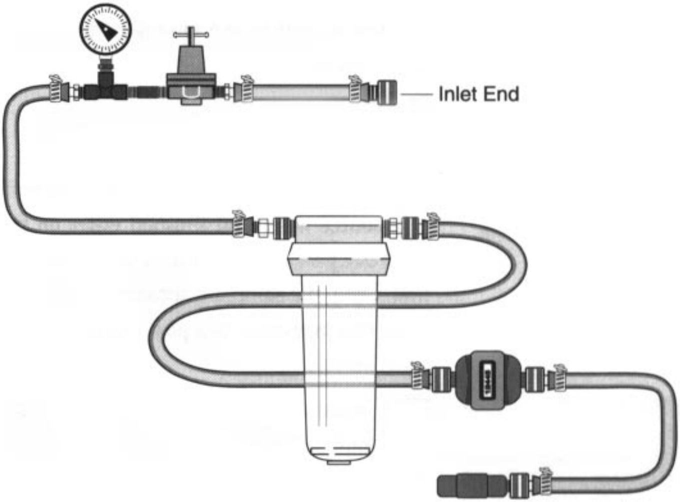


3 Turn on the water at the tap and allow the water to flow for 2 to 3 minutes or until any debris that has accumulated in the sampling line has cleared or the turbidity in the water becomes uniform.

Turn off the water at the tap.

STEP 4 Put on new latex gloves to prevent contamination from outside sources. Sterile technique must be used when sampling for *Giardia* and *Cryptosporidium*. Any contamination of the sampling apparatus may bias the final results.

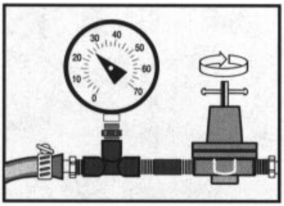
Assemble the sampling apparatus as shown below and connect the inlet end of the sampling apparatus to the sampling tap or to an extension hose connected to the tap.



! Be sure that the filter housing does *not* contain the filter.

Note the water meter reading, then slowly turn on the water.

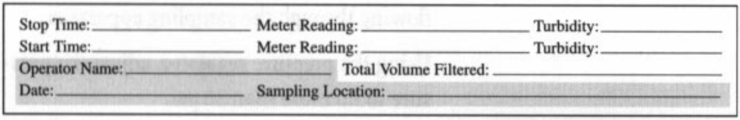
5 Using the pressure regulator, adjust the water pressure to no more than 30 psi. Flush the sampling apparatus with 20 gallons/ 76 liters of water by allowing the water to flow through the system and out the effluent hose.



Sampling Step	Volume In GALLONS	Volume In LITERS	Volume In FT^3
System Flush	20	76	2.7

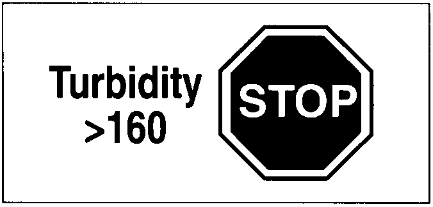
While the water is flushing the sampling apparatus, begin completing your sample label. Record the following information:

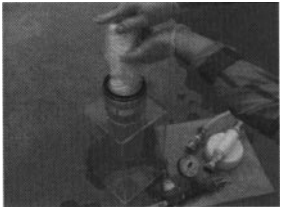
- Sampler's name
- Date
- Sample location



Stop Time: ____ Meter Reading: ____ Turbidity: ____
Start Time: ____ Meter Reading: ____ Turbidity: ____
Operator Name: ____ Total Volume Filtered: ____
Date: ____ Sampling Location: ____

6 Measure the turbidity of the source water flowing from the effluent hose. Record the readings on the sample label. If the turbidity is greater than 160 Nephelometric Turbidity Units (NTU), sampling should be rescheduled for a day when the turbidity is lower.





STEP 7 After the system has been flushed with 20 gallons / 76 liters of water, turn off the tap and disconnect the inlet and outlet hoses from the filter housing.

Using the filter wrench, open and drain the filter housing.

Open the filter packaging as aseptically as possible and carefully drop the filter into the filter housing.

! Be sure to hold the loose gasket in place using aseptic technique.

Reassemble the filter housing, and reconnect the inlet and outlet hoses. Place the filter housing in an upright position.

Slowly, turn on the tap and start the water flowing through the sampling apparatus.

Using the pressure regulator, adjust the pressure to no more than 30 psi.

Record the following information on the sample label:

- Time sampling started
- Initial water meter reading (including units)
- Turbidity

Stop Time: ________ Meter Reading: ________ Turbidity: ________
Start Time: ________ Meter Reading: ________ Turbidity: ________
Operator Name: ________ Total Volume Filtered: ________
Date: ________ Sampling Location: ________

Monitor the water meter to ensure that the flow rate does not exceed 1 gallon/min (approximately 4 liters/min).

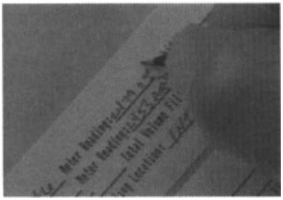
8 Allow at least 26 gallons/100 liters of water to pass through the filter. At a flow rate of approximately 1 gallon/minute, this will require about 30 minutes.

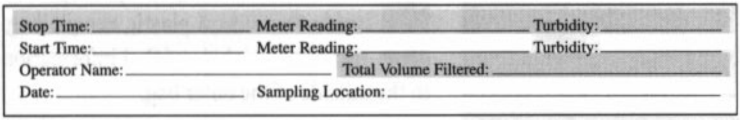
Sampling Step	**Volume In GALLONS**	**Volume In LITERS**	**Volume In FT^3**
Protozoa Flow Rate	1 per minute	4 per minute	.13 per minute
Protozoa Source Water Sample	26	100	3.5

9 When the water meter indicates that 26 gallons/100 liters of water have passed through the filter, turn off the water at the tap.

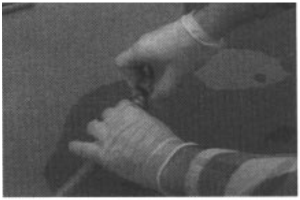
Record the following information on the sample label:

- Time sampling stopped
- Final water meter reading (including units)
- Final turbidity
- Total volume filtered





Stop Time: ______ Meter Reading: ______ Turbidity: ______
Start Time: ______ Meter Reading: ______ Turbidity: ______
Operator Name: ______ Total Volume Filtered: ______
Date: ______ Sampling Location: ______

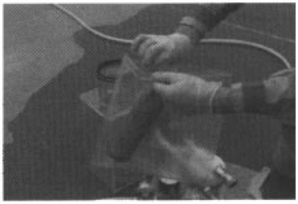


STEP 10 Disconnect the sampling apparatus from the water tap.

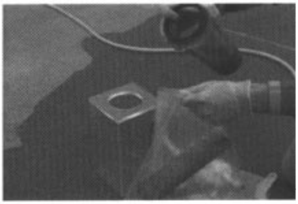
! Be sure to hold the inlet hose *above the level of the outlet hose opening* while the water drains from the housing. This will prevent backwash and loss of particulate matter from the filter.

Disconnect the inlet and outlet hoses from the filter housing.

! Put on fresh latex gloves.



STEP 11 As aseptically as possible, remove the filter from the housing and put it into a plastic sample bag.



STEP 12 Pour all of the water remaining in the filter housing into the same plastic bag.

STEP 13 Seal the plastic sample bag and place it inside the second plastic sample bag. Transfer the label or label information to the outside of the outer bag.

14 Put the bags containing the filter into the shipping container. Place the ice packs around, but not on, the sample bag to prevent freezing the sample. You may want to insert several inflated, empty sample bags between the sample and the ice packs.

15 Seal the container and follow the laboratory's instructions related to the cleaning, storage, and return of sampling equipment.

16 Ship the container by overnight courier to the laboratory. Call the laboratory and notify them of the sample shipment.

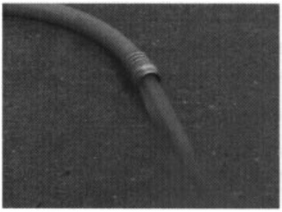
COLLECTING FINISHED WATER SAMPLES

If *Giardia* or *Cryptosporidium* concentrations in your source water samples exceed 1 per liter during the first 12 months of sampling, then you must monitor finished water as well as source water. If you are required to collect samples from both, collect the finished water sample first, then the source water sample.

Receiving and verifying the contents of your sampling kit are addressed in **STEPS 1** and **2** of the source water sampling section.

When you are ready to collect your finished water protozoa sample, bring the following items with you to the sampling location:

☐ Shipping container sent by the laboratory
☐ Sampling apparatus
☐ Fluid proportioning injector (for adding 2% thiosulfate solution to neutralize effects of chlorination or other disinfectant treatments)
☐ Plastic sample bags
☐ Sample labels
☐ Frozen ice packs
☐ Several pairs of new latex gloves
☐ Approximately 2 gal (4 L) of 2% sodium thiosulfate solution
☐ Sterile, 250- or 500-mL graduated cylinder
☐ Thermometer

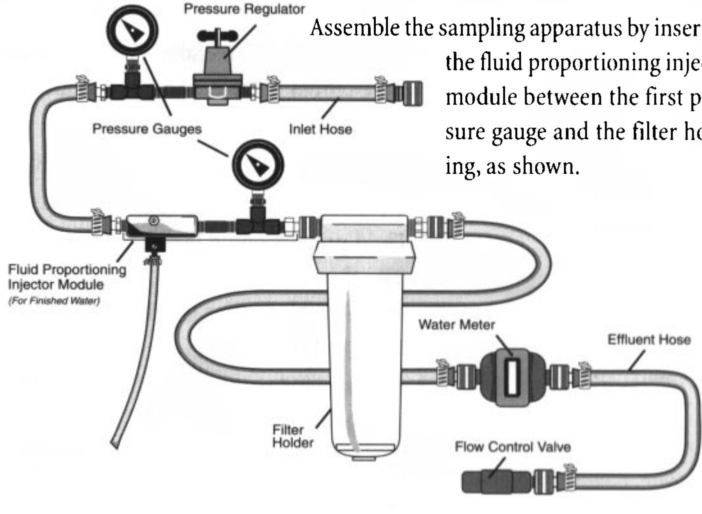


STEP 3 Turn on the water at the tap and allow the water to flow for 2 to 3 minutes or until any debris that has accumulated in the sampling line has cleared or the turbidity in the water becomes uniform.

Turn the water off at the tap

STEP 4 Put on new latex gloves to prevent contamination from outside sources. Sterile technique must be used when sampling for *Giardia* and *Cryptosporidium.* Any contamination of the sampling apparatus may bias the final results.

Assemble the sampling apparatus by inserting the fluid proportioning injector module between the first pressure gauge and the filter housing, as shown.

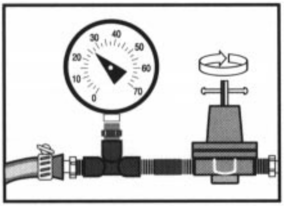


Connect the inlet end of the sampling apparatus to the sampling tap or to an extension hose connected to the tap.

Be sure that the filter housing does NOT contain the filter.

Note the water meter reading, then slowly turn on the water.

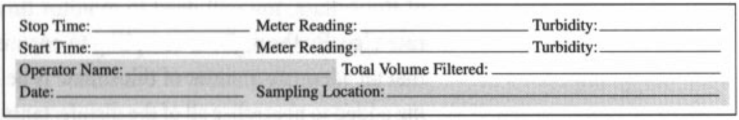
5 Using the pressure regulator, adjust the water pressure on the first pressure gauge to no more than 30 psi.



Flush the sampling apparatus with 20 gallons/ 76 liters of water by allowing the water to flow through the system and out the effluent hose.

While the water is flushing the sampling apparatus, begin completing your sample label. Record the following information:

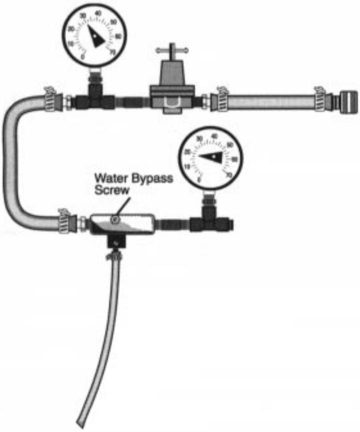
- Sampler's name
- Date
- Sample location



Stop Time: ____________ Meter Reading: ____________ Turbidity: ____________
Start Time: ____________ Meter Reading: ____________ Turbidity: ____________
Operator Name: ____________ Total Volume Filtered: ____________
Date: ____________ Sampling Location: ____________

6 Now, you must adjust the thiosulf injector.

First, using the water bypass screw, the larger top screw in the injector, adjust the pressure on the downstream pressure gauge to be at least 35% less than the pressure shown on the upstream gauge. For ample, if the upstream gauge reads 30| then the second gauge should read no m than 19psi.



Pour the 2% sodium thiosulfate solution into a graduated cylinder. Place the injector tube in the thiosulfate solution, and adjust the smaller injector screw, located on the bottom of the injector, so that the flow rate of the 2% thiosulfate solution is approximately 10 milliliters per minute.

! If there is no suction visibly drawing down the thiosulfate solution, or if too much is flowing, adjust the water bypass screw further to increase or decrease the pressure differential between the two gauges. A greater differential between the upstream and downstream gauges increases the flow rate; a smaller differential decreases the flow rate.

After the thiosulfate flow rate is adjusted properly, transfer the injector tube to a carboy of thiosulfate. You will need to monitor this rate visually throughout sampling to ensure that an adequate amount of thiosulfate is being added to neutralize all of the disinfectants.

Turn off the water at the tap and empty the water in the filter housing.

7 Open the filter packaging as aseptically as possible and carefully drop the filter into the filter housing.

! Hold the loose gasket in place.

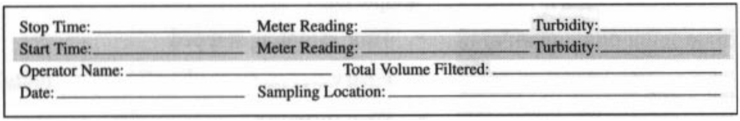
Reassemble the filter housing, and reconnect the inlet and outlet hoses.

Slowly, start the water flowing through the sampling apparatus.

Using the pressure regulator, adjust the pressure on the upstream pressure gauge to no more than 30 psi. Using the water bypass screw, readjust the downstream pressure gauge to read 35% less than the upstream gauge, if necessary.

Record the following information on the sample label:

- Time sampling started
- Initial water meter reading (including units)
- Turbidity



Stop Time:______ Meter Reading:______ Turbidity:______
Start Time:______ Meter Reading:______ Turbidity:______
Operator Name:______ Total Volume Filtered:______
Date:______ Sampling Location:______

Place the filter housing in an upright position.

Monitor the water meter to ensure that the flow rate does not exceed 1 gallon/min (approximately 4 liters/min).

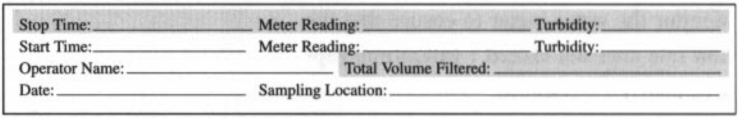
STEP 8 Allow at least 264 gallons/1000 liters of water to pass through the filter. At a flow rate of approximately 1 gallon/minute, this will require about 4 hours and 45 minutes.

Sampling Step	**Volume In GALLONS**	**Volume In LITERS**	**Volume In FT^3**
Protozoa Flow Rate	1 per minute	4 per minute	.13 per minute
Protozoa Finished Water Sample	264	1000	36

STEP 9 When the water meter indicates that 264 gallons/1000 liters of water have passed through the filter, turn off the water at the tap.

Record the following information on the sample label:

- Time sampling stopped
- Final water meter reading (including units)
- Final turbidity
- Total volume filtered



Stop Time: ______ Meter Reading: ______ Turbidity: ______
Start Time: ______ Meter Reading: ______ Turbidity: ______
Operator Name: ______ Total Volume Filtered: ______
Date: ______ Sampling Location: ______

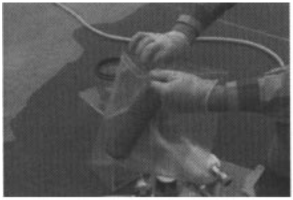
STEP 10 Disconnect the sampling apparatus from the water tap.

! Be sure to hold the inlet hose *above the level of the outlet hose opening* while the water drains from the housing. This will prevent backwash and loss of particulate matter from the filter.

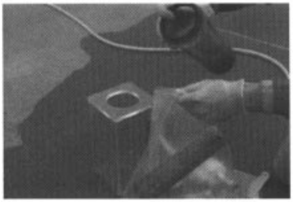
Disconnect the inlet and outlet hoses from the filter housing.

! Put on fresh latex gloves.

11 As aseptically as possible, remove the filter from the housing and put it into a plastic sample bag.



12 Pour all of the water remaining in the filter housing into the same plastic bag.

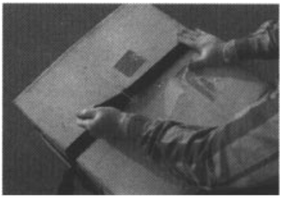


13 Seal the plastic sample bag and place it inside the second plastic sample bag.

Transfer the label or label information to the outside of the outer bag.

14 Put the bags containing the filter into the shipping container.

Place the ice packs around, but not on, the sample bag to prevent freezing the sample. You may want to insert several inflated, empty sample bags between the sample and the ice packs.



15 Seal the container and follow the laboratory's instructions related to the cleaning, storage, and return of sampling equipment.

16 Ship the container by overnight courier to the laboratory.

Call the laboratory and notify them of the sample shipment.

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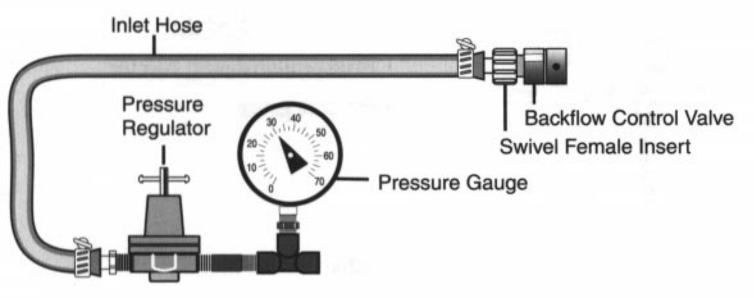
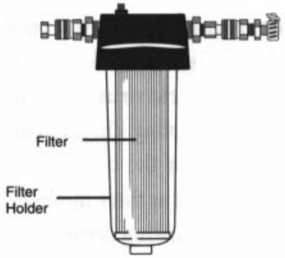
SAMPLE COLLECTION PROCEDURES FOR DETECTING ENTERIC VIRUSES IN WATER

STEP 1

Each month, your laboratory will send you all of the equipment needed to collect samples for enteric virus analyses. When you receive the sampling kit, immediately check the contents of the carton. The sampling kit will be shipped as three modules, and should contain the following items:

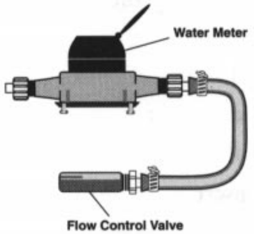
- ☐ Plastic sample bags
- ☐ Ice packs for shipping the collected samples
- ☐ Sample data sheet
- ☐ Regulator Module (below):
  - Backflow control valve
  - Swivel female insert
  - Inlet hose
  - Pressure regulator with pressure gauge





☐ Cartridge Housing Module:

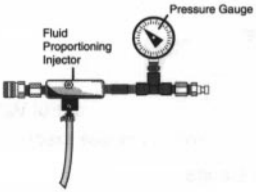
- 1-MDS Zetapor Virosorb filter inside a filter holder



☐ Discharge Module:

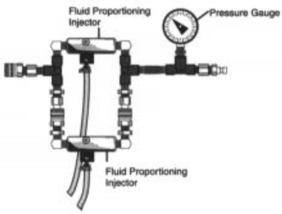
- Water meter
- Flow control valve

The laboratory will also ship three additional modular sections, as required by your facility. These may include:



☐ Single Injector Module:

- Fluid proportioning injector
- Pressure gauge

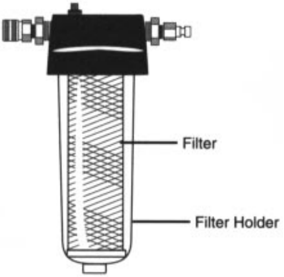


☐ Double Injector Module:

- Two fluid proportioning injectors, in parallel
- Pressure gauge

☐ Prefilter Module:

- 10 µm polypropylene filter inside a filter holder



❗ The ends of each module should be wrapped in foil to ensure that the equipment remains free of contamination. If your modules are unprotected or compromised, please contact your laboratory immediately for further instructions.

If you are missing any items, contact your laboratory immediately. Do not attempt to collect the samples without a complete sampling kit.

Once you have verified the contents of the sampling kit, place the ice packs in the freezer and repack the box.

COLLECTING SOURCE WATER SAMPLES

When you are ready to collect your virus sample, bring the following items with you to the sampling location:

☐ Shipping container sent by the laboratory

☐ Regulator Module

☐ Cartridge Housing Module

☐ Discharge Module

☐ Single Injector Module (for adding 0.1-molar hydrochloric acid to adjust pH, if necessary)

☐ Prefilter Module (for filtering sediment from highly turbid water, if necessary)

☐ Approximately 2 gal (4 L) of 0.1-molar hydrochloric acid solution (for adjusting pH, if necessary)

☐ Sterile, 250- or 500-mL graduated cylinder

☐ Plastic sample bags

☐ Sample data sheet

☐ Frozen ice packs

☐ Several pairs of new latex gloves

☐ pH meter

☐ Thermometer

☐ Turbidimeter

2 Turn on the water at the tap and allow the water to flow for 2 to 3 minutes or until any debris that has accumulated in the sampling line has cleared or the turbidity in the water becomes uniform.

3 Put on new latex gloves to prevent contamination from outside sources. Sterile technique must be used when sampling for enteric viruses. Any contamination of the sampling apparatus may bias the final results.

Turn off the water at the tap.

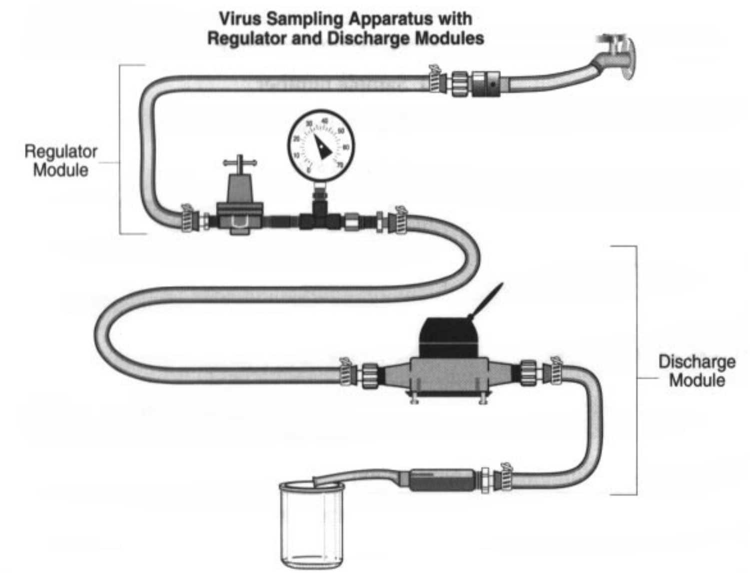
Remove the foil from the backflow regulator on the Regulator Module and connect it to the water tap or to an extension hose connected to the tap.

Remove the foil from the other end of the Regulator Module and from the Discharge Module. Connect the Discharge Module to the Regulator Module.

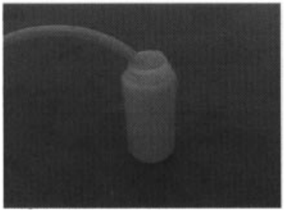
Place the end of the Discharge Module, or an extension hose connected to the Discharge Module, into a 1-liter plastic bottle.

Note the water meter reading, then slowly turn on the water.

Using the pressure regulator, adjust the water pressure to no more than 30 psi.



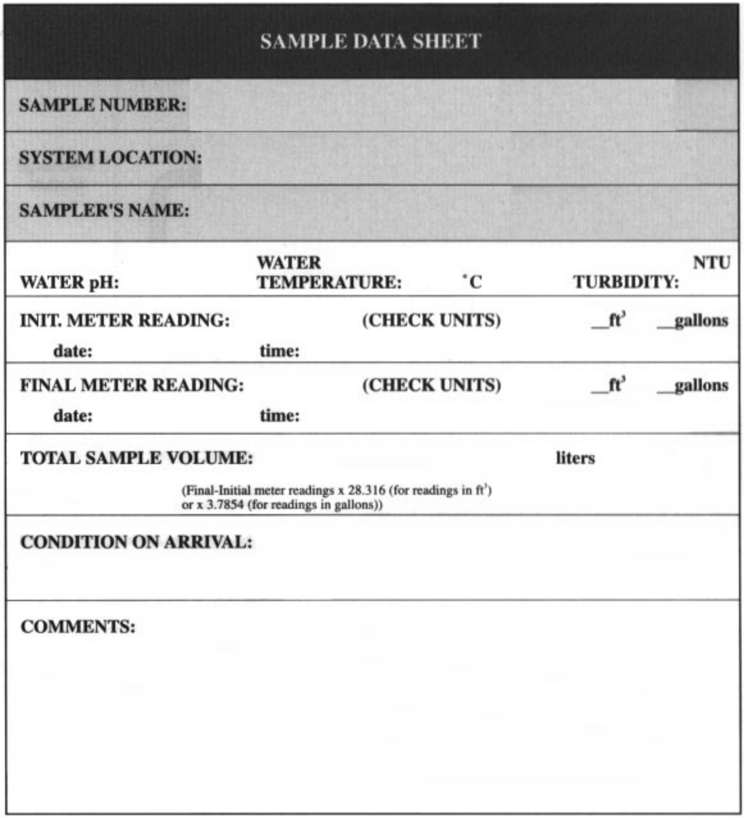
4 Flush the sampling apparatus with 20 gallons / 76 liters of water by allowing the water to flow through the system, out the effluent hose into the 1-liter plastic bottle.



Sampling Step	Volume In GALLONS	Volume In LITERS	Volume In FT^3
System Flush	20	76	2.7

While the water is flushing the sampling apparatus, begin completing your sample data sheet. Record the following information:

- ☐ Sample number
- ☐ System location
- ☐ Sampler's name



SAMPLE DATA SHEET

SAMPLE NUMBER:

SYSTEM LOCATION:

SAMPLER'S NAME:

WATER pH: **WATER TEMPERATURE:** °C **TURBIDITY:** NTU

INIT. METER READING: **(CHECK UNITS)** __ft³ __gallons
date: **time:**

FINAL METER READING: **(CHECK UNITS)** __ft³ __gallons
date: **time:**

TOTAL SAMPLE VOLUME: **liters**
(Final-Initial meter readings x 28.316 (for readings in ft³)
or x 3.7854 (for readings in gallons))

CONDITION ON ARRIVAL:

COMMENTS:

5 Measure the pH, temperature, and turbidity of the source water flowing from the effluent hose. Record the readings on the sample data sheet.

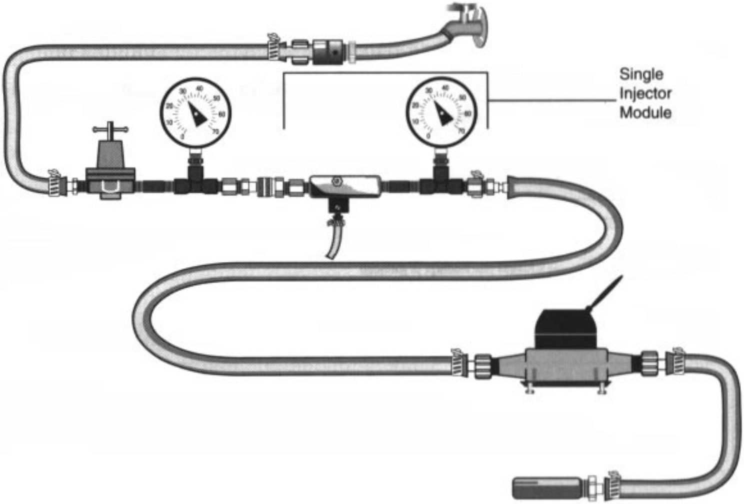
SAMPLE DATA SHEET			
SAMPLE NUMBER:			
SYSTEM LOCATION:			
SAMPLER'S NAME:			
WATER pH:	**WATER TEMPERATURE:** °C	**TURBIDITY:** NTU	
INIT. METER READING: **date:**	**time:**	**(CHECK UNITS)**	__ft^3 __gallons
FINAL METER READING: **date:**	**time:**	**(CHECK UNITS)**	__ft^3 __gallons
TOTAL SAMPLE VOLUME:	(Final-Initial meter readings x 28.316 (for readings in ft^3) or x 3.7854 (for readings in gallons))	**liters**	
CONDITION ON ARRIVAL:			
COMMENTS:			

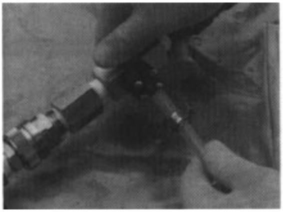
6 Turn off the water at the tap and decide whether you need to insert additional modules into the sampling train.

For source water sampling, you may need to use the Single Injector Module and/or the Prefilter Module.

First, determine if you need to use the Single Injector Module.

If your pH value is greater than 8.0, you need to insert the Single Injector Module between the Regulator and Discharge Modules before proceeding.

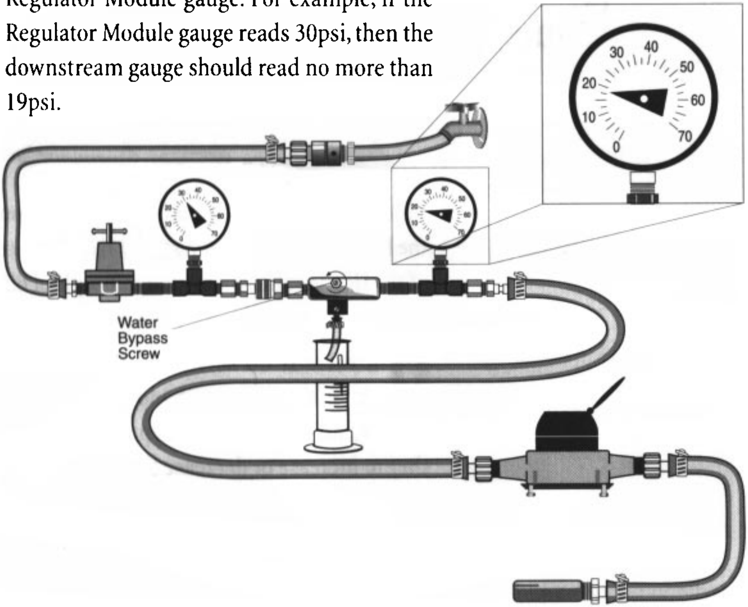


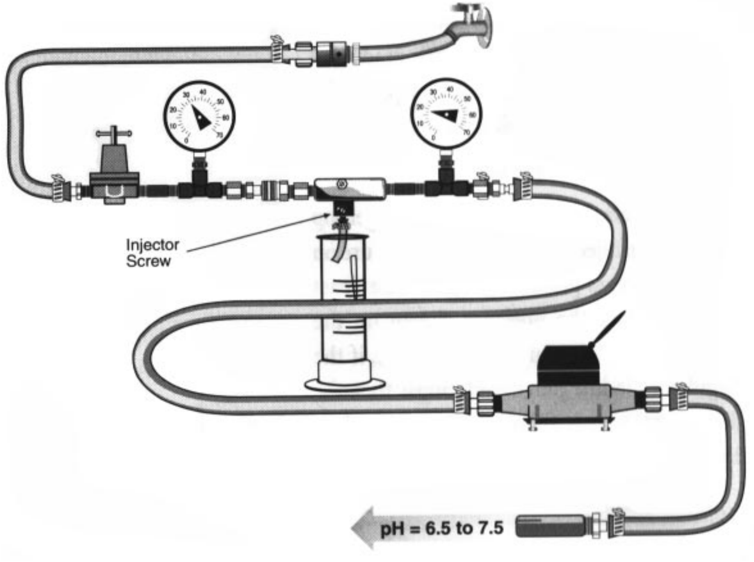


Using aseptic technique, connect the sterile tubing to the injector. Fill the sterile graduated cylinder with 0.1-molar HCl and place the tube in the graduated cylinder.

Turn on the water at the tap.

Using the water bypass screw—the larger top screw in the injector—adjust the pressure on the downstream pressure gauge to be at least 35% less than the pressure shown on the Regulator Module gauge. For example, if the Regulator Module gauge reads 30psi, then the downstream gauge should read no more than 19psi.





Adjust the smaller injector screw, located on the bottom of the injector, so that the flow rate of the HCl is sufficient to maintain a pH of 6.5 to 7.5.

! If there is no suction visibly drawing down the HCl, or if too much HCl is flowing, adjust the water bypass screw further to increase or decrease the pressure differential between the two gauges. A greater differential between the upstream gauges increases the flow rate; a smaller differential decreases the flow rate.

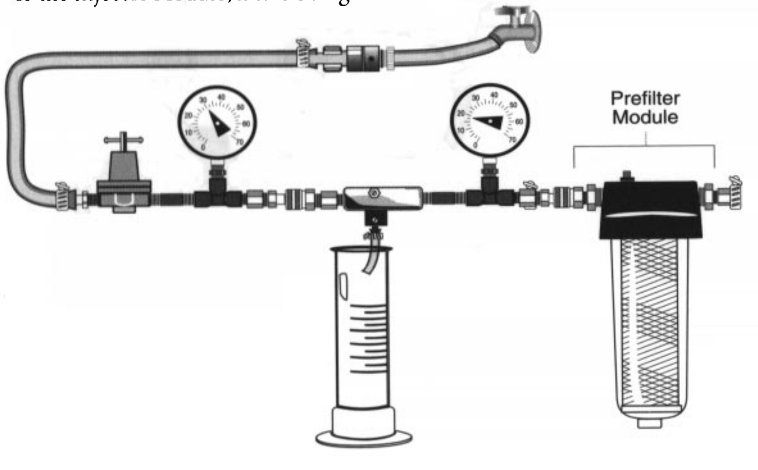
After the HCl flow rate is adjusted properly, transfer the injector tube to a carboy of HCl. Periodically check the pH to ensure that sufficient HCl is being added to maintain a pH of 6.5 to 7.5.

Record the adjusted pH on the Sample Data Sheet.

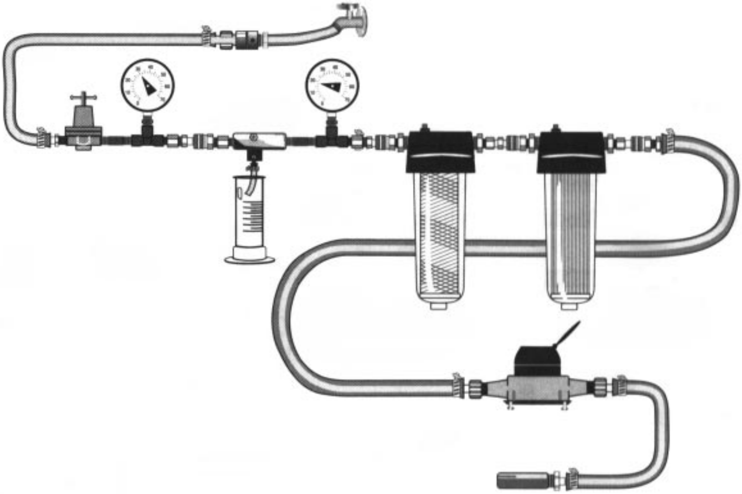
Next, determine if you need to use the Prefilter Module.

Turn off the water at the tap, and note the turbidity. If the turbidity is greater than 75 NTU, or for conditions where the 1-MDS filter is expected to clog before sampling is completed, you will need to use the Prefilter Module.

Disconnect the Discharge Module and connect the Prefilter Module to the Regulator Module or the Injector Module, if it is being used.

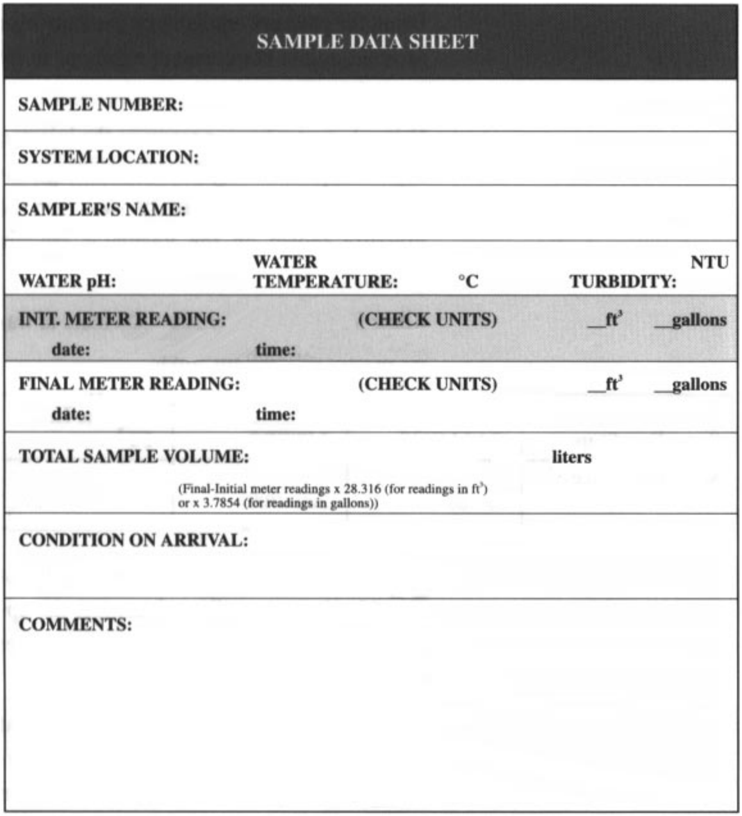


7 Connect the Cartridge Housing Module containing the 1-MDS filter to the Prefilter Module. Then, reconnect the Discharge Module to the outlet end of the Cartridge Housing Module.



Record the following information on the Sample Data Sheet:

- ☐ Date sampling started
- ☐ Time sampling started
- ☐ Initial water meter reading (including units)



SAMPLE DATA SHEET

SAMPLE NUMBER:

SYSTEM LOCATION:

SAMPLER'S NAME:

WATER pH: **WATER TEMPERATURE:** °C **TURBIDITY:** NTU

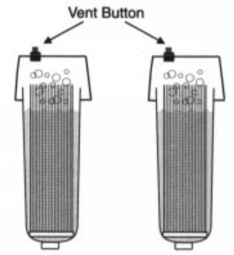
INIT. METER READING: **(CHECK UNITS)** __ft^3 __gallons
date: **time:**

FINAL METER READING: **(CHECK UNITS)** __ft^3 __gallons
date: **time:**

TOTAL SAMPLE VOLUME: **liters**
(Final-Initial meter readings x 28.316 (for readings in ft^3) or x 3.7854 (for readings in gallons))

CONDITION ON ARRIVAL:

COMMENTS:



STEP 8 Slowly, start the water flowing through the sampling apparatus.

Push the red vent buttons on top of the filter housings to expel air in the filters. When the air is totally expelled from the filters, release the button and open the water tap completely.

Using the pressure regulator on the Regulator Module, adjust the pressure regulator to no more than 30 psi.

Using the water bypass screw on the injector, adjust the pressure regulator on the Single Injector Module to be at least 35% less than the pressure shown on the Regulator Module gauge.

Allow 53 - 80 gallons / 200 - 300 liters of water to pass through the filter.

Sampling Step	Volume In GALLONS	Volume In LITERS	Volume In FT^3
Sampling Source Water	53 - 80	200 - 300	7 - 11

! If the virus filter clogs before 53 gallons/ 100 liters are collected, contact the approved analyst at your laboratory for further instructions.

STEP 9 When the water meter indicates that 53 - 80 gallons / 200 - 300 liters of water have passed through the filter, turn off the water at the tap.

Record the following information on the Sample Data Sheet:

☐ Date sampling ended

☐ Time sampling ended

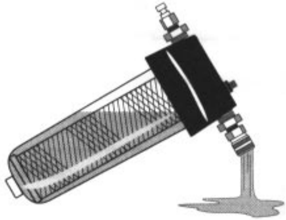
☐ Final water meter reading (including units)

SAMPLE DATA SHEET			
SAMPLE NUMBER:			
SYSTEM LOCATION:			
SAMPLER'S NAME:			
WATER pH:	**WATER TEMPERATURE:** °C	**TURBIDITY:**	**NTU**
INIT. METER READING: **date:**	**time:**	**(CHECK UNITS)**	__ft^3 __gallons
FINAL METER READING: **date:**	**time:**	**(CHECK UNITS)**	__ft^3 __gallons
TOTAL SAMPLE VOLUME:	(Final-Initial meter readings x 28.316 (for readings in ft^3) or x 3.7854 (for readings in gallons))	**liters**	
CONDITION ON ARRIVAL:			
COMMENTS:			

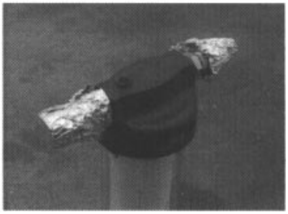
Put on fresh latex gloves.

Carefully, disconnect the sampling apparatus from the water tap.

Disconnect the Cartridge Housing Module from the sampling train.



Turn the filter housing upside down and allow excess water to flow out as waste water.



Turn the housing upright, and cover the module ends with sterile foil.

Do not attempt to open the filter housing.

If you are using the Prefilter Module, disconnect it from the sampling train, repeat the draining procedure, and cover the module ends with sterile foil.

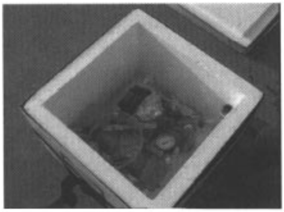
The filters and filter housings are shipped to the laboratory intact. The Discharge Module may be retained at the utility and reused.

Place the filter housings into an insulated shipping box.

Set the ice packs around the housings.

Return the Regulator Module and the Injector Module to the laboratory for cleaning and sterilization.

Place the Sample Data Sheet in a plastic bag and pack it on top of the sampling apparatus.



You may need to use additional packing material to ensure that the contents of the box will not shift during transport.

11 Seal the container and ship it by overnight courier to the laboratory. Call the laboratory and notify them of the sample shipment.

COLLECTING FINISHED WATER SAMPLES

STEP 1

If the concentration of any pathogen in your source water samples exceeds 1 per liter during the first 12 months of sampling, then you must monitor finished water as well as source water.

Sampling of finished water begins in the same manner as sampling of source water described previously, as follows:

When you are ready to collect your finished water virus sample, bring the following items with you to the sampling location:

☐ Shipping container sent by the laboratory

☐ Regulator Module

☐ Cartridge Housing Module

☐ Discharge Module

☐ Single Injector Module (for adding 2% thiosulfate solution to neutralize effects of chlorination or other disinfectant treatments)

☐ Double Injector Module (for adding 2% thiosulfate solution to neutralize effects of chlorination or other disinfectant treatments while adding 0.1-molar hydrochloric acid to adjust pH, if necessary)

☐ Approximately 2 gal (4 L) of 2% sodium thiosulfate solution

☐ Approximately 2 gal (4 L) of 0.1-molar hydrochloric acid solution (for adjusting pH, if necessary)

☐ 2 sterile, 250- or 500-mL graduated cylinders

☐ Plastic sample bags

☐ Sample data sheet

☐ Frozen ice packs

☐ Several pairs of new latex gloves

☐ pH meter

☐ Thermometer

2 Turn on the water at the tap and allow the water to flow for 2 to 3 minutes or until any debris that has accumulated in the sampling line has cleared or the turbidity in the water becomes uniform.

Turn off the water at the tap.

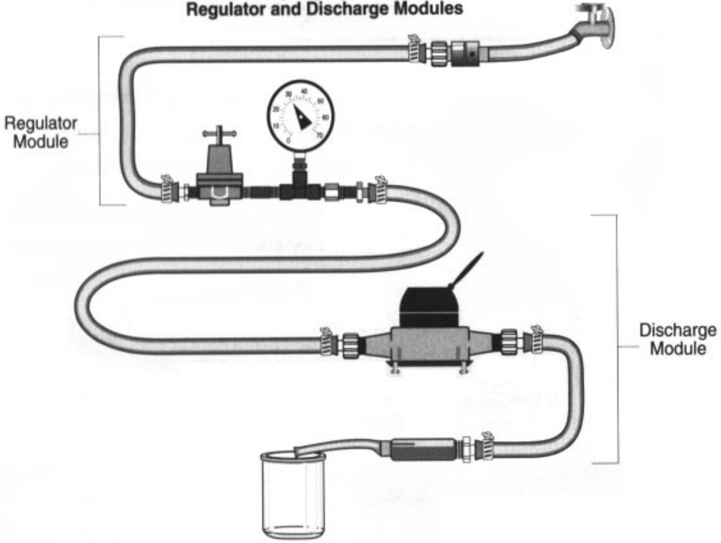
3 Put on new latex gloves to prevent contamination from outside sources. Sterile technique must be used when sampling for enteric viruses. Any contamination of the sampling apparatus may bias the final results.

Remove the foil from the backflow regulator on the Regulator Module and connect the module to the water tap or to an extension hose connected to the tap.

Remove the foil from the other end of the Regulator Module and from the Discharge Module and connect the Discharge Module to the Regulator Module.

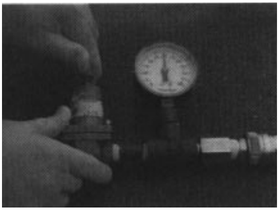
Place the end of the Discharge Module, or an extension hose connected to the Discharge Module, into a 1-liter plastic bottle.

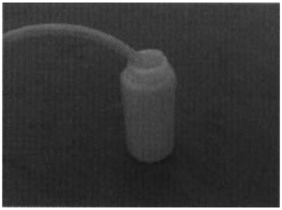
Virus Sampling Apparatus with Regulator and Discharge Modules



Note the water meter reading, then slowly turn on the water.

Using the pressure regulator, adjust the water pressure to no more than 30 psi.



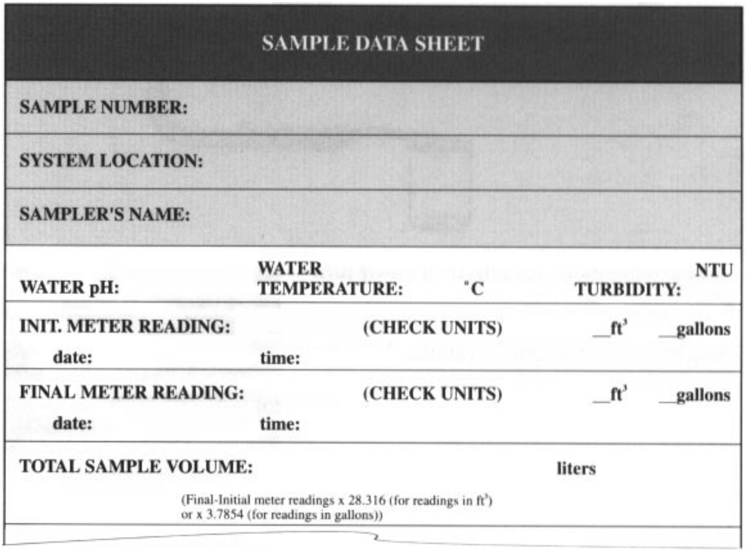


STEP 4 Flush the sampling apparatus with 20 gallons / 76 liters of water by allowing the water to flow through the system, out the effluent hose into the 1-liter plastic bottle.

Sampling Step	Volume In GALLONS	Volume In LITERS	Volume In FT^3
System Flush	20	76	2.7

While the water is flushing the sampling apparatus, begin completing your sample data sheet. Record the following information:

- ☐ Sample number
- ☐ System location
- ☐ Sampler's name



SAMPLE DATA SHEET

SAMPLE NUMBER:

SYSTEM LOCATION:

SAMPLER'S NAME:

WATER pH: WATER TEMPERATURE: °C TURBIDITY: NTU

INIT. METER READING: (CHECK UNITS) _ft^3 _gallons
date: time:

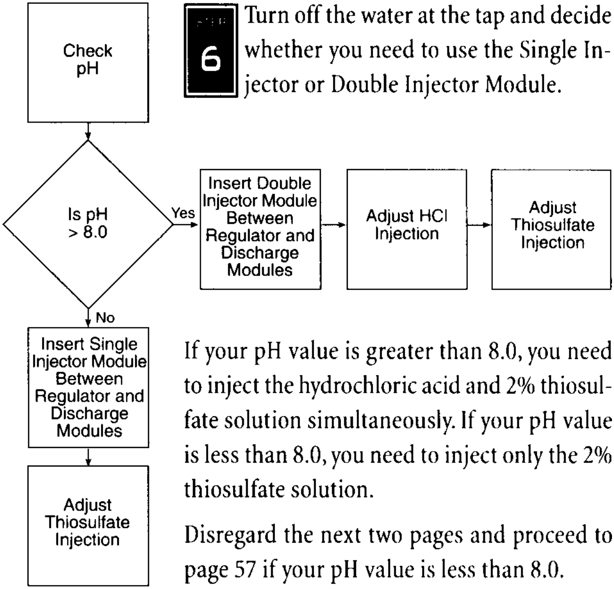
FINAL METER READING: (CHECK UNITS) _ft^3 _gallons
date: time:

TOTAL SAMPLE VOLUME: liters
(Final-Initial meter readings x 28.316 (for readings in ft^3) or x 3.7854 (for readings in gallons))

5 Measure the pH, temperature, and turbidity of the source water flowing from the effluent hose. Record the readings on the sample data sheet.

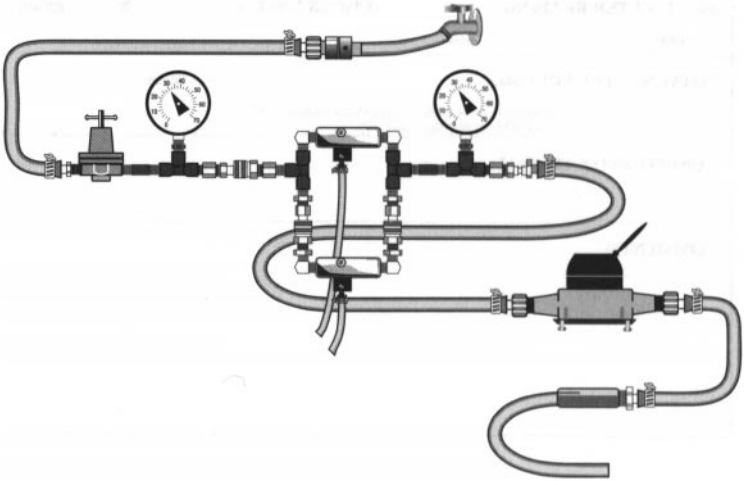
SAMPLE DATA SHEET			
SAMPLE NUMBER:			
SYSTEM LOCATION:			
SAMPLER'S NAME:			
WATER pH:	**WATER TEMPERATURE:** °C	**TURBIDITY:** NTU	
INIT. METER READING: **date:**	**time:**	**(CHECK UNITS)**	**__ft³ __gallons**
FINAL METER READING: **date:**	**time:**	**(CHECK UNITS)**	**__ft³ __gallons**
TOTAL SAMPLE VOLUME:	(Final-Initial meter readings x 28.316 (for readings in ft³) or x 3.7854 (for readings in gallons))	**liters**	
CONDITION ON ARRIVAL:			
COMMENTS:			

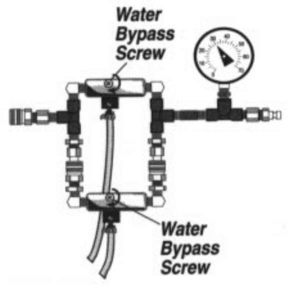
STEP 6 Turn off the water at the tap and decide whether you need to use the Single Injector or Double Injector Module.



If your pH value is greater than 8.0, you need to inject the hydrochloric acid and 2% thiosulfate solution simultaneously. If your pH value is less than 8.0, you need to inject only the 2% thiosulfate solution.

Disregard the next two pages and proceed to page 57 if your pH value is less than 8.0.





pH > 8.0 Insert the Double Injector Module between the Regulator and Discharge Modules before proceeding.

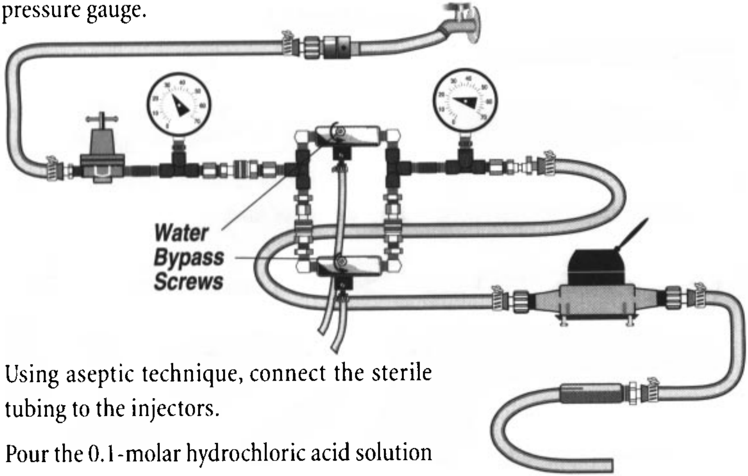
Ensure that both injectors are completely closed before proceeding.

Adjust the water bypass screws on each injector clockwise as far as possible.

Turn on the water.

Next, turn each of the screws one half turn counterclockwise.

Continue opening the water bypass screws in half-turn increments until the reading on the second pressure gauge is approximately 35% less than that shown on the Regulator Module pressure gauge.



Using aseptic technique, connect the sterile tubing to the injectors.

Pour the 0.1-molar hydrochloric acid solution into a sterile graduated cylinder and place one of the injector tubes into it.

Pour the 2% thiosulfate solution into a second, sterile graduated container. Place the tube from the second injector into the thiosulfate solution.

❗ If there is no suction visibly drawing down the 2% thiosulfate or the HCl, or if too much is flowing, adjust the water bypass screws further to increase or decrease the pressure differential between the two gauges, until the flow is regulated properly.

Adjust the smaller injector screw on the hydrochloric acid injector to add sufficient hydrochloric acid to maintain a pH of 6.5 to 7.5.

After adjusting the injector, transfer the injector tube to the carboy of 0.1-molar hydrochloric acid. As sampling proceeds, periodically check the pH to ensure that it remains between 6.5 and 7.5.

Record the adjusted pH on the Sample Data Sheet.

Next, using the formula below, calculate the rate of thiosulfate injection and adjust the thiosulfate injector to deliver 10 mL of thiosulfate per gallon of flow.

$$\left(\begin{array}{c}\text{Water}\\ \text{Flow}\\ \text{Rate}\end{array}\right)\frac{\text{gallons}}{\text{minute}} \times \frac{\text{10 ml Thiosulfate}}{\text{1 gallon water}} = \left(\begin{array}{c}\text{Thiosulfate}\\ \text{Injection Rate}\end{array}\right)\frac{\text{ml}}{\text{minute}}$$

After the thiosulfate flow rate is adjusted, transfer the injector tube to the carboy of thiosulfate.

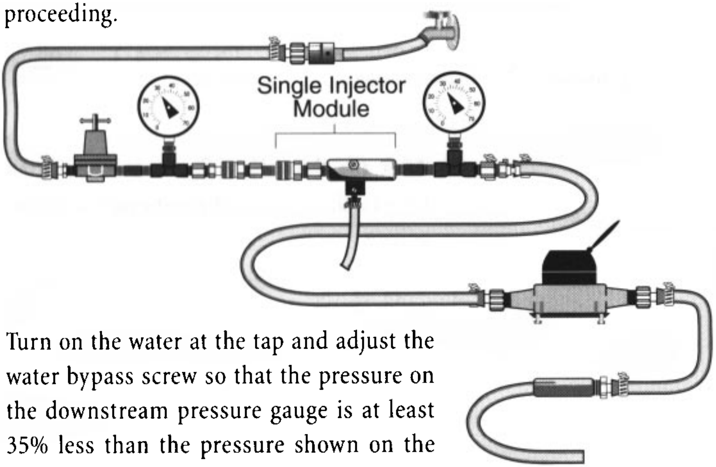
Monitor the thiosulfate flow rate visually throughout sampling.

Disregard the next section and proceed to step 7 (page 58).

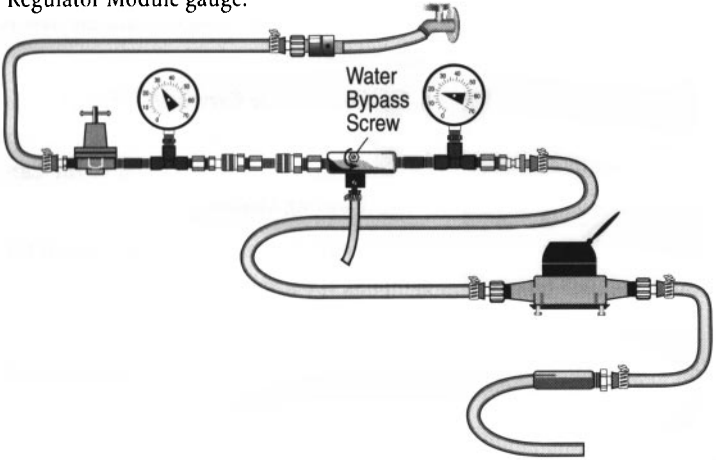
pH < 8.0

If your pH value is less than 8.0, it does not need to be adjusted, and you can use the Single Injector Module to inject the 2% sodium thiosulfate solution.

Insert the Single Injector Module between the Regulator and Discharge Modules before proceeding.



Turn on the water at the tap and adjust the water bypass screw so that the pressure on the downstream pressure gauge is at least 35% less than the pressure shown on the Regulator Module gauge.



Pour the 2% thiosulfate into a graduated cylinder.

Next, using the formula below, calculate the rate of thiosulfate injection and adjust the thiosulfate injector to deliver 10 mL of thiosulfate per gallon of flow.

$$\begin{pmatrix}\text{Water}\\ \text{Flow}\\ \text{Rate}\end{pmatrix}\frac{\text{gallons}}{\text{minute}} \times \frac{\text{10 ml Thiosulfate}}{\text{1 gallon water}} = \begin{pmatrix}\text{Thiosulfate}\\ \text{Injection Rate}\end{pmatrix}\frac{\text{ml}}{\text{minute}}$$

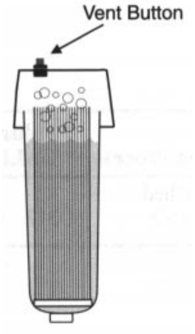
After the thiosulfate flow rate is adjusted, transfer the injector tube to the carboy of thiosulfate.

Monitor the thiosulfate flow rate visually throughout sampling.

! If there is no suction visibly drawing down the thiosulfate, or if too much is flowing, adjust the water bypass screw further to increase or decrease the pressure differential between the two gauges, until the flow is regulated properly.

STEP 7 Connect the Cartridge Housing Module. Then reconnect the Discharge Module to the outlet end of the Cartridge Housing Module.

Slowly, start the water flowing through the sampling apparatus.



Push the red vent button on top of the filter housing to expel air in the filter. When the air is totally expelled from the filter, release the button and open the water tap completely.

Using the pressure regulator on the Regulator Module, adjust the pressure to no more than 30 psi.

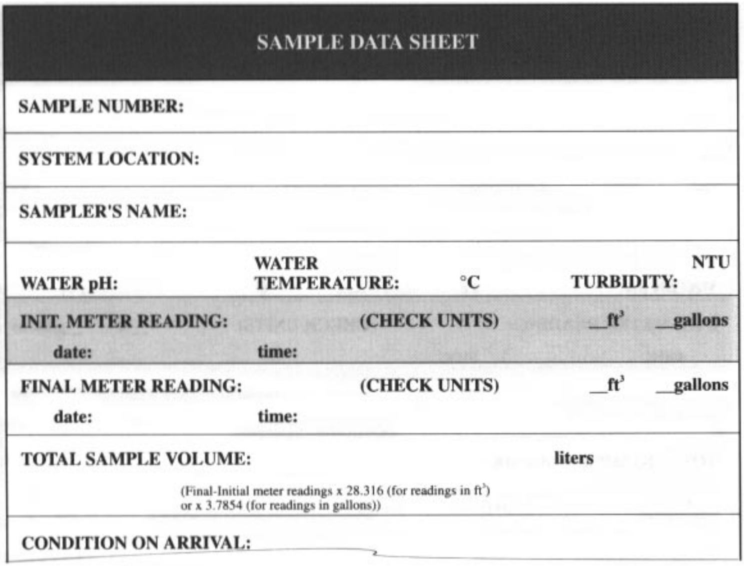
Using the water bypass screw on the injector, adjust the pressure gauge on the Single Injector Module to be at least 35% less than the pressure shown on the Regulator Module gauge .

Record the following information on the Sample Data Sheet:

☐ Date sampling started

☐ Time sampling started

☐ Initial water meter reading (including units)



SAMPLE DATA SHEET			
SAMPLE NUMBER:			
SYSTEM LOCATION:			
SAMPLER'S NAME:			
WATER pH:	**WATER TEMPERATURE:** °C		**TURBIDITY:** NTU
INIT. METER READING: **date:**	**time:**	**(CHECK UNITS)**	**_ft^3 _gallons**
FINAL METER READING: **date:**	**time:**	**(CHECK UNITS)**	**_ft^3 _gallons**
TOTAL SAMPLE VOLUME:	(Final-Initial meter readings x 28.316 (for readings in ft^3) or x 3.7854 (for readings in gallons))	**liters**	
CONDITION ON ARRIVAL:			

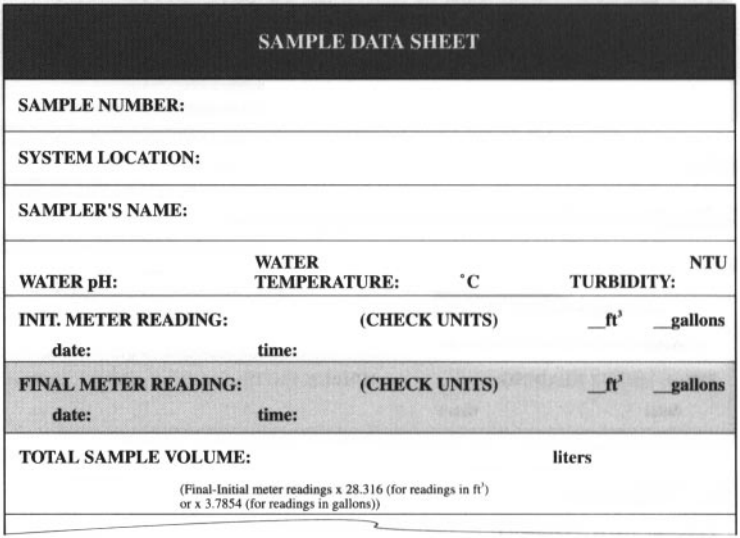
STEP 8 Collect 317 - 396 gallons or 1200 to 1500 liters of finished water.

Sampling Process	Volume In GALLONS	Volume In LITERS	Volume In FT^3
Virus Finished Water Sample	317 - 396	1200 - 1500	43 - 53

STEP 9 When the water meter indicates that 317 - 396 gallons / 1200 - 1500 liters of water have passed through the filter, turn off the water at the tap.

Record the following information on the Sample Data Sheet:

- ☐ Date sampling ended
- ☐ Time sampling ended
- ☐ Final water meter reading (including units)



SAMPLE DATA SHEET

SAMPLE NUMBER:

SYSTEM LOCATION:

SAMPLER'S NAME:

WATER pH: WATER TEMPERATURE: °C TURBIDITY: NTU

INIT. METER READING: (CHECK UNITS) __ft³ __gallons
date: time:

FINAL METER READING: (CHECK UNITS) __ft³ __gallons
date: time:

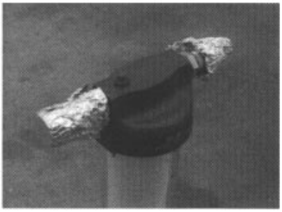
TOTAL SAMPLE VOLUME: liters
(Final-Initial meter readings x 28.316 (for readings in ft³) or x 3.7854 (for readings in gallons))

Put on fresh latex gloves.

Carefully, disconnect the sampling apparatus from the water tap.

Disconnect the Cartridge Housing Module from the sampling train. Turn the filter housing upside down and allow excess water to flow out as waste water.

Turn the housing upright, and cover the module ends with sterile foil.



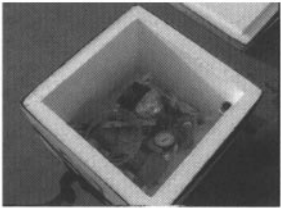
Do not attempt to open the filter housing.

The filter and filter housing are shipped to the laboratory intact. The Discharge Module may be retained at the utility and reused.

STEP 10

Place the filter housing into an insulated shipping box.

Set the ice packs around the housing.



Return the Regulator Module and the Injector Module to the laboratory for cleaning and sterilization.

Place the Sample Data Sheet in a plastic bag and pack it on top of the sampling apparatus. Seal the container.

You may need to use additional packing material to ensure that the contents of the box will not shift during transport.

STEP 11 Ship the container by overnight courier to the laboratory. Call the laboratory and notify them of the sample shipment.

CREDITS AND ACKNOWLEDGMENTS

The use of Manufacturer Trade Names in the production does not constitute endorsement by the U.S. Environmental Protection Agency.

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Special thanks to the management and staff of the Fairfax County Water Authority.

APPENDIX K – Memorandum: *Findings and Recommendations of the Advanced Water Purification Facility Subcommittee Meeting,* November 15, 2010, NWRI

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Joint Powers Agreement Members

Inland Empire Utilities Agency

Irvine Ranch Water District

Los Angeles Department of Water and Power

Orange County Sanitation District

Orange County Water District

West Basin Municipal Water District

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City of San Diego
600 B Street, Suite 600
San Diego, CA 92101

From: James Crook, Ph.D., P.E.
Vice Chair, NWRI Independent Advisory Panel for the City of San Diego's Indirect Potable Reuse/Reservoir Augmentation Demonstration Project

Jeff Mosher
Executive Director
National Water Research Institute

Subject: Findings and Recommendations of the Advanced Water Purification Facility Subcommittee Meeting

Date: November 15, 2010

The NWRI Independent Advisory Panel (IAP) for the City of San Diego's Indirect Potable Reuse/Reservoir Augmentation Demonstration Project held an Advanced Water Purification Facility (AWPF) Subcommittee meeting on October 21, 2010, at the City of San Diego's Ocean Monitoring Laboratory in San Diego, California.

Specifically, the Subcommittee of the IAP was charged with the following:

- Review the Draft Testing and Monitoring (T&M) Plan for the Advanced Water Purification Demonstration Facility.
- Resolve key comments on the IAP Report (dated September 17, 2009) as related to the T&M Plan.
- Review key items requiring input from the IAP and California Department of Public Health (CDPH) on the Draft T&M Plan.
- Review the schedule for the approval of the T&M Plan.

Members of the Advanced Water Purification Facility Subcommittee include:

- *Subcommittee Chair:* James Crook, Ph.D., P.E., Water Reuse Consultant (Boston, MA)
- Joseph A. Cotruvo, Ph.D., Joseph Cotruvo Associates (Washington, D.C.)
- Richard Gersberg, Ph.D., San Diego State University (San Diego, CA)
- Audrey D. Levine, Ph.D., P.E., DEE, U.S. Environmental Protection Agency (Washington, D.C.)
- David R. Schubert, Ph.D., The Salk Institute for Biological Studies (La Jolla, CA)

Attendees of the subcommittee meeting are listed in Appendix A. The subcommittee meeting agenda is provided in Appendix B.

The subcommittee findings and recommendations, provided below, will be presented to the full IAP for approval and/or revisions at the next IAP meeting and may be modified prior to inclusion in the next IAP report.

FINDINGS AND RECOMMENDATIONS

The IAP Subcommittee would like to commend the City of San Diego for its efforts in developing a comprehensive T&M Plan for the AWPF and for organizing the Subcommittee to review this effort.

Treatment Process

- To ensure that the pilot testing provides robust data, it is important to integrate potential upstream changes into the overall testing program. It would be worthwhile to identify possible process upgrades that might impact water quality, such as changes in nutrient removal, disinfection, or filtration. Changes to the tertiary wastewater treatment process should be integrated into the testing program now to evaluate the complete range of water quality conditions that might impact the performance and operation of the AWPF. For example:
    - Changes in the type and dose of coagulant should be tested to evaluate water quality impacts, such as pH, conductivity, and mineral composition. As a minimum, the effects of ferric chloride coagulation, currently shown as optional, should be assessed along with other potential treatment modifications.
    - The technical and economic feasibility of conducting partial demineralization by electrodialysis reversal (EDR) should be assessed to optimize the use of reverse osmosis (RO) or identify opportunities to use it as a back-up or supplementary system. Since RO has the capacity to handle some increased total dissolved solids (TDS) loading, it is not clear whether upstream EDR provides enough additional benefits to plant operations to justify the additional expense.
    - The status of the existing filtration process should be evaluated in the context of projected upgrades or modifications. Since filtration will now be functioning as pretreatment for the microfiltration/ultrafiltration (MF/UF) process, its performance should be optimized in conjunction with the pilot testing.

- In recognition of the fact that the UV reactor in the pilot plant is not representative of the UV system to be used in the full-scale AWFP, the IAP recommends that verification of the log removal requirements for NDMA and 1,4-dioxane by the advanced oxidation process (AOP), as specified in the August 4, 2008 California Department of Public Health draft groundwater recharge regulations, be performed on the full-scale facility prior to implementation of the project.

- The IAP Subcommittee was presented with some pilot plant data relating to NDMA removal. This data set was very limited and should not be considered definitive at this time. The IAP would appreciate the opportunity to review additional data related to NDMA removal as it becomes available.

Water Stabilization

The stability of the product water is important to ensure the integrity of the pipeline from a microbial and corrosion perspective. It would be worthwhile to consider evaluating the options for controlling biofilm growth and corrosion. Using a pipe-loop study or annular reactor to evaluate microbial growth and the effectiveness of alternative control strategies could be a valuable complement to the pilot study once the system is operating at steady-state. These tests could be used to determine the extent to which a secondary disinfectant and/or corrosion control in addition to lime treatment is needed.

Water Quality

The IAP suggests that, except for water quality monitoring needed at startup of the AWPF to optimize the unit processes, water quality monitoring of the full-scale AWPF not begin until the system has been stabilized and is operating at steady-state conditions to obtain representative data.

Microbial

- The draft routine bacteria and virus surrogate monitoring plan proposes direct bacteria and virus monitoring using epifluorescence microscopy (with SYBR-green ATP measurements), which is not an approved method. Further, the analysis is expensive and does not determine organism viability. The IAP recommends that the use of epifluorescence microscopy for direct monitoring of bacteria and viruses not be included in the routine surrogate monitoring plan.

- For the component that calls for the direct monitoring of pathogens, the IAP concluded that, due to the well-known performance of the treatment train for pathogen removal and the substantial indicators analyses, monitoring for bacterial and viral pathogens may not necessary. However, the IAP recognizes the value of such monitoring from a public confidence perspective, and suggests that the proposed pathogen monitoring component be reevaluated at the next IAP meeting.

- The IAP suggests that it may be possible to reduce the monitoring frequency for *Cryptosporidium* (before and after MF/UF) by sampling for aerobic spores like *B. subtilis* as potential surrogates for *Cryptosporidium*. *B. subtilis* are much smaller than *Cryptosporidium* and, thus, would be a conservative indicator that can be analyzed quickly and inexpensively. *B. subtilis* analyses could be performed in conjunction with the *Cryptosporidium* studies, and more frequently as potential MF/UF process performance indicators. The use of aerobic spores would be appropriate if the spores survive the prior disinfection process. This would need to be evaluated.

Constituents of Emerging Concern (CECs)

- The major purpose for the design of the monitoring strategy should be to: 1) determine which constituents are likely to either break-through or not be removed; and 2) use the information obtained as a basis to identify surrogates for operational tracking purposes at different stages of treatment. Experience at Orange County Water District's Groundwater Replenishment System and other similar projects demonstrates that many chemicals (e.g., metals and other priority pollutants) are easily handled by the treatment train if any are in the treated wastewater influent to the advanced treatment plant. In addition, breakthroughs of some chemicals such as NDMA and 1,4-dioxane (and a few others) at ng/L levels are expected, and do not *per se* indicate significant health risks. The IAP recommends that San Diego design a monitoring strategy for the pilot program that collects sufficient numbers of samples to determine appropriate surrogates for managing the processes and also provides public confidence on the effectiveness of the treatment system.

- The IAP recommends that the draft strategy include an approach for selecting appropriate surrogate constituents. Initially, screening tests should be conducted for a suite of CECs that may be present in the influent wastewater. Based on the results of the screening studies, a set of surrogate parameters can be selected that could be linked back to the constituents in the wastewater. This study should be initiated after the treatment system has been running for perhaps a minimum of 4 months and is operating at steady-state conditions. The analytical list may be drawn from the City's currently proposed monitoring list of 90 CECs, as well as other sources. The parallel analyses of chemicals and surrogate candidates would include the feed water, before and after RO, and potentially, some chemicals that survive after the advanced oxidation process (AOP). This assessment is important since it will serve as the basis for process operating decisions in the full-scale plant.

- It is doubtful that contaminants will routinely break through at concentrations that have health significance, which is one of the reasons for focusing on surrogate analyses. The IAP disagrees with the SWRCB-sponsored report entitled "Final Report: Monitoring Strategies for Chemicals of Emerging Concern (CECs) in Recycled Water" that caffeine and triclosan should be considered as health-related; however, it may be advisable to include them for monitoring process performance. That report also included NDMA and 17 β-estradiol (although it is unlikely to survive the process). They, as well as many other chemicals, would represent potential health concerns if they occurred at higher than expected levels. Therefore, it is appropriate to have health advisory levels available in the event that any were detected.

- The IAP has some suggestions related to the monitoring strategy. DEET, carbamazepine, and primidone could be analyzed because they are ubiquitous in domestic wastewaters and refractory in nature. Among the other suggested chemicals, PFAAs might be candidates, even though their removal by RO has been well documented. 1,4-dioxane is also a good choice due to its known inefficient removal by RO. Chemicals included in the third Unregulated Contaminant Monitoring Rule, Cycle 3 (UCMR3) would best be addressed selectively, unless there is a regulatory requirement to analyze them. Chemicals like triclosan, caffeine, and sucralose and other artificial sweeteners are of no toxicological interest, but may be able to serve as surrogates. Hydrazine and quinoline are of little interest unless they are ubiquitous in the tertiary-treated wastewater and not readily removed by RO and/or AOP; hydrazine would likely not be well removed by RO, if present. Nicotine and cotinine could be considered for inclusion since they are cigarette-related and likely to be in sewage and of toxicity interest if at high enough levels in the finished water, although this is unlikely. They also are relatively low molecular weight molecules that could challenge RO, but not likely AOP. Extensive monitoring for the priority pollutants is of little value. Our understanding is that the Orange County Water District has had no detections in their extensive monitoring over several years. Perhaps a few samples could be analyzed for that group for verification and if the regulatory agencies require it. These types of analyses could also play a role in demonstrating the overall quality of the finished water to the public.

- The characteristics of wastewater can vary depending on the time of day and the loading to the wastewater treatment plant. For parameters that will be monitored using grab-samples, it is important to time sample collection to reflect the range of conditions that are likely (e.g., peak-flow, peak-loading, etc.). It is also important to ensure that the sampling program can yield statistically defensible results. Prior to initiating the routine sampling program, initial quality assurance studies should be conducted to determine the appropriate sample volumes (relates to detection limits), sampling frequency and timing, and which parameters should be monitored using grab-samples versus composite samples. The City should confer with San Diego Regional Water Quality Control Board (RWQCB) to get input on the parameters that should be measured using composite samples and whether the composites should be generated using a flow-weighted or time-based approach.

- Trihalomethanes (THMs) are a grouping of disinfection byproducts (DBPs) that are formed when chlorine is added to water containing organics. It is likely that DBPs are present in the wastewater at μg/L levels, and they may not be entirely removed by RO or AOP. THMs are currently regulated as a group at 80 μg/L in drinking water, and it is our understanding that the RWQCB may impose more stringent requirements. It is important to have a clear understanding of any current and proposed RWQCB requirements and incorporate these considerations into the testing program.

- The Orange County Water District has experienced inconsistencies in comparing the monitoring results from grab samples versus online measurements for TOC. Thus, the City should consider relying entirely on online TOC measurements as they would be more informative – and likely more accurate – than using grab samples.

- The IAP finds that although definitive nutrient requirements for phosphorus and nitrogen have not been determined by the RWQCB, narrative and numeric nutrient requirements already included in the Basin Plan for discharges to surface water (such as San Vicente Reservoir) may allow the use of a 0.1 mg/L total phosphorus goal to determine compliance. Using the nominal N:P ratio of 10:1 to determine compliance for total nitrogen, it is possible that a 1.0 mg/L goal may be promulgated for total nitrogen to prevent eutrophication of the reservoir. The presentations to the IAP by the City of San Diego and their consultants suggests that modifications of the existing treatment process to date at the North City Water Reclamation Plant enhance denitrification and lower nitrate levels has had some success, but nitrate levels are still somewhat above 10 mg/L in the tertiary effluent. Using an 80- to 90-percent removal value for nitrate (provided at the meeting by the City's consultants) as that potentially-achieved by the RO system may yield an effluent nitrate level above the potential compliance limit for discharge to the reservoir. Therefore, the IAP suggests that more attention be paid to the operation of the existing tertiary treatment plant at the North City Water Reclamation Plant (NCWRP) to try to maximize denitrification to achieve lower the nitrate levels in the tertiary-treated water (to well below 10 mg/L) in order to demonstrate that such compliance may be achieved by the AWPF under future effluent limitation scenarios.

Source Control

- The IAP acknowledges the City's efforts to identify potential contaminants of concern in the NCWRP watershed from industries, including pharmaceutical and research facilities.

- Because the opportunity exists for the discharge of (probably small) amounts of chemical, radioactive, and biological material into the wastewater stream, it is advisable to contact each industry, particularly pharmaceutical manufacturers, hospitals, and laboratories, to raise awareness in those industries that their discharges will be feed water to the AWPF that will process the wastewater to be used for potable reuse.

- The IAP is interested in hearing more about the City's source control program. The IAP requests that a presentation on the source control program be provided at the next IAP meeting.

Appendix A: Subcommittee Meeting Attendees

Subcommittee:

- *Subcommittee Chair:* James Crook, Ph.D., P.E., Water Reuse Consultant (Boston, MA)
- Joseph A. Cotruvo, Ph.D., Joseph Cotruvo Associates (Washington, D.C.)
- Richard Gersberg, Ph.D., San Diego State University (San Diego, CA)
- Audrey D. Levine, Ph.D., P.E., DEE, U.S. Environmental Protection Agency (Washington, D.C.)
- David R. Schubert, Ph.D., The Salk Institute for Biological Studies (La Jolla, CA)

National Water Research Institute:

- Jeff Mosher, Executive Director
- Gina Melin Vartanian, Outreach and Communications Manager

City of San Diego:

- Amy Dorman
- Jeffrey Pasek
- William Pearce
- Joseph Quicho
- Marsi Steirer
- Anthony Van

City of San Diego Consultants

- Greg Bradshaw, RMC Water and Environment
- Debra Burris, DDB Engineering, Inc.
- Jay DeCarolis, Operations and Testing Manager, MWH
- Randy Hill, P.E., Project Manager, CDM
- Tom Richardson, RMC Water and Environment
- Greg Watterau, Team Leader for Membranes and Desalination, CDM

California Department of Public Health

- Brian Bernados, P.E., Recycled Water and Treatment Technology Specialist
- Heather Collins, P.E., Section Chief, Drinking Water Program, Region V (San Bernardino)
- Cindy A. Forbes, P.E., Chief, Southern California Branch
- Bob Hultquist, P.E., Chief, Drinking Water Technical Operations Section (retired)
- Sean Sterchi, Division of Drinking Water and Environmental Management

California Regional Water Quality Control Board, San Diego Region

- Brian Kelley

Appendix B: Subcommittee Meeting Agenda

City of San Diego
Water Purification Demonstration Project
Advanced Water Purification Facility (AWP)
Independent Advisory Panel (IAP)/AWP Subcommittee Meeting

Proposed Meeting Agenda

October 21, 2010
(8:30 a.m. – 5:00 p.m.)

Meeting Location
City of San Diego's
Environmental Monitoring &
Technical Services (EMTS)
Laboratory

On-Site Contacts:
Anthony Van (City)
Cell: (619) 980-9512
Tom Richardson (RMC)
Cell: (408) 239-6164

Goals of the Meeting

- Review the Draft Testing and Monitoring (T&M) Plan for the AWP Demonstration Facility.
- Resolve Comments on IAP Report related to the T&M Plan.
- Review Key Items Requiring input from IAP/CDPH on the Draft T&M Plan.
- Review schedule for approval of the T&M Plan.

Program		**Presenters**
8:30 am – 9:00 am	Welcome and Introduction	
	• Meeting Objectives	Marsi Steirer
	• T&M Plan Critical Path Schedule	Anthony Van
	• IAP's Role on T&M Plan	Jim Crook
	• Regulatory Context	Tom Richardson
9:00 am – 10:00 am	Overview of the Draft T&M Plan	Jay DeCarolis
	• Objectives	
	• Materials and Methods	
	• Process Operations, Activities and Schedule	
	• AWP Facility Process Evaluation	
	• Specialty Testing	
	• QA/QC	
10:00 am - 10:15 am	BREAK	
10:15 am - 1:00 pm	CDPH T&M Related Comments on IAP Final Report	

	- Overview of Comments/Proposed Solutions	Greg Wetterau
	- Open Discussion	All
Noon - 12:30 pm	WORKING LUNCH	
1:00 pm - 1:15 pm	BREAK	
1:15 pm – 2:30 pm	T&M Plan Approach Key Items Requiring IAP/CDPH Input	
	- AWP Facility Treated Water Quality Goals	Jay DeCarolis
	- Monitoring of Local Contaminants based on NCWRP Collection System Catchment Investigation	Tom Richardson
	- Proposed Framework for defining criteria that will drive sampling frequency requirements to achieved statistical certainty	Jay DeCarolis
2:30 pm - 2:40 pm	Wrap up Schedule Completion and Final Approval of T&M Plan	Anthony Van
2:40 pm – 5:00 pm	IAP Subcommittee Convene	Closed Session

THE CITY OF SAN DIEGO

April 4, 2011

Ms. Heather L. Collins, P.E.
California Department of Public Health
South Coast Regional Engineer
464 West 4th Street, Suite 437
San Bernardino, CA 92401

Dear Ms. Collins:

Subject: Water Purification Demonstration Project (WPDP) - Revised Draft Testing and Monitoring Plan (TMP) for the Advanced Water Purification (AWP) Facility

The City of San Diego Public Utilities Department (City) would like to thank the Department of Public Health (CDPH), Division of Drinking Water and Environmental Management team for assisting with the review of the subject Testing and Monitoring Plan submitted on December 2, 2010. Enclosed with this letter are the City's responses to CDPH comments, which were conveyed in your letter dated January 31, 2011.

Please contact me at (619) 533-4112 if you have any questions regarding our responses, or if you need additional information on our overall WPDP effort.

Sincerely,

Marsi A. Steirer
Deputy Director, Public Utilities Department

AV/ctc

Enclosures: 1. CDPH Letter dated January 31, 2011 – Detailed comments Water Purification Demonstration Project – Revised Draft Testing and Monitoring Plan for the Advanced Water Purification Facility.

2. City's responses to comments from CDPH letter dated January 31, 2011, regarding the Draft TMP of the AWP Facility.

DIVERSITY
BRINGS US ALL TOGETHER

Public Utilities Department
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cc: Cindy Forbes, Southern California Branch Chief, California Department of Public Health
Sean Sterchi, San Diego District Engineer, California Department of Public Health
Brian Bernados, Senior Sanitary Engineer - Technical Specialist, California Department of Public Health
Randy Barnard, Senior Sanitary Engineer - Technical Specialist, California Department of Public Health
Bob Hultquist, Annuitant - California Department of Public Health
David W. Gibson, Executive Officer, California Regional Water Quality Control Board
Jeff Mosher, Executive Director, National Water Research Institute
Amy Dorman, Senior Civil Engineer, City of San Diego, Public Utilities Department

City of San Diego
Indirect Potable Reuse/Reservoir Augmentation Demonstration Project
Advanced Water Purification (AWP) Facility
Draft Testing and Monitoring Plan (12/2/10)

Responses to comments from the California Department of Public Health, Division of Drinking Water and Environmental Management (letter dated January 31, 2011) regarding the Draft Testing and Monitoring (T&M) Plan of the AWP Facility are listed below.

Comment No. 1: Peroxide Dose

Comment Response.

The project team agrees with the CDPH recommendation. To clarify the peroxide doses (1 and 5 mg/L) presented on page 6-4 refer to doses proposed to be tested during the proposed NDMA / 1,4 dioxane spiking experiments only. The baseline peroxide dose proposed for normal operational will be 3 mg/L, based on the dose currently approved by CDPH for the OCWD Groundwater Replenishment System. The T&M plan will be revised accordingly. Response to Comment 6 is also relevant.

Comment No. 2: CEC Overview

Comment Response.

The project team agrees and will add sucralose and cotinine to the current 91 compound CEC list to be analyzed at all sampling locations as part of the initial feed water characterization monthly for the first four months (Table 5-5). Based on occurrence and removal data gained during the initial characterization period the list of compounds shown in Table 5-5 to be measured quarterly may be modified.

Comment Number 3: Trojan Phox UV System

Comment Response

As discussed during the IAP Sub-committee meeting on 10/21/10, the project team recognizes the UV/AOP system proposed for use in the Demonstration Facility will not provide the same electric power efficiency as a full scale system to produce a given product water quality. We anticipate the demonstration unit to be more conservative in determining the EEO, electrical energy per order reduction. Regardless, the City's goals do not include developing the design criteria for the full scale UV/AOP system. However one goal is to operate the Demo scale UV/AOP system to demonstrate that it is effective for achieving 1.2 log removal of NDMA and 0.5 log removal 1,4 dioxane on these source waters. In addition, data collected from the spiking experiments will be used to compare the EEO values from the demonstration unit with the EEO values from permitted / operating full scale systems.

Comment No. 4: Effectiveness of Advanced Oxidation Process

The project team agrees a targeted chemical indicator removal demonstration of the AOP to develop a relevant surrogate parameter should be included in the test plan. See Comment Response 5 for more information.

Comment No. 5: Surrogate Indicator Framework to establish efficacy in AOP

Comment Response

In general, the project team agrees with CDPH's recommendation to develop and implement the Surrogate/Indicator approach with some validation at full-scale. The steps recommended by CDPH to demonstrate efficacy of the advanced oxidation process along with the project team's response provided in italic follow:

1. Validation monitoring during start-up. ***Response:*** *Agreed.*

2. Compliance monitoring during full-scale operation for the first twelve months of operation. ***Response:*** *Agreed.*

3. On-going compliance monitoring after the first twelve months of operation ***Response:*** *Agreed.*

4. Identification of operational parameters that is suitable to demonstrate a measurable change of a viable continuous online surrogate parameter under normal operating conditions. ***Response:*** *See comment response 8.*

5. Conduct challenge (spiking) tests with select indicator compounds to determine removal differentials under normal operating conditions using ten compounds as listed in footnote 3. Response: ***Response:*** *The UV/AOP technology being demonstrated has been proven at many facilities to be a reliable technology for reducing NDMA and 1, 4 dioxane. The City has collected useful data in 2005 on the efficacy of UV/AOP on many of the indicators listed in the CDPH letter including the target compound of NDMA. The intent of the demonstration study is to collect more information on removal efficiencies of different membrane configurations and operation data for consideration for the potential full scale AWPF.*

   However, the project team understands the concept of using the indicator/surrogate approach for compliance monitoring is new and needs some validation. As such, the project team proposes to conduct one spiking experiment after the first quarter of testing is complete to demonstrate the removal of several indicator compounds with the removal of surrogate parameters (UVA, chloramines), which can be easily measured on a frequent basis. The indicator compounds to be included in the spiking experiment will be based on occurrence data collected in the feed and product water of the AOP process with the overall goal of selecting compounds that will serve as good indicator compounds representative of wide range of characteristics for ongoing monitoring. The project team will work closely with the project advisory team including Dr. Jorg Drewes and Dr. Shane Snyder to develop the list of compounds to be included in the CEC spiking experiment. Note: The

CEC spiking experiment will be conducted under the UV/AOP conditions determined from the NDMA, 1,4 dioxane spiking experiment that provide 1.2 log removal of NDMA and 0.5 log removal of 1,4 dioxane.

6. The identified performance indicators are then monitored during start up to determine removal efficiencies under normal operating conditions. ***Response:*** *Agreed.*

7. Differentials of surrogates and indicators should be developed according to the table presented on p. 3. ***Response:*** *Agreed.*

Response to additional comments on page 4:

- CDPH Comment: add S10 as an additional sampling location for initial characterization.

  Response: *The project team accepts this recommendation.*

- CDPH Comment: add triclosan, gemfibrozil, carbamazepine, dilantin, erymthromycin, iopromide, meprobamate, naproxen, primidone, sulfamethoxazole, TCEP and trimethroprim to the monitoring plan in Table 5-6 for weekly samples over four weeks, including S10.

  Response: *The team has evaluated past monitoring results and believes it is likely to detect compounds currently listed in Table 5-6. Adding additional compounds as suggested by CDPH is defeating the purpose of using a limited list of suitable indicator compounds, a concept that CDPH endorses. However, we do propose to monitor the compounds suggested by CDPH at the same locations (S1, S6, S9, S10) monthly for the first four months, which will provide insight on their occurrence level.*

- CDPH Comment: add clofibric acid, musk ketone, TCPP and TDCPP to compounds listed in Table I-2.

  Response: *Table I-2 was intended to include clofibric acid, TCPP and TDCPP and will be modified accordingly. Additional information on the occurrence and analytical methods for the CDPH recommended compounds for monitoring follow:*

  - ***Clofibric acid*** *is a metabolite of a blood-lipid regulator that is not administered in the U.S. anymore and therefore occurrence levels are very low. It is not expected that this compound is present in recycled water.*
  - ***Musk ketone*** *is a compound that is well amendable to oxidation. Since we have other compounds with similar properties project team recommend NOT adding this compound to Table I-2.*

- ***TCPP and TCDPP*** *are chlorinated flame retardants. We have the chlorinated flame retardant TCEP in our target list as a representative of this class of compounds. Since analytical (isotope) standards are not readily available for TCPP and TDCPP, accurate determination of these compounds in recycled water can be questioned.*

- CDPH Comment: requesting to develop a list of ten UV/AOP performance indicator compounds and monitor them monthly instead of quarterly.

  Response: *Based on results of the initial characterization sampling (Table 5-5) and CEC spiking experiment, the project team will select several indicator compounds for AOP performance monitoring that are present at quantifiable levels in the RO product water. The removal of these compounds will be correlated with surrogate removal including UVA and chloramines. The surrogates will be monitored daily. The project team recommends sampling the selected indicator compounds every other month and that this frequency of sampling provides a sufficient data set to assess performance.*

- CDPH is suggesting 3D TRASAR at location S10.
  Response: See comment response 11.

Comment No. 6: NDMA and 1,4 dioxane Spiking Experiment
Comment Response

As outlined in the Section 6.2.3, the main purpose of the spiking experiment to is to confirm the flow, power and peroxide dose settings of the UV/AOP system to achieve 1.2 log NDMA removal and 0.5 log removal of 1,4 dioxane. As the RO product water will not contain concentrations sufficient to demonstrate these log removals, spiking would be required. The project team recommends the experiments be conducted as it will establish the operating conditions under which all sampling events will be conducted. The results from the spiking experiments will also be used to calculate the EEO (electrical energy per order) removal for NDMA, for comparison to measured EEO values from full scale permitted UV/AOP systems including Orange County and West Basin.

The project team will conduct the spiking experiment using the baseline dose of 3 mg/L to demonstrate the AWPF achieves the same log reduction values of permitted and operating full scale AWT facilities including Orange County and West Basin. Data will also be collected at lower doses (1 or 2 mg/L) for informational purposes only. This will provide the City preliminary data that may serve as the basis future studies to determine optimal peroxide dose. It is believed the lower doses of peroxide even at low conversion efficiency might be sufficient for destruction of trace organic chemicals given the low demand in the RO permeate.

Comment No. 7: Grab-samples versus composite samples
Comment Response

CDPH is suggesting collecting sequential grab samples for certain analytes to assess diurnal variations. The team acknowledges that certain compounds are subject to diurnal variations however the diurnal variation at NCWRP may be less significant than the Tillman Plant due to differences in hydraulic detention time and other operating conditions. In response to the CDPH comment, the project team recommends conducting two 24 hour sampling events during the 12 month operating period to collect grab samples of the RO feed every 4 hours for the following preliminary list of compounds:

1. *Caffeine*
2. *Sucralose*
3. *Total nitrogen*
4. *Nitrate*
5. *1,4 dioxane*
6. *NDMA*
7. *Total phosphorus*

The above list may be modified based on occurrence data collected during the first 4 months.

Note: the project team recommends off-setting the increased analytical requirements related to the above sampling events by reducing the sample locations shown in Table 5-4 for parameters to be collected as 24 hour composite samples to only include locations S6 (RO Feed), S7 (RO 1 permeate), S8 (RO 2 permeate). In addition, the number of NDMA and sister compound samples proposed for measurement in Table 6-3 may be reduced.

The sampling frequency of "bi-weekly" refers to once every two weeks.

Comment No. 8: Grab Samples versus on-line

Comment Response

The current UV/AOP design incorporates 1 on-line UVA-254 analyzer to be located at the UV/AOP inlet (S9) for UV process control similar to the AOP system used at OCWD GWRS. While the project team agrees on-line monitoring of UVA in the feed and effluent may be useful there are several concerns:

- *Changes in UVA removal across the UV/AOP may fluctuate and be inconsistent over the course of operation;*
- *The unique calibration of each on-line unit may mask the actual UVA removal.*

Instead of adding an online UVA meter to the UV/AOP outlet, the project team recommends during the demonstration period to collect grab samples from UV/AOP feed and effluent and measuring UVA and total chloramines using desktop meters daily (using a 10 cm cell for more accuracy). This will allow a data set to be established to assess the viability of both surrogates for UV/AOP process performance validation and make recommendations for online measurements for the potential full scale AWPF.

Comment No. 9: NCWRP Operational Changes to Reduce Effluent Total Nitrogen

Comment Response

Trussell Technologies is currently working on the North City Water Reclamation Plant Denitrification Optimization Study to assess operational changes to reduce effluent nitrogen of the NCWRP. The City will address this item under separate correspondence by early May 2011.

Comment No. 10: Testing of RO Membranes

Comment Response

The intention of Section 3.6.1 is to require that all membranes used for the demonstration project undergo direct integrity testing by the manufacturer (via vacuum decay or pressure hold testing) prior to delivery to the site. The project team will be requesting the RO suppliers to provide a statement that membranes were selected randomly from a standard production lot. The requirement that membranes used for IPR projects achieve a specified pressure decay or pressure hold rate prior to installation is something the project team would like to further discuss with CDPH.

Comment No. 11: TRASAR Challenge Testing

Comment Response

The project team agrees challenge testing of the RO membranes using the TRASAR system may provide valuable insight to the potential use of this technology to provide assurance of RO membrane integrity and possibly AOP performance. However, at this time it is NOT intended to conduct this testing as part of the current demonstration project. The City may decide to conduct TRASAR testing as part of future evaluations outside the current scope of the demonstration project.

Comment No. 12: MS2 Virus Challenge Testing

Comment Response

The project team agrees challenge testing of the RO membranes using the MS2 in conjunction with TRASAR testing could provide valuable research for the water reuse industry. However, at this time it is not planned to request from CDPH virus removal credits for the RO system and therefore it is currently not planned to conduct MS2 challenge testing. This requirement may change during the 3rd Quarter once the regulatory requirements for the full scale project become more defined. At this time the City will re-assess the possibility of such testing.

State of California—Health and Human Services Agency
California Department of Public Health

CDPH

MARK B HORTON, MD, MSPH
Director

EDMUND G. BROWN JR.
Governor

January 31, 2011

Ms. Marsi Steirer
Deputy Director
City of San Diego Water Department
600 B Street, Suite 600
San Diego, CA 92101

Subject: Water Purification Demonstration Project - Revised Draft Testing and Monitoring Plan for the Advanced Water Purification (AWP) Facility

Dear Ms. Steirer:

The Department of Public Health, Division of Drinking Water and Environmental Management (Department) has reviewed the subject Testing and Monitoring Plan (TMP) submitted on December 2, 2010. Enclosed with this letter are comments on the TMP which was reviewed by our program staff.

The Department would like to thank you for allowing us additional time for our review and to provide comments on this plan. We look forward to working with your project team as this project develops.

If you have you have any comments regarding the content of this letter, please feel free to contact Brian Bernados at (619) 525-4497, Randy Barnard at (619) 525-4022, Sean Sterchi at (619) 525-4159, or myself at (909) 383-4328.

Very truly yours,

Heather L. Collins

Heather L. Collins, P.E.
South Coast Regional Engineer
CDPH-DDWEM

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Enclosure - CDPH Detailed Comments Water Purification Demonstration Project - Revised Draft Testing and Monitoring Plan for the Advanced Water Purification (AWP) Facility

cc: David W. Gibson
Executive Officer
California Regional Water Quality Control Board
San Diego Region
9174 Sky Park Court, Suite 100
San Diego, CA 92123-4353

Mr. Jeffrey J. Mosher
National Water Research Institute
18700 Ward Street
P.O. Box 8096
Fountain Valley, CA 92728-8096

SUBJECT: City of San Diego - Water Purification Demonstration Project Revised Draft Testing and Monitoring Plan for the Advanced Water Purification (AWP) Facility

CDPH Drinking Water Program field and technical staff have reviewed the report referenced above and make the following comments:

Peroxide Dose

On Page 6-4, two doses are proposed for the AOP demonstration testing – one mg/L and five mg/L. On other pages other peroxide doses are mentioned. Please clarify. A dose target of one mg/L will be too low because the resultant creation of hydroxyl radicals will likely be too low to oxidize organic chemicals effectively. OCWD reports that approximately 13% of peroxide is converted to hydroxyl radicals; therefore, a higher dose should be used. CDPH recommends a dose level between 1-5 mg/L. We also would recommend that along with doses of 5 mg/l and 1 mg/l that you evaluate an additional dose between that range such as 2 or 3 mg/l. A dose of 3 mg/L is the target for current AOP projects. A strategy to develop the optimum operation of AOP and the proper dose of peroxide is important to meet the goals of the demonstration project. This will be especially important in order to address the issues regarding the AOP demonstration delineated below.

Constituents of Emerging Concern (CECs) - Overview

Findings and Recommendations of the Advanced Water Purification Facility Subcommittee Meeting, November 15, 2010 made the following comment,

> "The IAP has some suggestions related to the monitoring strategy. DEET, carbamazepine, and primidone could be analyzed because they are ubiquitous in domestic wastewaters and refractory in nature. Among the other suggested chemicals, PFAAs might be candidates, ... Chemicals like triclosan, caffeine, and sucralose and other artificial sweeteners are of no toxicological interest, but may be able to serve as surrogates. Hydrazine and quinoline are of little interest unless they are ubiquitous in the tertiary-treated wastewater and not readily removed by RO and/or AOP; hydrazine would likely not be well removed by RO, if present. Nicotine and cotinine could be considered for inclusion since they are cigarette-related and likely to be in sewage and of toxicity interest if at high enough levels in the finished water, although this is unlikely. They also are relatively low molecular weight molecules that could challenge RO, but not likely AOP."

Quarterly monitoring is proposed for these compounds in Table 5-5, except for sucralose and cotinine. CDPH recommends that they be added to Table 5-5. While sucralose is included in Table 5-6, it is to be sampled at different locations.

Trojan Phox UV system

November 30, 2010 Final Draft Testing and Monitoring Plan, Page 2-1 states the following:

> "Section 2.1 Testing and Monitoring Objectives The ultimate goal of testing and monitoring the AWP Facility is to generate the necessary data to support the regulatory approval and permitting of the proposed full-scale IPR/RA project. Specific objectives of the testing and monitoring component are provided in the following paragraphs." On Page 2-3, it states, "Validate the performance of AWP Facility unit processes using full-scale treatment equipment. . . The proposed UV/AOP demonstration system is the UV Phox Model 72AL75, which is a single chamber version of the

> reactors used at OCWD. During the initial phase of testing, the ability of the unit to achieve 1.2-log (93.7%) removal of N-Nitrosodimethylamine (NDMA) at a flow of 1 MGD will be verified. Results obtained during initial testing will establish the power setting at which to operate the system for the remainder of the operations period."

As noted previously, the Trojan Phox UV system at OCWD consists of three reactors (six chambers) per treatment train (8.75 MGD capacity). Essentially the demonstration project consists of one 72-lamp chamber that will have a lower flow, longer residence time and very different hydraulics than the full-scale; all of which affects AOP performance and efficiency. The issue of whether the results from a one-MGD demo can be used to predict actual full-scale performance, in regard to AOP, was noted in the *Final Report of the May 11-12, 2009, Meeting of the IAP,* which made the important point,

> "It is important that the unit provide treatment that will simulate the full-scale system and ensure that the UV dose is proportional to the flow. As full-scale units like the Trojan UV Phox system do not scale well"

Closed-vessel UV reactor systems are not designed to be scalable. *Final Report of the May 11-12, 2009, Meeting of the IAP* stated,

> "The scaling of the UV reactor design will require consulting with UV manufacturers. It may be possible to provide the same UV dose, but given reactor flow dynamics at different velocities, assuring the scalability of the UV system could be critical."

Since, the demonstration work will use a smaller reactor and the flow will be less than full-scale, the test plan must address flow dynamics and different velocities. While the test plan attempts to address these issues, CDPH has sufficient concerns to recommend a more targeted chemical indicator removal demonstration of the AOP to develop relevant surrogate parameters. Therefore, CDPH recommends the following Surrogate / Indicator Framework:[1]

Effectiveness of Advanced Oxidation Process

Based upon comments CDPH received from the public regarding the August 5, 2008 version of the *Groundwater Recharge Reuse DRAFT Regulation*, CDPH has been evaluating recent studies to assess the effectiveness of treatment technologies. Accordingly, CDPH is willing to consider alternative approaches to determine the efficacy of the AOP treatment train. While not necessarily the only alternative, a Surrogate / Indicator Framework should applied to this demonstration project.

Surrogate / Indicator Framework to establish efficacy in AOP

The relationship between process performance, online surrogates, and indicator chemical reduction shall be validated for advanced oxidation process. Initially, an occurrence study shall confirm detection of viable indicator compounds in the feed water to the unit process. Performance of the process shall be determined during three phases:

1. validation monitoring during piloting/start-up,
2. compliance monitoring during full-scale operation for the first twelve months of operation,
3. on-going compliance monitoring after the first twelve months of operation.

Operational parameters shall be proposed that demonstrate a measurable change of a viable continuous online surrogate parameter under normal operating conditions (i.e., UVA_{254}, fluorescence or ozone exposure)[2]. Challenge or spiking tests shall be conducted with select

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[1] Similar in concept to the San Diego IAP recommendations and the SWRCB-sponsored report entitled "*Final Report: Monitoring Strategies for Chemicals of Emerging Concern (CECs) in Recycled Water*":

[2] For example, a 50% removal of UVA_{254} measured pre-AOP and post AOP; a 50% reduction in fluorescence intensity, or an ozone CT = 10 mg/l-min.

indicator compounds to determine the removal differential under normal operating conditions. A minimum of ten indicator chemicals[3] shall be examined, during piloting/start-up, that exhibit both "good" and "intermediate" removal expected based upon research detailed in the categories below. An operational correlation shall be developed between the surrogate and the indicator. Operational parameters shall be evaluated that demonstrate a measurable change in the surrogate parameter (X_i) under normal operating conditions. In parallel, an occurrence study needs to be performed confirming detection ratios of viable indicator compounds in the feed water to the AOP. During piloting or start-up, challenge or spiking tests can be conducted with select indicator compounds (Y_i) to determine the removal differential ΔY_i under normal operating conditions.

Surrogate / indicator framework to establish efficacy in AOP		
	Surrogate Parameters	**Indicator Compounds**
Piloting and / or Start-up		
Step 1	Establish anticipated operational conditions of process; i.e., typical flow range, dosage application range, seasonal variation in critical water quality parameters, etc.	
Step 2	Select surrogate parameters that demonstrate a measurable change under normal operating conditions and quantify this differential $\Delta X_i = \lvert (X_{i,in}-X_{i,out}) \rvert$	Conduct occurrence study to confirm detection ratio of viable indicator compounds is in the feed water of unit process
Step 3		Conduct challenge or spiking study with ten representative indicator compounds during pilot- or start-up to determine the removal differentials under normal operating conditions $\Delta Y_i = (Y_{i,in}-Y_{i,out})/Y_{i,in}$
Step 4	Select viable surrogate and operational parameters for unit process	Select 3-5 indicator compounds from representative chemical structure categories with expected removal rates of 90% via AOP AND Select 3-5 indicator compounds from representative chemical structure categories with expected removal rates of 50-90% via AOP

Operational parameters shall be evaluated that demonstrate a measurable change surrogate parameter (X_i) under normal operating conditions. In parallel, an occurrence study needs to be performed confirming detection ratios of viable indicator compounds in the feed water to the unit process. During piloting or start-up of a new treatment process, challenge or spiking tests can be conducted with select indicator compounds (Y_i) to determine the removal differential ΔY_i under normal operating conditions.

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[3] If present, example indicators include caffeine, estradiol, NDMA, triclosan, DEET, gemfibrozil, iopromide, sucralose, BPA, carbamazepine, atenolol, clofibric acid, dilantin, ibuprofen, meprobamate, musk ketone, naproxen, primidone, sulfamethoxazole, TCEP, TCPP, TDCPP, and trimethroprim.

Example advanced oxidation treatment removal categories for indicator compounds And Structure
Typical Expected Good Removal > 90%[4]

Hydroxy Aromatic:	*Amino / Acylamino Aromatic:*	*Nonaromatic C=C:*	*Deprotonated Amine:*	*Alkoxy Polyaromatic:*	*Alkyl Aromatic:*
Acetominophen	Sulfamethoxazole	Acetyl cedrene	Atenolol	Naproxen	Benzophenone
Atorvastatin (o-hydroxy)	Atorvastatin	Carbamazepine	Caffeine	Propranolol	Benzyl acetate
Atorvastatin (p-hydroxy)	Triclocarban	Codeine	Diclofenac		Bucinal
Benzyl salicylate		Hexylcinnamaldehyde	EDTA	*Alkoxy Aromatic:*	DEET
Bisphenol A		Methyl ionine	Erythromycin-H_2O	Gemfibrozil	Dilantin
Estrone		OTNE	Fluoxetine	Hydrocodone	Dibutyl Phthalate
Hexyl salicylate		Simvastatin hydroxy	Metoprolol		Diphenhydramine
Isobutylparaben		Terpineol	Nicotine		Galaxolide
Methyl salicylate			Norfluoxetine		Ibuprofen
Nonylphenol			Ofloxacin		Indolebutyric acid
Oxybenzone			Paraxanthine		Primidone
Propylparaben			Pentoxifylline		Tonalide
Salicyclic acid			Trimethoprim		
Triclosan					
Clorfibric Acid					

Example advanced oxidation treatment removal categories for indicator compounds And Structure <90%

Typical Expected Intermediate Removal		**Typical Expected Poor Removal**	
90-50%		**50-25%**	**< 25%**
Saturated Aliphatic:	***Nitro Aromatic:***	***Nitrosamine:***	***Halogenated Aliphatic:***
Iopromide	Musk ketone	NDMA	Chloroform
Isobornyl acetate	Musk xylene		TCEP (Tris (2-chloroethyl) phosphate)
Meprobamate			TCPP (Tris (chloroisopropyl) phosphate)
Methyl dihydrojasmonate			TDCPP (Tris (1, 3-dichloropropyl) Phosphate)

November 30, 2010 Final Draft Testing and Monitoring Plan, Section 5.2.3 is generally in agreement with this approach; however, some modifications should be made as follows:

1. Add S10 in Table 5-6, sampling locations, under initial characterization (weekly for four weeks) for DEET, sucralose, NDMA, and caffeine.
2. Based upon IAP Sub-committee recommendations, chemical structures, and occurrence data from 2005 (Table 3-2), add triclosan, gemfibrozil, carbamazepine, dilantin, Erythromycin-H_2O, iopromide, meprobamate, naproxen, primidone, sulfamethoxazole,

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[4] Dickenson, Drewes, Sedlak, Wert, & Snyder. Applying Surrogates and Indicators to Assess Removal Efficiency of Trace Organic Chemicals during Chemical Oxidation of Wastewaters. *Environ. Sci. & Tech.* 2009, 43, 6242-6247.

TCEP (Tris (2-chloroethyl) phosphate), and trimethroprim to Table 5-6, initial characterization (weekly for four weeks), including sampling at S10.

3. Add clofibric acid, musk ketone, TCPP, and TDCPP to Table I-2.
4. Modify Table 5-6, On-going Monitoring to Assure UV/AOP Performance by adding monthly monitoring for approximately ten chemical indicators chosen based upon the initial four weeks of sampling in Table 5-6 and the initial four months of sampling in Table 5-5. Additionally, monitor UVA (or UVT) frequently, online if possible, at the time that the indicator monitoring is conducted.
5. Consider online monitoring using the 3D TRASAR at sample location S10 to evaluate fluorescence as a potential surrogate compared to UVA_{254}.

NDMA and 1,4-Dioxane Spiking Experiment

While the special monitoring proposed in Section 6.2 "NDMA and 1,4-Dioxane Spiking Experiment" may have some value, CDPH considers it of limited application to the full-scale project. As noted above, the UV system and AOP will not be tested under relevant flow and hydraulic conditions during the demonstration project. The results will not provide sufficient demonstration of the full-scale performance. Therefore, this special testing would need to be repeated at full-scale start-up. CDPH would consider deletion of this spiking experiment in favor of the "**Surrogate / indicator framework to establish efficacy in AOP**" detailed previously. One of the stated goals of the demonstration project is to develop applicable surrogates and indicators for full-scale application. If done properly, surrogates and indicators can be identified for this project that are known to occur and in which removal can indicate efficacy of the process performance.

NDMA and 1,4-Dioxane can be monitored on a frequent basis at full-scale to ensure that the effluent levels are below the Notification Levels. Additionally, NDMA formation can be reduced either via a source control program or via modification of upstream processes to decrease NDMA formation or precursors.

Grab-Samples Versus Composite Samples

Findings and Recommendations of the Advanced Water Purification Facility Subcommittee Meeting, November 15, 2010 made the following comment,

> "The characteristics of wastewater can vary depending on the time of day and the loading to the wastewater treatment plant. For parameters that will be monitored using grab-samples, it is important to time sample collection to reflect the range of conditions that are likely (e.g., peak-flow, peak-loading, etc.). . . .Prior to initiating the routine sampling program, initial quality assurance studies should be conducted to determine the appropriate sample volumes (relates to detection limits), sampling frequency and timing, and which parameters should be monitored using grab-samples versus composite samples."

While Table 5-4 specifies some composite samples (TOC, ammonia, nitrate, total nitrogen, and total phosphorus), other compounds should be considered, such as caffeine and sucralose, which could vary significantly based upon different times of the day. Since it has been shown via diurnal monitoring at the Tillman plant in LA that NDMA can vary widely throughout the day, NDMA grab-samples may not adequately characterize the diurnal effect. Therefore, CDPH recommends that additional focused sampling be performed to capture the diurnal effect. For NDMA, this may mean picking a 24-hour period in which to collect grab samples once every four hours. This should be repeated to confirm the diurnal effect. In general, CDPH recommends a similar 24-hour monitoring period for other important chemicals, such as nitrogen, nitrate, 1,4-dioxane, etc. With this data, a standard deviation or whisker plot can be developed to indicate the variability.

Additionally, Table 5-4 specifies "Bi-weekly" as the monitoring frequency for some constituents. Please clarify whether this means twice a week or once every two weeks.

Grab-Samples Versus Online
In Table 5-6, daily monitoring for UVA-254 nm is proposed. CDPH recommends online monitoring via a standard UVT analyzer as is commonly used in UV disinfection systems. This could serve as an online surrogate for AOP performance. Table 5-1 monitors UVT twice per day at the feed, but not at sample locations S9 and S10. Table 5-3 is confusing as both grab and online are noted for some surrogate parameters that are normally online.

NCWRP Operational Changes to Reduce Effluent Total Nitrogen
Page 3-5 to 3-6, Section 3.1.3.1 mentions the study to "assess improving the NCWRP recycled water quality by enhancing the plant's denitrification process (Trussell et al., 2010)." Please provide an update on this study and conclusions reached. CDPH is interested in which of the Trussell recommendations have been implemented or will be in the future. As stated in previous correspondence, CDPH recommends optimization of the treatment process. Additionally, the San Diego Regional Water Quality Control Board should be consulted.

Testing of RO Membranes Prior to Installation
Section 3.6 discusses the manufacturer testing prior to delivery. The RO suppliers should not hand pick the best membrane cartridges of the lot. Instead they should be randomly selected in order to indicate the performance of the average RO cartridge of the particular model. Therefore, manufacturers should supply a statement to that effect.

TRASAR Challenge Testing
Section 3.6.4 describes this potential monitoring tool. Previous piloting work in 2005 performed for the City of San Diego gave a reasonable indication that TRASAR® would provide a method to determine integrity of the RO membranes. CDPH is in favor of TRASAR® Challenge Testing, since direct integrity testing methods for RO have not been developed yet. If successful, the TRASAR® unit could provide assurance of membrane integrity, similar to the pressure decay tests used as a standard test for microfiltration and ultrafiltration type membranes.

TRASAR® is composed of fluorescent molecules. The trace leak detection (TLD) system detects TRASAR® by measuring fluorescence. Therefore, it may have potential application in monitoring other processes, including AOP.

MS2 Virus Challenge Testing
Page 3-19, Section 3.6.3 states,

> "Though it is not an objective of the testing plan to demonstrate the ability of the RO membranes to remove viruses, conducting virus challenge experiments is a powerful means of monitoring RO system integrity. Accordingly, an optional service for consideration, challenge experiments can be performed on each RO system during start up and upon completion of the target 5,000 hour test period."

While not necessarily required, CDPH would appreciate seeing and evaluating the outcome of any MS2 virus challenge testing performed on the RO processes. If this testing is performed, it could provide valuable research for the water reuse industry, especially in conjunction with membrane integrity testing such as the proposed TRASAR testing. It should be noted that if the City of San Diego would like to obtain credit for the virus removal capability of the RO process, such a MS2 virus challenge testing scheme may provide justification. It should be noted that CDPH is in the preliminary stages of developing new regulations for surface water augmentation with recycled water and new research is encouraged.

Since there is currently no accepted integrity test for RO, awarding credit for pathogen removal may not be feasible; however, CDPH is open to new demonstration work. Referring to the EPA Membrane Filtration Guidance Manual, integrity testing must meet requirements for resolution, sensitivity, and frequency. The sensitivity of a membrane module is defined as the maximum Log Removal Value that can be reliably verified by an integrity test, which must be equal to or greater than the Cryptosporidium removal credit awarded to the module via challenge testing. The feasibility of performing a daily integrity test for RO would be of interest to CDPH.

California Regional Water Quality Control Board
San Diego Region
Over 50 Years Serving San Diego, Orange, and Riverside Counties
Recipient of the 2004 Environmental Award for Outstanding Achievement from U.S. EPA

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Acting Secretary for Environmental Protection

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Edmund G. Brown Jr.
Governor

February 28, 2011

In reply refer to:
244506:JCOFRANCESCO

Ms. Marsi A. Steirer
Deputy Director, Public Utilities Department
City of San Diego
600 B Street, Suite 600, MS 906
San Diego, CA, 92101

Dear: Ms. Steirer

SUBJECT: WATER PURIFICATION DEMONSTRATION PROJECT, NOVEMBER 30, 2010 DRAFT TESTING AND MONIOTRING PLAN, AND REGULATION OF PROJECT UNDER ORDER NO. 97-03

The California Regional Water Quality Control Board, San Diego Region (San Diego Water Board) appreciates having the opportunity to review the *Final Draft Testing and Monitoring Plan, November 30, 2010* (Draft Plan). The Draft Plan provides a comprehensive approach to generating the data necessary for addressing numerous and varied concerns regarding indirect potable reuse and the quality of the product produced by an Advanced Water Purification Facility. The following comments on the Draft Plan are being provided for the City's consideration with the purpose of facilitating the NPDES permitting process.

Comments Regarding the Draft Plan

1. The monitoring that will be conducted provides an opportunity to develop data for establishing applicability of water quality-based effluent limitations for priority pollutant criteria/ objectives in a National Pollutant Discharge Elimination System (NPDES) permit. Specifically, sufficient data of the discharge is necessary to perform a reasonable potential analysis (RPA) for each of priority pollutant. The monitoring location must be representative of the quality of the product water and the monitoring be conducted according to the U.S. Environmental Protection Agency test procedures approved at 40 CFR Part 136, *Guidelines Establishing Test Procedures for Analysis of Pollutants Under the Clean Water Act* as amended.

   In general, the monitoring parameters should include all constituents having water quality objectives listed in the *Water Quality Control Plan for the San Diego Basin* (Basin Plan) for the San Vicente Reservoir.

2. The Draft Plan should include provisions for addressing the State Water Resources Control Board's (State Water Board) draft Policy for Toxicity Assessment and Control (Policy). The Policy includes a new method to determine the toxicity of effluents, statewide numeric objectives, and further standardization of toxicity provisions for National Pollutant Discharge Elimination System (NPDES) permittees. A copy of the Policy may be obtained at:

http://www.waterboards.ca.gov/water_issues/programs/state_implementation_policy/index.shtml.

3. Although as stated in the Draft Plan, the Basin Plan sets a threshold limit for total phosphorus concentration for any streams at the point of entering inland standing body surface waters, such as San Vicente Reservoir, of 0.05 milligrams phosphorus per liter (mg-P/L). San Vicente Reservoir, however, is considered a "standing body of water", not "flowing waters". Therefore, the threshold total phosphorus concentrations shall not exceed 0.025 mg/l in the Reservoir.

4. The Draft Plan should continue to be updated when necessary to implement new monitoring strategies for chemicals of emerging concern in recycled water as decided by the State Water Resource Control Board and California Department of Public Health.

Comments Regarding Order No. 97-03

As discussed in the City of San Diego's December 16, 2010 letter, the City proposes distribute a blend the effluent from the Advanced Water Purification Facility and the North City Water Reclamation Plant to reuse customers in accordance with the requirements of Order No. 97-03. The San Diego Water Board does not require a modification of Order No. 97-03 for the City's proposal because the Advanced Water Purification Facility will provide supplemental treatment to the tertiary effluent produced by the North City Water Reclamation Plant.

For questions pertaining to the above comments, please contact Joann Cofrancesco by email at jcofrancesco@waterboards.ca.gov, or by phone at 858-637-5589.

PLEASE INCLUDE "244506:JCOFRANCESCO" IN THE SUBJECT LINE OF FUTURE CORRESPONDENCE.

Sincerely,

Robert Morris

ROBERT W. MORRIS
Senior Water Resource Control Engineer
San Diego Regional Water Quality Control Board

cc: (by email):
Amy Dorman, Senior Civil Engineer, Long-Range Planning & Water Resource, ADorman@sandiego.gov
Anthony Van, Associate Engineer-Civil, Long-Range Planning & Water Resource, AVan@sandiego.gov

City of San Diego
Indirect Potable Reuse/Reservoir Augmentation Demonstration Project
Advanced Water Purification Facility

Draft Testing and Monitoring Plan (10/8/10) IAP Subcommittee Comments received letter Dated 11/15/10

Comment 1 Treatment Process
Changes in the type and dose of coagulant should be tested to evaluate water quality impacts, such as pH, conductivity, and mineral composition. As a minimum, the effects of ferric chloride coagulation, currently shown as optional, should be assessed along with other potential treatment modifications.

Comment Response
Based on consultation with the NCWRP operations, coagulant and polymers will either not be used during the AWP testing period or would be used at constant concentrations. Currently, NCWRP only uses cation polymer during plant upsets which occur on a very limited basis (i.e. 1 or 2 per year). However, coagulant dosing will be tested upstream of the UF membranes to enhance membrane productivity. The need for coagulant (type and dose) upstream of the UF system will be established by assessing baseline (i.e. no coagulant addition) fouling performance data and recommendations from the UF membrane manufacturer.

Comment 2 Treatment Process
The technical and economic feasibility of conducting partial demineralization by electrodialysis reversal (EDR) should be assessed to optimize the use of reverse osmosis (RO) or identify opportunities to use it as a back-up or supplementary system. Since RO has the capacity to handle some increased total dissolved solids (TDS) loading, it is not clear whether upstream EDR provides enough additional benefits to plant operations to justify the additional expense.

Comment Response
The AWP Demonstration Facility is designed to receive feedwater from the tertiary effluent of the NCWRP upstream of EDR. While the team agrees conducting partial demineralization using EDR upfront of the AWP treatment train may provide benefits (i.e. lower TDS and nitrate) this is not in the scope of the current demonstration testing. Should the baseline train being used at the demonstration scale not meet the nitrogen objectives, the option of using EDR for the full scale AWPF could be considered for nitrate removal, however this option would need to be compared to other possible treatment processes such as ion exchange (IX). Also, further analysis on whether the current EDR system at NCWRP would provide enough capacity for the full scale AWPF would need to be evaluated.

Comment 3 Treatment Process
The status of the existing filtration process should be evaluated in the context of projected upgrades or modifications. Since filtration will now be functioning as pretreatment for the microfiltration/ultrafiltration (MF/UF) process, its performance should be optimized in conjunction with the pilot testing.

Comment Response
The 2009 annual monitoring data from the NCWRP showed Average Daily Turbidity (NTU) from Jan. to Dec. ranged from 0.41 to 0.75 with average a yearly value of 0.56. This data indicates the plant is producing fairly consistent and good quality filter

effluent. It is our understanding that the filter process at NCWRP has been optimized over the years to achieve the current performance and that no further changes / optimization of the process will be made during the operational period of the AWP Demonstration Facility.

Comment 4 Treatment Process
In recognition of the fact that the UV reactor in the pilot plant is not representative of the UV system to be used in the full-scale AWFP, the IAP recommends that verification of the log removal requirements for NDMA and 1,4-dioxane by the advanced oxidation process (AOP), as specified in the August 4, 2008 California Department of Public Health draft groundwater recharge regulations, be performed on the full-scale facility prior to implementation of the project.

Comment Response
The project team is in agreement.

Comment 5 Treatment Process
The IAP Subcommittee was presented with some pilot plant data relating to NDMA removal. This data set was very limited and should not be considered definitive at this time. The IAP would appreciate the opportunity to review additional data related to NDMA removal as it becomes available.

Comment Response
The AWT pilot testing conducted at NCWRP in 2005 showed NDMA measured in the product water to be below the current CDPH notification limit (10 ng/L) in all samples with only 1 detection above the MDL (2 ng/L). Testing and monitoring of the AWP Demonstration facility will generate a greater number of NDMA removal results than the pilot. This information will be included in quarterly progress reports, which will be provided to the IAP to review.

Comment 6 Water Quality
The IAP suggests that, except for water quality monitoring needed at startup of the AWPF to optimize the unit processes, water quality monitoring of the full-scale AWPF not begin until the system has been stabilized and is operating at steady-state conditions to obtain representative data.

Comment Response
Please clarify the comment is referring to water quality monitoring of the demonstration scale AWPF and not the full- scale AWPF. The project team agrees it is important that the demonstration facility operation is stabilized prior to beginning extensive water quality monitoring (i.e. complete list of parameters identified for quarterly sampling). The sampling plan will be executed accordingly.

Comment 7 Microbial

The draft routine bacteria and virus surrogate monitoring plan proposes direct bacteria and virus monitoring using epifluorescence microscopy (with SYBR-green ATP measurements), which is not an approved method. Further, the analysis is expensive and does not determine organism viability. The IAP recommends that the use of epifluorescence microscopy for direct monitoring of bacteria and viruses not be included in the routine surrogate monitoring plan.

Comment Response

The project team appreciates the IAPs input and will remove direct monitoring of bacteria and viruses using epifluorescence microscopy (with SYBR-green ATP measurements).

Comment 8 Microbial

For the component that calls for the direct monitoring of pathogens, the IAP concluded that, due to the well-known performance of the treatment train for pathogen removal and the substantial indicators analyses, monitoring for bacterial and viral pathogens may not necessary. However, the IAP recognizes the value of such monitoring from a public confidence perspective, and suggests that the proposed pathogen monitoring component be reevaluated at the next IAP meeting.

Comment Response

The project team appreciates the IAP's feedback and will hold off on revising the draft plan for direct monitoring of pathogens until further feedback is provided.

Comment 9 Microbial

The IAP suggests that it may be possible to reduce the monitoring frequency for Cryptosporidium (before MF/UF) by sampling for aerobic spores like B. subtilis as potential surrogates for Cryptosporidium. B subtilis are much smaller than Cryptosporidium and thus would be a conservative indicator that can be analyzed quickly and inexpensively. B. subtilis analyses could be performed in conjunction with Cryptosporidium studies and more frequently as potential MF/UF process performance indicators. The use of aerobic spores would be appropriate if the spores service the prior disinfection process. This would need to be evaluated.

Comment Response

The project team agrees B. subtilis may serve a good surrogate for Cryptosporidium as it is smaller and should be removed by sieving. However, it is unknown if the spores will survive the addition of chloramines upstream of the MF/UF systems to have substantial levels. Also, it may be difficult to differentiate whether observations of reduced concentrations in the MF/UF filtrate is due to disinfectant contact time during filtration, or actual removal. In order to answer these questions, the project team would recommend conducting conventional microbial inactivation bench scale experiments using B. subtilis under various conditions including chloramines concentration, pH and contact time. At this time, such testing is not in the scope of the current demonstration testing.

*The project team would also like to point out that the type of UF and MF membranes being used at the demonstration facility have been tested under the **Drinking Water Membrane Testing Protocol For California Department of Public Health (CDPH) Conditional Acceptance** (April 2007) and received CDPH conditional approval for membrane filtration products and log removal credits. This testing includes direct challenge testing experiments with an approved Cryptosporidium and Giardia surrogate. Additionally, during the demonstration testing period daily pressure decay testing will be performed to assess membrane integrity of both UF and MF systems in accordance to the **EPA Membrane Filtration Guidance Manual** (November 2005).*

Comment 10 Constituents of Emerging Concern
The major purpose for the design of the monitoring strategy should be to: 1) determine which constituents are likely to either break-through or not be removed; and 2) use the information obtained as a basis to identify surrogates for operational tracking purposes at different stages of treatment. Experience at Orange County Water District's Groundwater Replenishment System and other similar projects demonstrates that many chemicals (e.g., metals and other priority pollutants) are easily handled by the treatment train if any are in the treated wastewater influent to the advanced treatment plant. In addition, breakthroughs of some chemicals such as NDMA and 1,4-dioxane (and a few others) at ng/L levels are expected, and do not *per se* indicate significant health risks. The IAP recommends that San Diego design a monitoring strategy for the pilot program that collects sufficient numbers of samples to determine appropriate surrogates for managing the processes and also provides public confidence on the effectiveness of the treatment system.

Comment Response
The project team agrees with the goals the IAP has provided with regards to the CEC monitoring plan and will incorporate these into the test plan. The project team has revised the CEC monitoring plan to increase the initial sampling of surrogate / indicators, and increase the list of compounds and sampling locations to be monitored on a quarterly basis based on past performance seen at the City of San Diego AWT pilot and CDPH Recommendations.

Comment 11 Constituents of Emerging Concern
The IAP recommends that the draft strategy include an approach for selecting appropriate surrogate constituents. Initially, screening tests should be conducted for a suite of CECs that may be present in the influent wastewater. Based on the results of the screening studies, a set of surrogate parameters can be selected that could be linked back to the constituents in the wastewater. This study should be initiated after the treatment system has been running for perhaps a minimum of 4 months and is operating at steady-state conditions. The analytical list may be drawn from the City's currently proposed monitoring list of 90 CECs, as well as other sources. The parallel analyses of chemicals and surrogate candidates would include the feed water, before and after RO, and potentially, some chemicals that survive after the advanced

oxidation process (AOP). This assessment is important since it will serve as the basis for process operating decisions in the full-scale plant.

Comment Response
This comment is noted and the recommendations will be implemented in the execution of the CEC monitoring plan.

Comment 12 Constituents of Emerging Concern
It is doubtful that contaminants will routinely break through at concentrations that have health significance, which is one of the reasons for focusing on surrogate analyses. The IAP disagrees with the SWRCB-sponsored report entitled "Final Report: Monitoring Strategies for Chemicals of Emerging Concern (CECs) in Recycled Water" that caffeine and triclosan should be considered as health-related; however, it may be advisable to include them for monitoring process performance. That report also included NDMA and 17 estradiol (although it is unlikely to survive the process). They, as well as many other chemicals, would represent potential health concerns if they occurred at higher than expected levels. Therefore, it is appropriate to have health advisory levels available in the event that any were detected.

Comment Response
The project team appreciates the comment and it is noted.

Comment 13 Constituents of Emerging Concern
The IAP has some suggestions related to the monitoring strategy. DEET, carbamazepine, and primidone could be analyzed because they are ubiquitous in domestic wastewaters and refractory in nature. Among the other suggested chemicals, PFAAs might be candidates, even though their removal by RO has been well documented. 1,4-dioxane is also a good choice due to its known inefficient removal by RO. Chemicals included in the third Unregulated Contaminant Monitoring Rule, Cycle 3 (UCMR3) would best be addressed selectively, unless there is a regulatory requirement to analyze them. Chemicals like triclosan, caffeine, and sucralose and other artificial sweeteners are of no toxicological interest, but may be able to serve as surrogates. Hydrazine and quinoline are of little interest unless they are ubiquitous in the tertiary-treated wastewater and not readily removed by RO and/or AOP; hydrazine would likely not be well removed by RO, if present. Nicotine and cotinine could be considered for inclusion since they are cigarette-related and likely to be in sewage and of toxicity interest if at high enough levels in the finished water, although this is unlikely. They also are relatively low molecular weight molecules that could challenge RO, but not likely AOP. Extensive monitoring for the priority pollutants is of little value. Our understanding is that the Orange County Water District has had no detections in their extensive monitoring over several years. Perhaps a few samples could be analyzed for that group for verification and if the regulatory agencies require it. These types of analyses could also play a role in demonstrating the overall quality of the finished water to the public.

Comment Response
This comment is noted and the recommendations will be implemented in the execution of the CEC and quarterly water quality monitoring plan.

Comment 14 Constituents of Emerging Concern
The characteristics of wastewater can vary depending on the time of day and the loading to the wastewater treatment plant. For parameters that will be monitored using grab-samples, it is important to time sample collection to reflect the range of conditions that are likely (e.g., peak-flow, peak-loading, etc.). It is also important to ensure that the sampling program can yield statistically defensible results. Prior to initiating the routine sampling program, initial quality assurance studies should be conducted to determine the appropriate sample volumes (relates to detection limits), sampling frequency and timing, and which parameters should be monitored using grab-samples versus composite samples. The City should confer with San Diego Regional Water Quality Control Board (RWQCB) to get input on the parameters that should be measured using composite samples and whether the composites should be generated using a flow-weighted or time-based approach.

Comment Response
The project team appreciates the IAPs suggestions with regards to water quality sampling plan. The Testing and Monitoring Plan has been updated to include a revised routine monitoring plan including the basis of the parameter selection, sampling frequency, sample collection type (grab vs. composite) and target demonstration goals. ***This information has been included in Table 5-2 and Table 5-4 located on pages 10 and 11, respectfully of this document.*** *The project team also confirmed with the NCWRP operations that the tertiary flow is constant therefore justifying the use of time weighted (as opposed to flow paced) composite sample collection. In addition, the sampling plan has been updated based on CDPH comments to assess diurnal variations, which will include conducting two 24 hour sampling events during the 12 month operating period to collect grab samples of the RO feed every 4 hours for the following preliminary list of compounds:*

- *Caffeine*
- *Sucralose*
- *Total nitrogen*
- *Nitrate*
- *1,4 dioxane*
- *NDMA*
- *Total phosphorus*

Prior to initiating the sampling plan, the project team will coordinate closely with all laboratories to ensure appropriate samples volumes are collected for each parameter to achieve method detection limits (MDLs) and reporting limits (RLs). The project team feels the revised changes to the sampling plan described above will provide statistically defensible results

Comment 15 Constituents of Emerging Concern
The Orange County Water District has experienced inconsistencies in comparing the monitoring results from grab samples versus online measurements for TOC. Thus, the City should consider relying entirely on online TOC measurements as they would be more informative – and likely more accurate – than using grab samples.

Comment Response
The project team agrees on-line TOC measurements have been reported to be more accurate and provide greater sensitivity than grab samples. The general consensus during the IAP subcommittee meeting with regards to TOC monitoring at the AWP Demonstration Facility was to have (1) one online portable TOC monitor on the combined RO product for each 24 hour period except when it is used to take grab samples from other locations (i.e. RO feed, RO 1 product, RO 2 product, UV/AOP product). During the operation period, the team will access differences (if any) between samples taken online vs. grab samples using the portable TOC monitor for a given sample location.

Comment 16 Constituents of Emerging Concern
The IAP finds that although definitive nutrient requirements for phosphorus and nitrogen have not been determined by the RWQCB, narrative and numeric nutrient requirements already included in the Basin Plan for discharges to surface water (such as San Vicente Reservoir) may allow the use of a 0.1 mg/L total phosphorus goal to determine compliance. Using the nominal N:P ratio of 10:1 to determine compliance for total nitrogen, it is possible that a 1.0 mg/L goal may be promulgated for total nitrogen to prevent eutrophication of the reservoir. The presentations to the IAP by the City of San Diego and their consultants suggests that modifications of the existing treatment process to date at the North City Water Reclamation Plant enhance denitrification and lower nitrate levels has had some success, but nitrate levels are still somewhat above 10 mg/L in the tertiary effluent. Using an 80- to 90-percent removal value for nitrate (provided at the meeting by the City's consultants) as that potentially-achieved by the RO system may yield an effluent nitrate level above the potential compliance limit for discharge to the reservoir. Therefore, the IAP suggests that more attention be paid to the operation of the existing tertiary treatment plant at the North City Water Reclamation Plant (NCWRP) to try to maximize denitrification to achieve lower the nitrate levels in the tertiary-treated water (to well below 10 mg/L) in order to demonstrate that such compliance may be achieved by the AWPF under future effluent limitation scenarios.

Comment Response
As mentioned in the Testing and Monitoring Plan Section 3.1.3.1 the City began a study in January 2008 to assess possible improvements to the NCWRP recycled water quality by enhancing the plants denitrification process. Over the course of the demonstration period, further refinements to the implemented changes are planned to occur with a focus to increase automation of the oxygen system to further reduce the plants effluent nitrate concentration. The project team will coordinate closely with

NCWRP operations staff to be sure data collected at the demonstration plant reflects these changes.

Comment 17 Source Control
The IAP acknowledges the City's efforts to identify potential contaminants of concern in the NCWRP watershed from industries, including pharmaceutical and research facilities.

Comment Response
Noted.

Comment 18 Source Control
Because the opportunity exists for the discharge of (probably small) amounts of chemical, radioactive, and biological material into the wastewater stream, it is advisable to contact each industry, particularly pharmaceutical manufacturers, hospitals, and laboratories, to raise awareness in those industries that their discharges will be feed water to the AWPF that will process the wastewater to be used for potable reuse.

Comment Response
The project team appreciates this advice. The team is preparing a workplan to address source control and will take this concept into consideration.

Comment 19 Source Control
The IAP is interested in hearing more about the City's source control program. The IAP requests that a presentation on the source control program be provided at the next IAP meeting.
Comment Response
Findings related to source control will be presented at a future IAP meeting.

Comment 20 Water Stabilization
The stability of the product water is important to ensure the integrity of the pipeline from a microbial and corrosion perspective. It would be worthwhile to consider evaluating the options for controlling biofilm growth and corrosion. Using a pipe-loop study or annular reactor to evaluate microbial growth and the effectiveness of alternative control strategies could be a valuable complement to the pilot study once the system is operating at steady-state. These tests could be used to determine the extent to which a secondary disinfectant and/or corrosion control in addition to lime treatment is needed.

Comment Response
The project team appreciates the IAP subcommittees recommendations related to water stabilization. At this time, the details of the pump station and pipeline design (pipe material, detention time, etc.) and requirements (including the need for secondary chlorination / dechlorination) for the full scale AWPF conveyance system

have not been determined. Accordingly, as part of the current demonstration testing the project team will only focus on the requirements to stabilize the AOP product water in terms of pH adjustment and lime addition for alkalinity recovery. To achieve this goal, the project team will conduct desktop modeling and bench scale testing using AOP product water collected at the demonstration facility. The City may consider additional testing as recommended by the IAP at a later stage in the demonstration project and / or during the pre-design phase of the possible full-scale AWPF.

Table 5-2 Anticipated Water Quality Goals for Regulated Constituents: San Diego AWP Facility

Constituent	Units	Proposed Demonstration Goal (average)	Anticipated Regulatory Limit (maximum)	Basis	Critical Beneficial Use/Issue
Total organic carbon (TOC)	mg/L	0.5	[1]0.5	CDPH	MUN
Ammonia (unionized as N)	ug/L	25	25 or Ce=25+Dm(25)	Basin Plan	Habitat
Nitrate (as N)	mg/L	[2]1	10 or Ce=10+Dm(10)	CDPH & Basin Plan	MUN
Total nitrogen	ug/L	[2]1000	[1]5000	CDPH	MUN
			[1,2]1000	Basin Plan	Biostimulation
Total phosphorus	ug/L	[2]100	[1,2]100	Basin Plan	Biostimulation
N-nitrodisodimethylamine (NDMA)	Log reduction	> 1.2-log	[1]1.2- log	CDPH	MUN
	ng/L	Not detected	[3]0.69 or Ce=0.69+Dm(0.69)	CTR/SIP	
1,4-Dioxane	Log reduction	> 0.5-log	[1]0.5- log	CDPH	MUN
1,2-Dichloroethane	ug/L	< 0.38	[3]0.38 or Ce=0.38+Dm(0.38)	California Toxics Rule	MUN
Total trihalomethanes	ug/L	< 80	[1]80	CDPH	MUN
Bromoform	ug/L	Not detected	[3]4.3 or Ce=4.3+Dm(4.3)	California Toxics Rule	MUN
Chlorodibromomethane	ug/L	Not detected	[3]0.401 or Ce=0.401+Dm(0.401)	California Toxics Rule	MUN
Dichlorobromomethane	ug/L	Not detected	[3]0.56 or Ce=0.56+Dm(0.56)	California Toxics Rule	MUN
Halo acetic acid (HAA)	ug/L	< 60	[1]60	CDPH	MUN
Methylene chloride	ug/L	< 4.7	[3]4.7 or Ce=4.7+Dm(4.7)	California Toxics Rule	MUN
Turbidity	NTU	< 0.2	[1]0.2	CDPH	MUN
Chloride	mg/L	50	[3]50 or Ce=50+Dm(50)	Basin Plan	MUN
Total dissolved solids (TDS)	mg/L	300	[3]300 or Ce=300+Dm(300)	Basin Plan	MUN

1. Potential limit based on best available information developed to date. Value subject to change.
2. Tentative goals based on providing best available treatment economically achievable and achieving Basin Plan total nitrogen and total phosphorus objectives for flowing waters.
3. Based on simplified version for determining California Toxics Rule (CTR) permit limits for priority pollutants. Section 1.4 of the State Implementation Plan contains specific steps and procedures that take into consideration ambient background concentration, the coefficient of variation of measured concentration data, and dilution credit. In some cases, the calculated effluent limitation can be lower than the CTR criterion. Ce - effluent concentration; Dm – dilution factor.

Table 5-4
Certified Laboratory Routine Water Quality Monitoring Plan for the San Diego AWP Facility

Constituent	[1] Sample Location	[2] Type of Sample	[3] Analytical Method	Monitoring Frequency	[4] Total Number of Samples per location
Total organic carbon (TOC)	S6, S7, S8	24-Hour Composite	SM2540C	[5] Monthly	12
Ammonia (unionized as N)	S6, S7, S8,	24-Hour Composite	EPA 300.0	[5] Bi-weekly (once per 2 weeks	26
Nitrate (as N)	S6, S7, S8	24-Hour Composite	EPA 300/351.2	[5] Bi-weekly (once per 2 weeks	26
Total nitrogen	S6, S7, S8	24-Hour Composite	SM4500P-E	[5] Bi-weekly (once per 2 weeks)	26
Total phosphorus	S6, S7, S8	24-Hour Composite	EPA 521	Bi-weekly (once per 2 weeks	26
N-nitrodisodimethylamine (NDMA)	S6, S7, S8, S9, S10	24-Hour Composite	EPA 522 MOD	Monthly	12
1,4-Dioxane	S6, S9, S10	Grab	ML/SW 8270 mod	Monthly	12
1,2-Dichloroethane	S6, S9, S10	Grab	ML/EPA 524.2	Monthly	12
Total trihalomethanes	S6, S9, S10	Grab	ML/EPA 524.2	Monthly	12
Bromoform	S6, S9, S10	Grab	ML/EPA 524.2	Monthly	12
Chlorodibromomethane	S6, S9, S10	Grab	ML/EPA 524.2	Monthly	12
Dichlorobromomethane	S6, S9, S10	Grab	ML/EPA 524.2	Monthly	12
Trichloromethane	S6, S9, S10	Grab	ML/EPA 524.2	Monthly	12
Halo acetic acid (HAA)	S6, S9, S10	Grab	EPA 552.2	Monthly	12
Methylene chloride	S6, S9, S10	Grab	ML/EPA 524.2	Monthly	12
Turbidity	S4, S5	24-Hour Composite		Daily	365
Chloride	S6, S7, S8	24-Hour Composite	ML/EPA 300.0	Bi-weekly (once per 2 weeks	26
Total dissolved solids (TDS)	S6, S7, S8	24-Hour Composite	SM 2540C	Bi-weekly (once per 2 weeks	26
Microbial	See endnote 5	See endnote 5	See endnote 6	See endnote 6	See endnote 6

[1]. Sampling locations: S4 = MF product; S5 = UF product; S6 = RO feed; S7 = RO 1 product; S8 = RO 2 product; S9 = UV/AOP feed; S10 = UV/AOP product.

[2]. Composite samples to be collected on a time weighted basis. NCWRP is operated to provide constant tertiary flow.

[3]. MDLs, RLs, TATs, sample hold times for each method are provided in Appendix E.

[4]. Based on a 12 month testing period.

[5]. Additional samples to be analyzed 2 per week collected 3 days apart at S10 in accordance to CDPH Groundwater Recharge Reuse Draft Regulations (2008).

[6]. See Section 5.2.4, Table 5-8 for microbial sampling plan.

Note: two 24 hour sampling events during the 12 month operating period will also be conducted to assess diurnal variations by collecting grab samples of the RO feed every 4 hours for the following preliminary list of compounds: Caffeine; Sucralose; Total nitrogen, Nitrate; 1,4 dioxane; NDMA; Total phosphorus.

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Final Testing and Monitoring Plan

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